

# **IMCSM Proceedings**

ISSN 2620-0597

**Volume XXI, Issue (1), (2025)**

An international serial publication for theory and  
practice of Management Science



**Editor-in-Chief: Prof. dr Đorđe Nikolić**

**Published by University of Belgrade, Technical Faculty in Bor,  
Department of Engineering Management**

## **Bor, 2025**

### *Scientific Board (SB) of the Conference:*

**Dorde Nikolić**, University of Belgrade, Technical Faculty in Bor, **president of the SB.**

**Marija Panić**, University of Belgrade, Technical Faculty in Bor, **vice-president of the SB.**

### *Members of SB:*

**Berto Usman**, University of Bengkulu, Indonesia;

**Daniel Pavlov**, “Angel Kanchev” University of Ruse, Bulgaria;

**Darko Stefanović**, University of Novi Sad, Serbia;

**Isidora Milošević**, University of Belgrade, Serbia.

**Ivan Mihajlović**, University of Belgrade, Serbia;

**Jacques Bazen**, Saxion University of Applied Sciences, Germany;

**Jovan Filipović**, University in Belgrade, Serbia;

**Ladislav Mura**, University of Economics in Bratislava, Slovakia;

**Loo-See Beh**, IMU University, School of Business and Technology, Kuala Lumpur, Malaysia;

**Luminita Parv**, Transilvania University of Brasov, Romania;

**Magdalena Radulescu**, National University of Science and Technology Politehnica Bucharest, Romania.

**Marek Szarucki**, Krakow University of Economics, Poland;

**Mario Carrassi**, University of Bari Aldo Moro, Italy;

**Michael Huth**, Fulda University of Applied Sciences, Germany;

**Milovan Vuković**, University of Belgrade, Serbia;

**Musin Halis**, Kocaeli University, Turkey;

**Pal Michelberger**, Obuda University, Hungary;

**Petar Mitić**, Institute of Economic Science, Serbia;

**Petra Grošelj**, University of Ljubljana, Slovenia;

**Rita Remeikiene**, Mykolas Romeris University, Lithuania;

**Simon Gao**, Edinburg Napier University, United Kingdom;

**Slobodan Aćimović**, University of Belgrade, Serbia;

**Slobodan Radosavljević**, RB Kolubara, Serbia;

**Snežana Urošević**, University of Belgrade, Serbia;

**Tomasz Ingram**, University of Economics in Katowice, Poland;

**Vasilika Kume**, Tirana Business University College, Albania;

**Vesna Spasojević Brkić**, University of Belgrade, Serbia;

**Željko Stević**, University of East Sarajevo, Bosnia and Herzegovina.

*Reviewers:*

**Berto Usman**, University of Bengkulu, Indonesia;  
**Daniel Pavlov**, “Angel Kanchev” University of Ruse, Bulgaria;  
**Darko Stefanović**, University of Novi Sad, Serbia;  
**Isidora Milošević**, University of Belgrade, Serbia.  
**Ivan Mihajlović**, University of Belgrade, Serbia;  
**Jacques Bazen**, Saxion University of Applied Sciences, Germany;  
**Jovan Filipović**, University in Belgrade, Serbia;  
**Ladislav Mura**, University of Economics in Bratislava, Slovakia;  
**Loo-See Beh**, IMU University, School of Business and Technology, Kuala Lumpur, Malaysia;  
**Luminita Parv**, Transilvania University of Brasov, Romania;  
**Magdalena Radulescu**, National University of Science and Technology Politehnica Bucharest, Romania.  
**Marek Szarucki**, Krakow University of Economics, Poland;  
**Mario Carrassi**, University of Bari Aldo Moro, Italy;  
**Michael Huth**, Fulda University of Applied Sciences, Germany;  
**Milovan Vuković**, University of Belgrade, Serbia;  
**Musin Halis**, Kocaeli University, Turkey;  
**Pal Michelberger**, Obuda University, Hungary;  
**Petar Mitić**, Institute of Economic Science, Serbia;  
**Petra Grošelj**, University of Ljubljana, Slovenia;  
**Rita Remeikienė**, Mykolas Romeris University, Lithuania;  
**Simon Gao**, Edinburg Napier University, United Kingdom;  
**Slobodan Aćimović**, University of Belgrade, Serbia;  
**Slobodan Radosavljević**, RB Kolubara, Serbia;  
**Snežana Urošević**, University of Belgrade, Serbia;  
**Tomasz Ingram**, University of Economics in Katowice, Poland;  
**Vasilika Kume**, Tirana Business University College, Albania;  
**Vesna Spasojević Brkić**, University of Belgrade, Serbia;  
**Željko Stević**, University of East Sarajevo, Bosnia and Herzegovina.

*Organizing Board of the Conference:*

**Aleksandra Fedajev**, president of the Organizational Committee,

**Danijela Voza**, vice president of the Organizational Committee,

**Milica Veličković**, member,

**Marija Panić**, member,

**Sanela Arsić**, member,

**Milena Gajić**, member,

**Adrijana Jevtić Tomić**, member,

**Aleksandra Radić**, member,

**Sandra Vasković**, member.

**Technical Editor:** Milica Veličković, Technical Faculty in Bor

**Technical Co-Editors:** Adrijana Jevtić Tomić, Technical Faculty in Bor

Aleksandra Radić, Technical Faculty in Bor



This work is available under Creative Commons  
Attribution - Non-commercial-NoDerivs Licence  
(CC BY - NC-ND)

CIP - Каталогизacija у публикацији  
Народна библиотека Србије, Београд

005.51(082)(0.034.2)

338.1:001.895(082)(0.034.2)

330.34(100)(082)(0.034.2)

**INTERNATIONAL May Conference on Strategic Management (21 ; 2025 ; Bor)**

[XXI] International May Conference on Strategic Management – IMCSM25, May 2025, Bor [Elektronski izvor] / [editor-in-chief Đorđe Nikolić]. - Bor : University of Belgrade, Technical Faculty, Management Department, 2025 (Niš : Grafika Galeb). - 1 USB fleš memorija ; 9 x 6 cm : tekst, slika. - (Edition IMCSM Proceedings ; vol. 21, issue (1) (2025), ISSN 2620-0597)

Sistemska zahteva: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-6305-160-7

a) Стратешки менаџмент -- Зборници b) Привреда -- Иновације -- Зборници v) Економски развој -- Међународни аспект -- Зборници

COBISS.SR-ID 169576201



*Gold Donor*



**塞尔维亚紫金矿业**  
**SERBIA ZIJIN MINING**

*Gold Donor*



**ZiJin**  
SERBIA ZIJIN COPPER DOO BOR

## CONTENT

<b>MANAGEMENT OF LAST-MILE DELIVERY THROUGH THE SELECTION OF LOCATIONS FOR PARCEL LOCKERS</b>	
Željko Stević, Eldina Huskanović .....	1
<b>E-COMMERCE IN THE DIGITAL AGE: EMPIRICAL EVIDENCE FROM SERBIA</b>	
Sanela Arsić .....	12
<b>INNOVATION MODELING TRAFFIC AND TRANSPORT</b>	
Nataša Pejić .....	30
<b>APPLICATION OF INNOVATIVE SOLUTIONS IN LOCAL GOVERNMENT IN CENTRAL EUROPEAN COUNTRY</b>	
Kamil Turčan, Ivana Butoracová Šindleryová .....	38
<b>THE RELATIONSHIP BETWEEN BURNOUT AND MENTAL WELL-BEING OF OLDER PEOPLE</b>	
Rita Remeikienė, Rusnė Katerina Jančaitytė, Beatričė Rūškienė .....	47
<b>VIOLENCE AGAINST WOMEN WITHIN THE CONTEXT OF DOMESTIC ABUSE IN BALTIC STATES AND ITS IMPACT ON LABOUR MARKET</b>	
Ligita Gaspareniene, Ilona Michailovič, Rita Remeikienė .....	61
<b>ALIGNING DIGITAL TRANSFORMATION WITH STRATEGIC MANAGEMENT IN LOGISTICS</b>	
Diana Daskevici, Aurelija Burinskiene .....	72
<b>RANKING OF THE MOST IMPORTANT GROUPS OF CRITERIA FOR THE SELECTION OF THE UNDERGROUND MINING METHOD FOR COAL DEPOSITS</b>	
Mohsen Jamshidi, Dejan Bogdanović, Hesam Dehghani .....	86
<b>THE BUREAUCRATIC GRIP OF EUROPEAN UNIVERSITY ALLIANCES</b>	
Edita Lenkauskaite, Caio Cesar Souza .....	94
<b>THE IMPACT OF FINTECH INNOVATION AND BANKING EFFICIENCY ON CUSTOMER LOYALTY: INVESTIGATING THE MEDIATING ROLE OF CUSTOMER TRUST</b>	
Sadiya Firdose R Z, Laxmana Rao Goranta .....	106
<b>LANGUAGE LEARNING MOTIVATION AS A REFLECTION OF PERSONAL POTENTIAL: THE ROLE OF EU ATTITUDES, ACTIVE CITIZENSHIP, EMPLOYABILITY, AND INFORMEDNESS</b>	
Tamara Verežan, Zrinka Fišer, Nataša Papić-Blagojević, Ivana Jošanov-Vrgović .....	119
<b>SUSTAINABILITY PROBLEM SOLVING IN THE MINING INDUSTRY: RISK ASSESSMENT APPROACH</b>	
Snežana Sando .....	129

**STRATEGIC STRUCTURING OF HUMAN RESOURCE MANAGEMENT THROUGH THE INTEGRATION OF INNOVATIONS**

Miloš Dimitrijević, Miloš Nikolić ..... 142

**INTEGRATED PLANNING OF LOGISTICS PROCESSES IN THE FIELD OF WAREHOUSING WITH SIMULATION SUPPORT**

Miriam Pekarcikova, Peter Trebuna, Jana Kronova, Marek Kliment ..... 152

**RELATION OF QMS VISION AND STRATEGY AND BALANCED SCORECARDS ACHIEVEMENTS OF HEIs IN INDUSTRY 5.0 ENVIRONMENT**

Maja Glogovac ..... 162

**INDUSTRY 5.0 IN THE NEW GLOBAL CIRCUMSTANCES OF MINING WITH RISK MAPPING**

Slobodan Radosavljević ..... 173

**ENERGY TRANSITION, ENERGY STRATEGIES, GLOBAL ENERGY SECURITY AND POTENTIAL RISKS**

Slobodan Radosavljević ..... 183

**INNOVATIVE APPROACHE TO FOREST MANAGEMENT IN THE CONTEXT OF THE SUSTAINABLE DEVELOPMENT GOALS**

Ljiljana Brašanac-Bosanac, Aleksandar Valjarević, Uroš Durlević, Milorad Šolević, Tatjana Ćirković-Mitrović ..... 193

**WHOLE-BODY VIBRATION MEASUREMENT AT THE MINING MACHINERY OPERATOR'S WORKPLACE IN SMES**

Vesna Spasojević Brkić, Mirjana Misita, Ivan Mihajlović, Katarina Dimić Misić, Martina Perišić, Nemanja Janev, Aleksandar Brkić ..... 205

**HAPS BETWEEN KESSLER SYNDROME, BENEFITS FOR HUMANITY, AND TECHNOLOGICAL CHALLENGES**

Damir Ilić, Vladimir Tomašević, Tatjana Ilić-Kosanović ..... 216

**INTEGRATING ENVIRONMENTAL MANAGEMENT INTO SUPPLY CHAIN STRATEGIES**

Stefan Ugrinov, Dragan Čočkalo, Mihalj Bakator, Mila Kavalić, Verica Gluvakov ..... 227

**THE ROLE OF DIGITIZATION IN SHAPING THE WORKING FUTURE OF OLDER EMPLOYEES IN SERBIA**

Andelka Stojanović, Milica Veličković, Sanela Arsić ..... 237

**A COMPARATIVE STUDY ON STUDENT INTENTIONS IN BULGARIA, ROMANIA AND SERBIA TO START FAMILY BUSINESSES**

Daniel Pavlov, Silvia Puiu, Milica Veličković ..... 247

**A COMPARATIVE ANALYSIS OF MCDM METHODS BASED ON PAIRWISE COMPARISON: AHP, BWM AND FUCOM**

Petra Grošelj, Gregor Dolinar ..... 256

**THE ROLE OF MANAGERS IN OPTIMIZING BUSINESS PROCESSES IN THE IT INDUSTRY**

Zorana Janković, Snežana Urošević ..... 267

**TRENDS AND DETERMINANTS OF STUDENTS' ENTREPRENEURSHIP INTEREST AND CAREER ASPIRATIONS ABROAD: A COMPARATIVE STUDY OF ALBANIA AND BULGARIA**

Fatma Jaupi, Anisa Kume, Daniel Pavlov ..... 275

**HIGH-ALTITUDE PLATFORM SYSTEMS: PERSPECTIVES ON CURRENT AND FUTURE TECHNOLOGICAL DEVELOPMENTS**

Damir Ilić, Vladimir Tomašević, Tatjana Ilić-Kosanović ..... 289

**THE USE OF SMART CONTRACTS TO PRESERVE THE INTEGRITY OF COLD SUPPLY CHAINS**

Dimitrije Soleša, Radovan Vladislavljević, Svetlana Marković ..... 297

**COSMETIC BRANDS PERCEPTION BY GENERATION Z THROUGH THE PRISM OF CONSCIOUS CONSUMPTION**

Marina Sheresheva, Daria Golub, Daniel Pavlov ..... 307

**REFRAMING PERFORMANCE APPRAISAL THROUGH EMPLOYEE PERCEPTIONS: INSIGHTS FROM THE ALBANIAN BANKING SECTOR**

Sllavka Kurti, Katerina Vasili, Vasilika Kume ..... 315

**STRENGTHENING STRATEGIC AND FINANCIAL STABILITY IN SCIENTIFIC INSTITUTES WITH IMPLEMENTATION OF STRATEGIC RISK MANAGEMENT**

Marija Jonović, Lidija Barjaktarović ..... 326

**CREATING CUSTOMER VALUE IN PRIVATE MEDICAL CLINICS BASED ON AN OMNICHANNEL INTERACTION SYSTEM**

Marina Sheresheva, Ekaterina Yudina1, Daniel Pavlov ..... 336

**IDENTIFICATION OF FACTORS FOR ANALYSIS AND EVALUATION OF HEIs PERFORMANCE**

Nedeljka Živković, Maja Glogovac, Isidora Milošević ..... 344

**SustainAbility: WHEN CAPITAL LETTER MATTERS**

Mario Carrassi, Anna Argeșe, Teresa D'Andrea, Tomasz Ingram ..... 353

**EVALUATING TRANSATLANTIC CRUISE SERVICE QUALITY: AN INTEGRATED SERVQUAL AND IPA APPROACH**

Predrag Đorđević, Anđelka Stojanović, Ivica Nikolić ..... 365

**APPLYING DIFFERENTIATION IN BUSINESS ENGLISH EFL CLASSROOMS: A STRATEGIC APPROACH TO ENHANCING LANGUAGE ACQUISITION AND PROFESSIONAL READINESS**

Slavica Stevanović, Sandra Vasković ..... 376

**DIGITALIZATION THROUGH E-INVOICES IN MICRO AND SMALL ENTERPRISES – CROATIAN EXPERIENCES**

Ivana Miklošević ..... 383

**ANALYSIS OF INNOVATION IN BRICS COUNTRIES**

Ivica Nikolić, Lidija Krstić, Anđelka Stojanović, Denis Stojkanović ..... 393

<b>A COMPARISON OF DIFFERENT LEADERSHIP APPROACHES IN THE HOTELS INDUSTRY AND THEIR IMPACT ON EMPLOYEE PERFORMANCE</b>	
Jovan Momirski .....	403
<b>CONFLICT MANAGEMENT STYLES IN PROJECT-BASED ORGANISATIONS: RELATION TO DEMOGRAPHIC FACTORS</b>	
Aleksandra Radić , Nenad Milijić .....	411
<b>DYNAMIC TRAFFIC LANES STRATEGY MANAGEMENT IN SMART CITY</b>	
Amit Vujic, Vladimir Tomasevic, Vladica Ristic, Marija Maksin .....	420
<b>HOW NEWCOMERS INFLUENCE GROUP MICROCLIMATE?</b>	
Rita Remeikienė, Beatričė Rūškienė, .....	430
<b>EXAMINING USE OF UNCONDITIONAL CASH TRANSFERS TO ENCOURAGE ENTREPRENEURSHIP EMANCIPATION: A SYSTEMATIC LITERATURE AND RESEARCH AGENDA</b>	
Kenneth Jerry Onyango, Nathaniel Boso, Hellen Otieno .....	437
<b>ASPECTS OF LEGAL REGULATION OF CO<sub>2</sub> EMISSIONS INTO THE ATMOSPHERE: A EUROPEAN UNION PERSPECTIVE</b>	
Evaldas Raistenskis, Ligita Gasparėnienė, Rita Remeikienė .....	447
<b>COMMUNICATION SATISFACTION AS A PREDICTOR OF ORGANIZATIONAL COMMITMENT</b>	
Danijela Voza, Zorana Janković, Milovan Vuković .....	455
<b>ENCRYPTION AND INFORMATION</b>	
Halima Onalla Ali, Sakina Almahzoum, Dušan Regodic, Velimir Dedić, Maja Andjelkovic .....	465
<b>AUTONOMOUS SYSTEMS ON THE BATTLEFIELD: THE MILITARY POTENTIAL AND RISKS OF SELF-DRIVING VEHICLES</b>	
Péter Szikora .....	476
<b>ANALYSIS OF TRAINING NEEDS OF PROFESSIONAL DEVELOPMENT OF SENIOR CIVIL SERVANTS IN THE REPUBLIC OF SERBIA</b>	
Jelena Ruso, Ana Rakić, Sara Dimitrijević, Isidora Milošević .....	488
<b>PRICE AND VOLUME DYNAMICS: A CORRELATION ANALYSIS OF MAJOR OIL COMPANIES</b>	
Adrijana Jevtić Tomić, Dejan Riznić .....	499
<b>ENVIRONMENTAL ASPECTS IN THE CASE-LAW OF THE COURT OF JUSTICE OF THE EUROPEAN UNION UNDER ARTICLE 260(2) TFEU</b>	
Deimilė Prapiestytė .....	514
<b>DO KNOWLEDGE MANAGEMENT AND GREEN INNOVATION CONTRIBUTE TO THE GREEN TRANSITION IN SERBIAN ENTERPRISES?</b>	
Sanela Golubović Corcione, Milica Veličković, Aleksandra Fedajev, Jelena Ružić .....	521

**WOMEN'S RURAL ENTREPRENEURSHIP – AN INTEGRATED APPROACH TO THE GENDER DIMENSION**

Marina Nedeljković ..... 534

**THE IMPACT OF ECONOMIC VARIABLES ON ATTRACTING FOREIGN DIRECT INVESTMENT IN LIBYA: AN ANALYTICAL STUDY OF THE PERIODS "1997–2010, 2011–2017, AND 2018–2024"**

Amel Kamel Abdulmalik ..... 542

**THE SIGNIFICANCE OF THE COURT OF JUSTICE OF THE EUROPEAN UNION JUDGMENT OF 30 APRIL 2024 IN CASE C-670/22 (“ENCROCHAT”) FOR THE ADMISSIBILITY OF EVIDENCE IN CRIMINAL PROCEEDINGS**

Remigijus Merkevičius ..... 551

**OVERTOURISM AND SUSTAINABLE TOURISM**

Lachi Cristina ..... 562

**EFFECTIVE ELIMINATION OF NETWORK FAILURES IN BROADCAST SYSTEM**

Jovan Zlatanovic, Ivana Milosevic, Mirko Milosevic ..... 575

**THE IMPACT OF THE CIRCULAR ECONOMY ON AN INDIVIDUAL’S QUALITY OF LIFE: A EUROPEAN UNION PERSPECTIVE**

Ligita Gasparėnienė, Rita Remeikienė ..... 585

**MADE IN ALBANIA FOR THE WORLD: A STUDY OF EXPORT STRATEGIES AND MARKET CHALLENGES**

Ariola Harizi, Denada Liça, Silvana Gashi ..... 594

**THE MODERATING EFFECT OF STAKEHOLDERS’ INFLUENCE ON THE RELATIONSHIP BETWEEN SUCCESSION MANAGEMENT AND HUMAN RESOURCE OUTCOMES IN PRIVATE UNIVERSITIES, KENYA**

Hilderlith Amimo-Ogut, Fred Walumbwa, Vincent Ogutu, Simon Ndiritu ..... 601

**SOCIAL RESOURCE ORCHESTRATION AND GROWTH OF SMALL AND MEDIUM ENTERPRISES: A SYSTEMATIC REVIEW**

Loise Oburu, Joseph Onyango, Ann Ndirangu ..... 611

**EMPOWERING CONSUMERS IN THE CIRCULAR ECONOMY: STRATEGIES FOR SUSTAINABLE AGRI-FOOD SYSTEMS IN THE REPUBLIC OF NORTH MACEDONIA**

Katerina Bojkovska ..... 621

**IMPLEMENTATION OF THE NEW INFORMATION SYSTEM FOR FINANCIAL MANAGEMENT (ERP SYSTEM) AT ŽRS A.D. DOBOJ**

Siniša Urumović, Nikola Simić ..... 633

**BRIDGING THE ESG AWARENESS GAP: CHALLENGES AND OPPORTUNITIES FOR SMEs IN NORTH MACEDONIA**

Vladimir Petkovski, Irina Piperkova, Elizabeta Djambaska, Aleksandra Lozanoska ..... 639

**DIGITAL READINESS LEVEL (DLR) AND TECHNOLOGY ORGANIZATION ENVIRONMENT (TOE) METHODOLOGY IMPLEMENTATION ON SME-S INDUSTRY 4.0 IMPLEMENTATION**

Aleksandra Kovačević, Aleksandar Jankulović ..... 649

<b>BLENDED, BRIEF, BUT IMPACTFUL? EVALUATING THE EFFECTIVENESS OF ERASMUS+ BLENDED INTENSIVE PROGRAMS</b>	
Jacob Cornelis Bazen, Florin Sebastian Duma .....	660
<b>IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN PROJECT-ORIENTED ORGANIZATIONS: A COMPARATIVE ANALYSIS OF SERBIA AND THE REGION</b>	
Jelena Ružić, Sanela Golubović Corcione, Ivan Jovanović .....	674
<b>DESIGN THINKING AS A CREATIVE APPROACH TO SUSTAINABILITY</b>	
Mario Carrassi, Anna Argeșe, Teresa D'Andrea, Tomasz Ingram .....	685
<b>OPTIMIZATION OF SALES CHANNELS THROUGH AI-DRIVEN CRM: SMART DATA ANALYSIS FOR BETTER RETAIL MANAGEMENT</b>	
Ankica Borota-Tišma, Draga Tišma .....	700
<b>THE CONDITIONAL NATURE OF GOSSIP: EXPLORING PSYCHOLOGICAL AND RELATIONAL PATHWAYS WITH FSQCA</b>	
Katarzyna Mielowska, Tomasz Ingram, Mario Carrassi .....	710
<b>ESG REPORTING IMPLICATIONS FOR ROAD CARRIERS' FINANCIAL OUTCOMES</b>	
Desislava Yosifova, Magdalena Petrova-Kirova .....	722
<b>INTELLIGENT TRANSPORT SYSTEMS AS A TOOL FOR SPEEDING PREVENTION</b>	
Veselin Grozdanov .....	728
<b>ECOLOGICAL DEBT RISK – HAVE WE ALREADY SPENT OUR RESOURCES FOR 2025?</b>	
Marija Panić .....	734
<b>THE PRINCIPLE OF SUSTAINABLE DEVELOPMENT IN POLISH TAX SYSTEM</b>	
Patryk Kowalski .....	744
<b>DETERMINANTS OF CO<sub>2</sub> EMISSIONS IN CENTRAL AND EASTERN EUROPE: AN EMPIRICAL PANEL DATA ANALYSIS</b>	
Aleksandra Fedajev, Petar Mitić, Aleksandar Zdravković, Gabrijela Popović .....	755
<b>DESIGNING THE SKANDIA NAVIGATOR TO MANAGE INTANGIBLE CAPITAL: WHAT RELEVANCE FOR MOROCCAN INDUSTRIAL COMPANIES?</b>	
Issam Bahnini, Sanae Benjeloun .....	770
<b>THE IMPACT OF PROCESS AUTOMATION ON MANAGEMENT CONTROL AND THE PERFORMANCE OF TOURISM COMPANIES: A BIBLIOMETRIC ANALYSIS</b>	
Sissah Safae, Hmioui Aziz .....	779



**INTERNATIONAL MAY CONFERENCE ON  
STRATEGIC MANAGEMENT**



## MANAGEMENT OF LAST-MILE DELIVERY THROUGH THE SELECTION OF LOCATIONS FOR PARCEL LOCKERS

Željko Stević \*, Eldina Huskanović

*University of East Sarajevo, Faculty of Transport and Traffic Engineering, Bosnia and  
Herzegovina*

**Abstract:** When observing e-commerce, it can be concluded that parcel lockers are an innovative solution to the everyday challenges faced in logistics. The fast pace of life and traffic congestion make parcel delivery difficult and expensive, while parcel lockers offer a more efficient way to receive and send packages 24/7. Key advantages include reduced delivery costs, environmental benefits (less CO<sub>2</sub> emissions), security of packages and greater availability to users. Parcel lockers are making access easier, while couriers can optimize their delivery routes. In this research, using the FUCOM (Full Consistency Method) and MARCOS (Measurement Alternatives and Ranking According to the Compromise Solution) methods, a model for selecting optimal locations for installing parcel lockers of the X-Express company for the Vitez distribution center was developed. The first step is data collection, while multi-criteria decision-making methods enable detailed analysis and ranking of potential locations. The introduction of parcel lockers contributes to the modernization of logistics, reduces administrative tasks and supports environmental sustainability.

**Keywords:** Parcel lockers, location, FUCOM, MARCOS.

### 1. INTRODUCTION

The growth of e-commerce represents a great challenge but also an opportunity for the modernization of postal and logistics services. In this context, one of the solutions to many logistical issues is the use of parcel lockers. The fast pace of life, along with the numerous locations a user visits throughout the day, often leads to challenges in deliveries made by courier vehicles. As a result, many deliveries are unsuccessful or must be postponed to another day. Additionally, increasing traffic congestion, which is caused, among other things, by delivery vehicles, has highlighted the need for a more efficient solution, which comes in the form of parcel lockers.

In order for parcel lockers to fulfill their purpose, one of the most important factors is their placement in busy areas – locations that are easily accessible to users to ensure their

---

\* Corresponding author: [zeljko.stevic@sf.ues.rs.ba](mailto:zeljko.stevic@sf.ues.rs.ba)

Željko Stević, ORCID: 0000-0003-4452-5768

Eldina Huskanović, ORCID: 0009-0007-7441-7254

maximum efficiency. Additionally, couriers can plan their routes more efficiently and deliver more parcels in less time, which saves resources and reduces delivery costs (fewer trips and delivery attempts), environmental benefits (fewer trips = reduced CO2 emissions), increased availability for users (packages can be picked up 24/7), fewer failed deliveries (deliveries are not dependent on the recipient's availability), security of packages (parcel lockers are equipped with advanced security systems, including video surveillance cameras and anti-theft systems). This ensures users feel safe when picking up or sending packages. The parcels are protected from external influence, and only those who possess the correct code or QR tag can access a specific locker, which further guarantees the security of the package contents.

The optimization achieved by using parcel lockers includes: data analysis (using pickup frequency data), integration with courier services (automatic notifications and package tracking reduce administrative tasks), optimization of delivery routes (couriers can plan optimal routes based on locker occupancy), and integration with smart technologies (such as the use of QR codes).

In this paper, we address the selection of locations for the installation of parcel lockers for the X-Express company in the area of the Vitez distribution center. X-Express is one of the leading companies in Bosnia and Herzegovina specializing in express delivery services, and as such it was among the first to recognize the need and importance of parcel lockers. In order to successfully select the locations for the installation of parcel lockers, it is crucial to take a comprehensive approach, considering as many criteria and alternatives as possible. Based on the results obtained, parcel lockers will be installed at the most suitable locations. Since the installation of parcel lockers represents a significant investment, selecting the right locations for the installation is especially important, as relocating parcel lockers after the initial installation is not a good option.

After collecting the necessary data, MCDM methods were used to develop a model for selecting the locations for parcel locker installation. In this paper, the FUCOM and MARCOS methods were applied. The FUCOM method was used to calculate the weights of the criteria, while the MARCOS method was used to rank potential locations for parcel locker installation. The introduction and expansion of parcel locker networks is becoming one of the key trends in logistics, as it enables faster, more cost-effective and environmentally friendly deliveries.

## **2. LITERATURE REVIEW**

Postal services have experienced significant growth following the development of e-commerce. In order to improve the operations of postal systems, numerous analyses have been conducted on current conditions as well as the future of these systems, which are facing a variety of challenges (Dobrodolac et al., 2015; Simić et al., 2021). Postal companies are striving to adapt to the new circumstances and meet user needs by improving their services. Users are finding it increasingly difficult to access postal services, as their business and personal obligations often coincide with the working hours of postal companies. One solution is to enable parcel delivery outside the recipient's home. In such cases, the aim is to make deliveries as close as possible to the recipient's residence, i.e., to the location of the business premises, if the recipient is a legal entity. One of the most advanced solutions to these challenges is the use of parcel lockers (Lazarević et al., 2022; Dong et al., 2023). Parcel lockers represent an efficient solution to the challenges of sending and delivering parcels along both the "first mile" and the "last mile". They have a positive impact on the economic, environmental and social sustainability of the parcel delivery industry (Bistrović, 2024; Palešćak, 2024). Operational challenges in last-mile logistics include delivery route optimization, fleet management, and the dynamics of delivery in increasingly dense urban environments, which increases costs (Olsson

et al., 2019; Jazemi et al., 2023). However, the advantage of parcel lockers is time flexibility, which means that users can collect their parcels at a time that suits them without being limited by the working hours of traditional pick-up locations. Furthermore, simplicity and speed are highlighted as other benefits. The process of collecting a parcel from a parcel locker takes only a few minutes. Users simply need to follow the on-screen instructions, enter a code or scan a QR code, and the locker containing the parcel will open (Narančić, 2023). Narančić also noted that parcel lockers offer increased security for users. Collecting parcels via parcel lockers eliminates the need to leave parcels on doorsteps or with neighbors when recipients are unavailable. The lockers are secure and users receive a unique identification code that allows only them to access their own parcels. This reduces the risk of theft or damage to parcels and provides users with additional security (Paleščak, 2024; Hlevnjak, 2024). The successful implementation of parcel lockers depends on several factors, including infrastructure availability, location security, and ease of access for delivery services (Boysen et al., 2020). Lagorio and Pinto (2020) analyze various factors that influence the success of parcel locker locations, including the sociodemographic characteristics of the population, movement patterns, and traffic congestion. Their study shows that it is important to consider not only the current state of infrastructure but also future changes in urban planning and development. Parcel lockers can be extremely useful in rural or hard-to-reach areas where delivering parcels to homes is challenging or expensive. By installing parcel lockers at strategic locations, users living outside large cities or in remote areas can have easier access to packaged shipments, thereby expanding the reach of e-commerce to people who otherwise would not have access to these services. Although parcel lockers are most commonly associated with e-commerce, their potential also extends to other industries, such as the pharmaceutical, textile, technology, and automotive industries. For example, pharmaceutical companies can use parcel lockers to distribute medications, while companies in the fashion industry can use them for easier returns or exchanges of products (Aghdam et al., 2024). This allows for the improvement of business processes and further reduces costs, which can directly benefit end users. As technology continues to develop, we can expect parcel lockers to become even more integrated with other innovations, such as autonomous vehicles. For example, parcel lockers could be connected to drones or autonomous vehicles that would deliver parcels directly to users or the lockers themselves, making logistics even faster and more efficient (Dimitrijević & Simić, 2021).

### **3. METHODOLOGY**

In the first phase of the research, the criteria and alternatives for selecting parcel locker locations were defined, and a questionnaire was created to collect data from the managers. In the second phase, multi-criteria decision-making methods were applied – first the FUCOM method for determining the weights of the criteria, followed by the MARCOS method for ranking the alternatives. In the third phase, the model results and sensitivity analysis were presented.

#### **3.1. FUCOM method**

The FUCOM method was developed by Pamučar, Stević and Sremac for determining the weights of criteria. FUCOM allows for model validation by calculating the error size for the obtained weight vectors through the determination of a consistency degree (Pamučar et al. 2018). The FUCOM algorithm is presented in Figure 1.

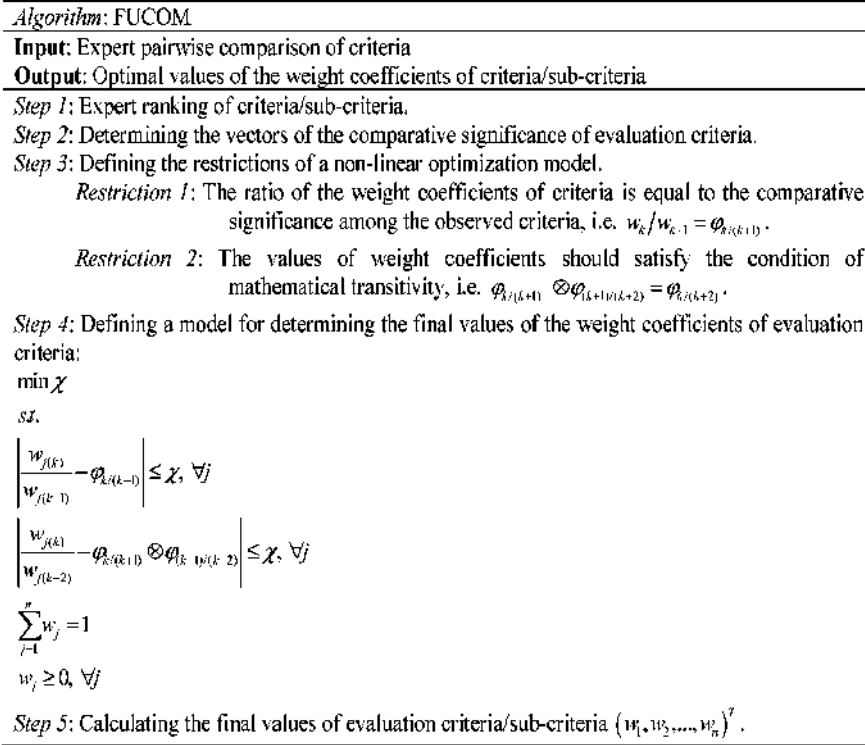


Figure 1. FUCOM algorithm (Stević & Brković, 2020)

### 3.2. MARCOS method

The MARCOS method is based on defining the relationship between each alternative and the reference values (ideal and anti-ideal alternatives). The best alternative is the one that is closest to the ideal and, at the same time, farthest from the anti-ideal reference point (Stević et al., 2020). The steps of the MARCOS method are presented in Figure 2.

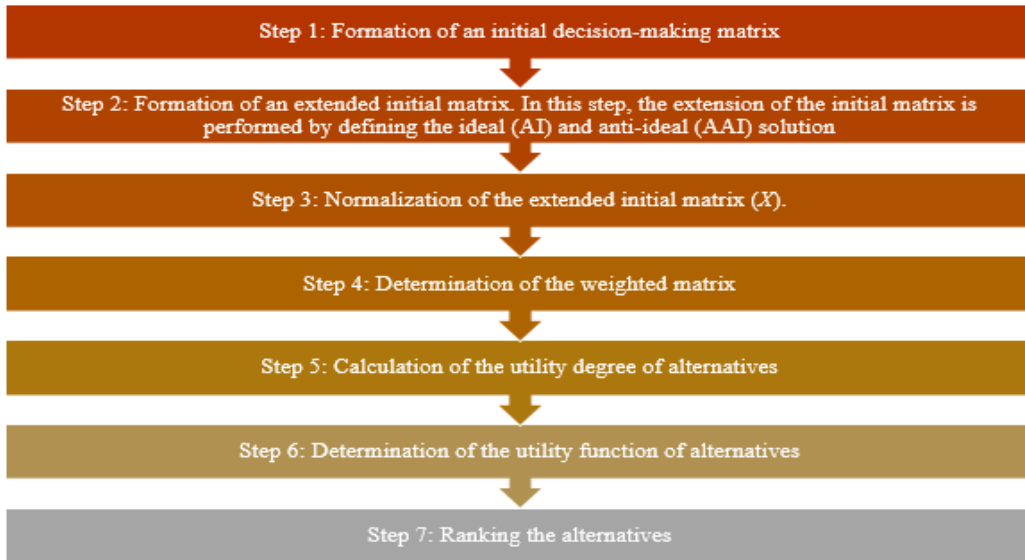


Figure 2. Steps of the MARCOS method (Stević et al., 2020)

#### 4. APPLICATION OF THE FUCOM-MARCOS MODEL FOR SELECTING LOCATIONS FOR PARCEL LOCKER INSTALLATION

This study focuses on identifying suitable locations for parcel locker installation within the Vitez distribution center, which covers the areas of Zenica, Vitez, Travnik, Novi Travnik and Busovača. All potential locations, i.e., alternatives, for parcel locker installation within the area of this distribution center are presented in Figure 3. In addition to the alternatives, seven criteria used to evaluate the potential alternatives have been defined: C1 - availability, C2 - accessibility, C3 - location rental costs, C4 - parcel locker maintenance costs, C5 - safety and security, C6 - pedestrian traffic density, C7 - frequency of user delivery requests.

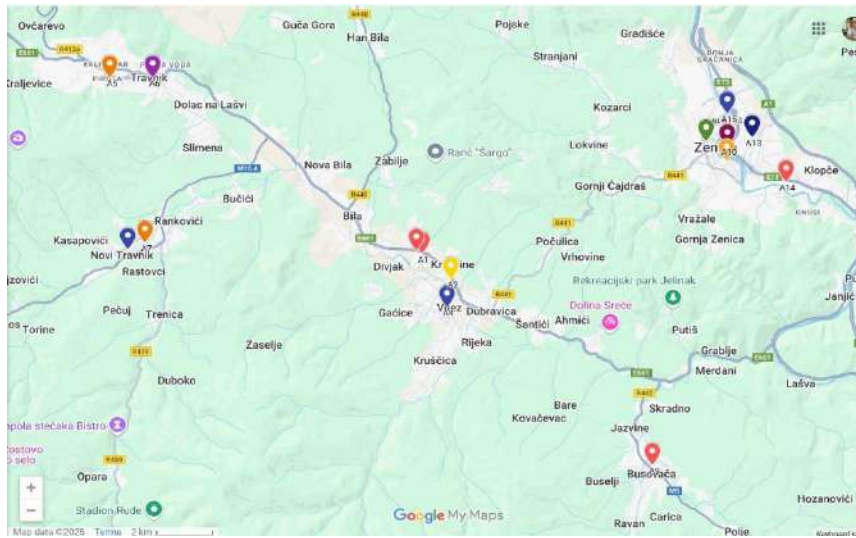


Figure 3. Potential locations within the Vitez distribution center

After defining the alternatives and criteria, the FUCOM method was applied based on the evaluations provided by the managers of the aforementioned company. The weights of the criteria obtained through the FUCOM method are shown in Figure 4.

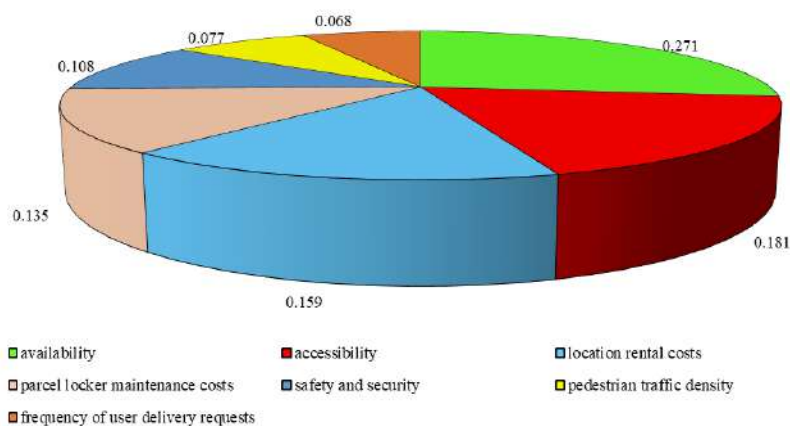


Figure 4. Criterion weights for determining the locations for parcel locker installation in the Vitez DC

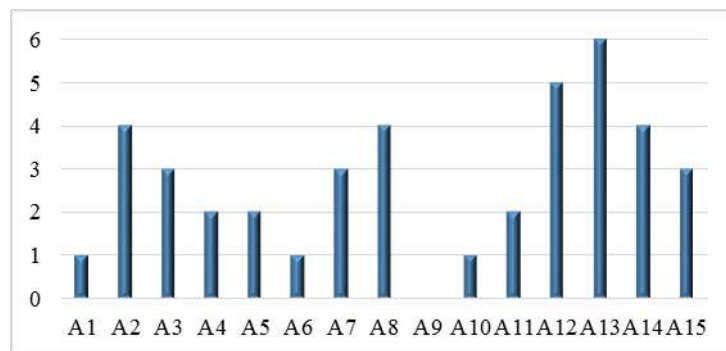
The results show that availability, i.e., the ability to collect and deliver parcels 24 hours a day, 7 days a week, is the most important criterion. It is followed in importance by criteria related to the frequency of user requests and accessibility. The least important criterion, in this case, is pedestrian traffic density. After defining the weights of the criteria, the MARCOS

method was applied to rank the potential locations for parcel locker installation, i.e., select the most suitable ones. The results of the MARCOS method are presented in Table 1.

*Table 1.* Final results for the Vitez DC obtained using the FUCOM-MARCOS model

	Si	Ki-	Ki+	fK-	fK+	Ki	Rank
AAI	0.489						
A1	0.990	2.022	0.990	0.329	0.671	0.850	2
A2	0.573	1.171	0.573	0.329	0.671	0.541	15
A3	0.720	1.472	0.720	0.329	0.671	0.658	10
A4	0.912	1.864	0.912	0.329	0.671	0.784	5
A5	0.946	1.934	0.946	0.329	0.671	0.817	4
A6	1.000	2.044	1.000	0.329	0.671	0.862	1
A7	0.866	1.769	0.866	0.329	0.671	0.754	6
A8	0.755	1.544	0.755	0.329	0.671	0.670	9
A9	0.990	2.022	0.990	0.329	0.671	0.850	2
A10	0.920	1.879	0.920	0.329	0.671	0.744	7
A11	0.893	1.824	0.893	0.329	0.671	0.724	8
A12	0.739	1.511	0.739	0.329	0.671	0.603	13
A13	0.675	1.379	0.675	0.329	0.671	0.549	14
A14	0.769	1.571	0.769	0.329	0.671	0.627	12
A15	0.788	1.610	0.788	0.329	0.671	0.653	11
AI	1.000		1.000				

Based on the results of the FUCOM-MARCOS model, it can be concluded that A6 represents the most suitable location for parcel locker installation. Following that, A1 and A9 are equally ranked and also represent proper locations for parcel locker installation. It can also be concluded that A3 is the least suitable solution for parcel locker installation among all the locations considered. However, in addition to this ranking of locations, it is also necessary to evaluate specific parts of the distribution center separately in order to ensure that the entire DC is adequately covered with parcel lockers, while maintaining a minimum required distance between them. Figure 5 shows the new results of the model when observing partial areas of the distribution center.



*Figure 5.* Model results by partial areas of DC

In Figure 5, the alternatives are grouped by locations as follows: A1-A4 represent the Vitez area, A5-A8 represent the Travnik and Novi Travnik area, and A10-A15 correspond to the Zenica area. A9 is a location in the Busovača area, which represents a connection point of all other areas, and certainly takes second place in the overall ranking, highlighting its importance. Based on these results, it can be concluded that the best location for parcel locker



installation in the Vitez area is A2. In the areas of Travnik and Novi Travnik, location A8 is predominant. In the city of Zenica, two locations are particularly significant, namely A13 and A12.

## 5. SENSITIVITY ANALYSIS AND COMPARATIVE ANALYSIS

In this section of the paper, an analysis was created involving changes to the weight coefficients of all criteria, within a range of 15 to 90%. The results of these changes in the weight coefficients for all criteria are presented in Figure 6.

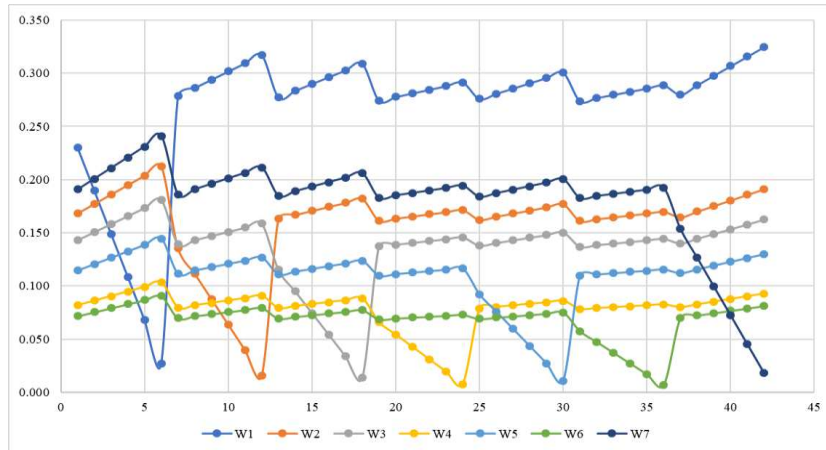


Figure 6. New simulated values of weight coefficients for all criteria

Figure 6 clearly shows that significant changes in the values of the weight coefficients for all criteria occur only when there are changes in the values of the weight coefficients of Criterion 1 and Criterion 7. After these changes and the mutual influence among the values of the weight coefficients of the criteria, a sensitivity analysis was conducted to examine how these changes in the values of the weight coefficients affected the final ranking of the alternatives. It was done through 42 scenarios, which are shown in Figure 7.

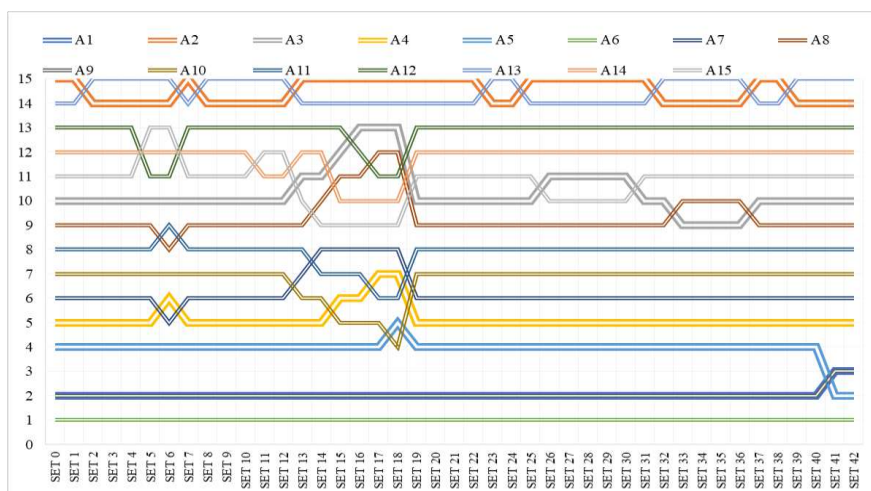


Figure 7. Results of the sensitivity analysis

Based on the results of the sensitivity analysis, it can be concluded that out of a total of 42 scenarios in which the weights of the criteria were changed, 10 scenarios, i.e., 23.8%, had



no effect on the ranking of the alternatives. It can also be concluded that in all scenarios, only alternative A6 maintained its first-place position, indicating that it was not sensitive to changes in the weight coefficients of the criteria. In addition, the following changes in the ranking of the alternatives were observed in response to changes in the weight coefficients of the criteria: for changes in Criterion 1 (S1-S6), more significant changes occurred in the rankings of A2 and A13; for changes in Criterion 2 (S7-S12), the greatest impact was also on the rankings of A2 and A13; changes in Criterion 3 (S13-S18) had the greatest impact on the ranking of the alternatives, causing 60% of the alternatives to change their position, particularly A3, A4, A5, A7, A8, A10, A11, A12, A14 and A15. Changes in the value of the weight coefficients of Criterion 4 (S19-S24) had the least impact, producing no significant changes in the ranking of alternatives. Changes in the value of Criterion 5 (S25-S30) had a significant impact on the positions of alternatives A3 and A15. Changes in the value of criterion 6 (S31-S36) influenced the positions of alternatives A2, A3, A8 and A13. Also, changes in the value of Criterion 7 (S37-S42) had the greatest impact on the rankings of alternatives A2 and A13.

After the sensitivity analysis, a comparative analysis was conducted, comparing the alternative ranking results obtained by the MARCOS method with the results of the ARAS (Zavadskas & Turskis, 2010), MABAC (Pamučar & Čirović, 2015), SAW (Podvezko, 2011), WASPAS (Zavadskas et al., 2012) and COCOSO (Yazdani et al., 2019) methods. The results of the comparative analysis are shown in Figure 8.

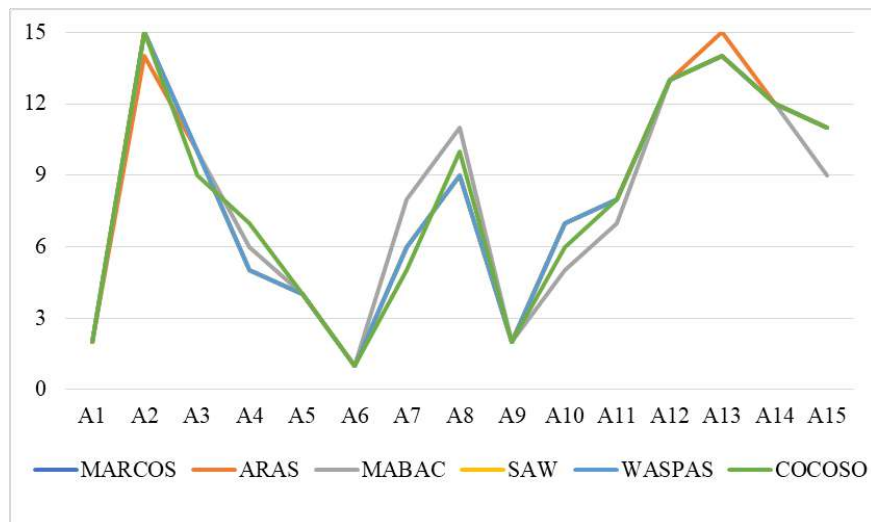


Figure 8. Results of comparative analysis

The results of the comparative analysis show that the results obtained using the MARCOS method are stable, i.e., there are no changes in the ranking of the alternatives when other multi-criteria decision-making methods are applied. Minor changes occurred for some alternatives, but these were not significant, as the alternatives shifted by only one or two positions in the ranking.

## 6. CONCLUSION

This paper analyzes potential locations for the installation of parcel lockers within the distribution center area of Vitez by using the FUCOM-MARCOS model based on seven criteria and fifteen alternatives. The results indicated that alternative A6 was the most suitable for installation, and the stability of its selection was confirmed through sensitivity analysis across 42 scenarios, as well as a comparative analysis with other multi-criteria decision-making

methods. In addition, partial analysis enabled an even distribution of parcel lockers across different parts of the distribution center. The overall analysis, along with the precision in defining alternatives and criteria, has a significant impact on the planning of logistics infrastructure. The next phases of the research will focus on identifying locations in other distribution centers of the X-Express company.

## ACKNOWLEDGMENT

The paper is a part of the research done within the project “Development of a location model for the installation of parcel lockers as an important factor in the sustainability of city logistics” supported by Ministry of Scientific and Technological Development and Higher Education of the Republic of Srpska.

## REFERENCES

- Aghdam, R.S., Shirazi, M.A., Karimi, B., (2024). Efficient Last-Mile Delivery in the Pharmaceutical Sector: A Novel Approach for Vehicle Routing with Smart Parcel Lockers, preprint
- Bistrović, M., (2024). Advantages of using parcel machines in last mile logistics in online retail (Doctoral dissertation, University of Zagreb. Faculty of Economics and Business. Department of Trade and International Business). (Bistrović, M., (2024). Prednosti korištenja paketomata u logistici posljednje milje u online maloprodaji (Doctoral dissertation, University of Zagreb. Faculty of Economics and Business. Department of Trade and International Business). In Croatian)
- Boysen, N., Fedtke, S., Schwerdfeger, S., (2020). Last-mile delivery concepts: a survey from an operational research perspective. *Or Spectrum*, 43(1), 1-58. <https://doi.org/10.1007/s00291-020-00607-8>
- Dimitrijević, B., Simić, V. (2021). Key factors for locating parcel lockers. XXXIX Symposium on New Technologies in Postal and Telecommunications Traffic – PosTel 2021, Belgrade, 30 November and 1 December, 33-42. (Dimitrijević, B., Simić, V. (2021). Ključni Faktori Izboru Lokacije Paketomata. XXXIX Simpozijum o novim tehnologijama u poštanskom i telekomunikacionom saobraćaju – PosTel 2021, Beograd, 30. novembar i 1. decembar, 33-42. In Serbian)
- Dobrodolac, M., Lazarević, D., Švadlenka, L., Blagojević, M., (2015). The impact of entropy on the efficiency of express courier systems. *Journal of Applied Engineering Science*, 13(3), 147-154. <https://doi.org/10.5937/jaes13-8586>
- Dong, B., Hovi, I.B. Pinchasik, D.R., (2023). Analysis of service efficiency of parcel locker in last-mile delivery: A case study in Norway. *Transportation Research Procedia*, 69, 918-925. <https://doi.org/10.1016/j.trpro.2023.02.253>
- Hlevnjak, J., (2024). Management of data from parcel machines (Doctoral dissertation, University of Zagreb. Faculty of Electrical Engineering and Computing). (Hlevnjak, J., (2024). Upravljanje podacima iz paketomata (Doctoral dissertation, University of Zagreb. Faculty of Electrical Engineering and Computing) In Croatian).
- Jazemi, R., Alidadiani, E., Ahn, K., Jang, J., (2023). A review of literature on vehicle routing problems of last-mile delivery in urban areas. *Applied Sciences*, 13(24), 13015. <https://doi.org/10.3390/app132413015>
- Lagorio, A., Pinto, R., (2020). The parcel locker location issues: An overview of factors affecting their location. In *Proceedings of the 8th International Conference on*

- Information Systems, Logistics and Supply Chain: Interconnected Supply Chains in an Era of Innovation, ILS, 414-421.*
- Lazarevic, D., Dobrodolac, M., Markovic, D., (2022). Analysis of the implementation of mobile parcel lockers in the postal system, XL Symposium on new technologies in postal and telecommunication traffic - PosTel 2022, Belgrade, 29-30. November, 161-170. (Lazarević, D., Dobrodolac, M., Marković, D., (2022). Analysis of the implementation of mobile parcel lockers in the postal system, XL Simpozijum o novim tehnologijama u poštanskom i telekomunikacionom saobraćaju – PosTel 2022, Beograd, 29-30. novembar, 161-170. In Serbian)
- Narančić, F., (2023). Analysis of the efficiency of package delivery by introducing a parcel machine system (Doctoral dissertation, University of Zagreb. Faculty of Transport and Traffic Sciences. Division of Transport. Department of Postal Transport). (Narančić, F., (2023). Analiza učinkovitosti dostave paketa uvođenjem sustava paketomata (Doctoral dissertation, University of Zagreb. Faculty of Transport and Traffic Sciences. Division of Transport. Department of Postal Transport). In Croatian)
- Olsson, J., Hellström, D., Pålsson, H. (2019). Framework of last-mile logistics research: A systematic review of the literature. *Sustainability*, 11(24), 7131. <https://doi.org/10.3390/su11247131>
- Palešćak, D., (2024). Vending machines as a last-mile logistics solution for cosmetics and personal care products (Doctoral dissertation, University of Zagreb. Faculty of Economics and Business). (Palešćak, D., (2024). Paketomati kao rješenje logistike posljednje milje za kozmetiku i proizvode osobne njege (Doctoral dissertation, University of Zagreb. Faculty of Economics and Business). In Croatian)
- Pamučar, D., & Ćirović, G. (2015). The selection of transport and handling resources in logistics centers using Multi-Attributive Border Approximation area Comparison (MABAC). *Expert systems with applications*, 42(6), 3016-3028. <https://doi.org/10.1016/j.eswa.2014.11.057>
- Pamučar, D., Stević, Ž., Sremac, S. (2018). A new model for determining weight coefficients of criteria in mcdm models: Full consistency method (fucom), *Symmetry*, 10(9), 393. <https://doi.org/10.3390/sym10090393>
- Podvezko, V. (2011). The comparative analysis of MCDA methods SAW and COPRAS. *Engineering Economics*, 22(2), 134-146. <http://dx.doi.org/10.5755/j01.ee.22.2.310>
- Simić, V., Lazarević, D., Dobrodolac, M., (2021). Picture fuzzy WASPAS method for selecting last-mile delivery mode: a case study of Belgrade. *European Transport Research Review*, 13, 1-22. <https://doi.org/10.1186/s12544-021-00501-6>
- Stević, Ž., & Brković, N. (2020). A novel integrated FUCOM-MARCOS model for evaluation of human resources in a transport company. *Logistics*, 4(1), 4. <https://doi.org/10.3390/logistics4010004>
- Stević, Ž., Pamučar, D., Puška, A., & Chatterjee, P. (2020). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to Compromise solution (MARCOS). *Computers & industrial engineering*, 140, 106231. <https://doi.org/10.1016/j.cie.2019.106231>
- Yazdani, M., Zarate, P., Kazimieras Zavadskas, E., & Turskis, Z. (2019). A Combined Compromise Solution (CoCoSo) Method for Multi-Criteria Decision-Making Problems. *Management decision*, 57(9), 2501-2519. <https://doi.org/10.1108/MD-05-2017-0458>
- Zavadskas, E. K., & Turskis, Z. (2010). A New Additive Ratio Assessment (ARAS) Method In Multicriteria Decision - Making. *Technological and economic development of economy*, 16(2), 159-172. <https://doi.org/10.3846/tede.2010.10>

Zavadskas, E. K., Turskis, Z., Antucheviciene, J., & Zakarevicius, A. (2012). Optimization of weighted aggregated sum product assessment. *Elektronika ir elektrotechnika*, 122(6), 3-6. <https://doi.org/10.5755/j01.eee.122.6.1810>



## E-COMMERCE IN THE DIGITAL AGE: EMPIRICAL EVIDENCE FROM SERBIA

Sanela Arsić\*

*University of Belgrade, Technical Faculty in Bor, Serbia*

**Abstract:** Electronic commerce or e-commerce has become integral to the contemporary business landscape. Organizations widely adopt e-commerce technologies to enhance efficiency and gain a competitive edge. As one of the crucial driver of economic growth, adopting e-commerce is essential for developing countries to promote their prosperity and contribute to sustainable economic development. The factors influencing e-commerce are diverse, and understanding them is vital for businesses aiming to thrive in this competitive digital landscape. Therefore, this study aims to identify the factors that impact consumers' online repurchase intentions. Employing quantitative methods, including partial least squares-structural equation modeling (PLS-SEM) and fuzzy set qualitative comparative analysis (fsQCA), the research analyses survey data from Serbia. This study contributes to the literature by offering new insights into the relationship among the predictors of online shopping behaviour and advancing the theoretical ground of how site quality, customer satisfaction, trust and commitment combine to explain high repurchase intentions better. The findings provide deeper insights into priority areas for strategic improvements in adopting e-commerce services and pave the way for future research.

**Keywords:** E-commerce, repurchase intention, consumers, PLS-SEM, fsQCA

### 1. INTRODUCTION

The widespread adoption of e-commerce worldwide has reshaped traditional commercial practices and emphasized the essential role of digital marketplaces in contemporary economies (Turban et al., 2015). The digital age has ushered in a remarkable surge in technological advancement, transforming how businesses conduct transactions and how consumers engage in shopping (Sharma, 2023). Recently, the increase in interest in online shopping has been significantly influenced by the COVID-19 pandemic.

E-commerce was significantly reshaping the global economy. By dismantling geographical barriers, e-commerce facilitates seamless cross-border transactions, fostering an inclusive and interconnected marketplace that is accessible to businesses and consumers

---

\* Corresponding author: [saarsic@fbor.bg.ac.rs](mailto:saarsic@fbor.bg.ac.rs)

Sanela Arsić, ORCID: 0000-0002-1957-566X

worldwide (Jauhar et al., 2024). This digital transformation has enabled small and medium-sized enterprises (SMEs) and individual entrepreneurs to engage in global trade without the financial burden of maintaining a physical store (Mahesh et al., 2022). Furthermore, e-commerce has enhanced accessibility in commerce by equalizing opportunities, allowing smaller businesses to compete with larger firms through innovative digital strategies. This change improved market access and supported economic growth, innovation, and diversification, establishing e-commerce as a key element of contemporary commerce (Mahesh et al., 2022).

This shift has not only transformed how businesses operate but has also significantly altered consumer behaviour (Kim et al., 2012; Raji et al., 2024). The rapid expansion of e-commerce was also reflected in consumer behavior in Serbia, as preferences shifted from traditional retail to the dynamic realm of online shopping. Etha et al. (2024) suggest that for an online store to profit from a customer, their spending must be four times the cost of their first purchase. Therefore, it is essential for e-commerce companies to understand the factors that encourage customers to participate in repeat online shopping. This research aims to identify the factors that influence consumers' propensity to shop online again or their intention to repurchase online, employing a quantitative methodology that includes partial least squares-structural equation modeling (PLS-SEM) and fuzzy set qualitative comparative analysis (fsQCA). PLS-SEM methodology was used to assess the direct and indirect effects of various factors influencing consumers' online repurchase intentions, providing insights into their significance and predictive power. On the other hand, fsQCA was employed to identify different combinations of conditions (factors) that lead to the same outcome. Unlike conventional regression-based methods that assume linear relationships, fsQCA recognizes that multiple pathways can lead to the same consumer behavior. By integrating PLS-SEM and fsQCA, this study provides a comprehensive analysis, leveraging the strengths of both methods. This combined approach ensures robust and insightful findings, contributing to both theoretical advancements and practical implications in the field of e-commerce and consumer behavior. Understanding the factors that drive online repurchase intentions is crucial for e-commerce businesses aiming to achieve sustainable growth and maintain a competitive edge. Repurchase intention serves as a vital determinant of e-commerce success, reflecting customer loyalty and the overall health of an online business.

## **2. THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES**

E-commerce has experienced exponential growth over the past two decades, driven by advancements in internet technology, increased accessibility to online platforms, and evolving consumer preferences (Chen et al., 2020). Initially, concerns regarding security and trust hindered widespread adoption, but as technology progressed and security measures improved, consumers became more comfortable engaging in online transactions. The COVID-19 pandemic further accelerated e-commerce growth, as lockdowns and social distancing measures compelled consumers to rely on online channels for essential goods and services. This surge in online activity has created both opportunities and challenges for businesses (Paștiu et al., 2020). While e-commerce offers access to a global customer base, it also intensifies competition and necessitates a profound understanding of consumer behavior to thrive in this environment. The growing number of internet users in countries like Serbia presents an opportunity for businesses to expand through e-commerce. This growth is supported by the increasing number of internet users and the government's initiatives to develop the digital economy. The percentage of individuals in Serbia using the Internet to purchase goods or services exhibited a consistent upward trend, increasing from 38.38% in 2020 to 59.69% in 2024 (Source of data: Eurostat,



2025). This represents a significant growth of 21.31 percentage points over four years, reflecting the country's rapid digital transformation of consumer behaviour. In Serbia, the e-commerce market is projected to experience a Compound Annual Growth Rate (CAGR, 2024) of 22.3% by 2027. Compared to other Balkan countries, Serbia stands out as the most developed in terms of e-commerce adoption. This trend shows a significant and ongoing rise, influenced by multiple factors such as enhanced internet infrastructure, broader access to e-commerce platforms, increased consumer confidence in online purchases, and the rapid digital transformation of businesses. Additionally, the younger, tech-savvy population and rising disposable incomes have further stimulated the shift toward digital consumption (Ljubicic & Štokić, 2024). As a result, Serbia is positioning itself as a regional leader in online shopping, with the potential for continued expansion in the coming years.

Online repurchase intention is a complex construct influenced by numerous factors. In recent years, an increasing number of researchers have examined this issue, including Mosavi and Ghaedi (2012), Shin et al., (2013), Keiningham et al. (2015), Sullivan and Kim (2018), Mbango (2018), Aslam et al. (2018), Chen et al. (2020), and Etha et al. (2024). Building on this growing body of research, the present study explores the roles of site quality, customer satisfaction, trust, and commitment, seeking to assess their distinct effects on consumer repurchase behavior and provide a more comprehensive understanding of the mechanisms that drive loyalty in online shopping contexts.

Site quality refers to the overall performance and usability of an online shopping platform. A well-designed website that is easy to navigate, visually appealing, and provides relevant information enhances the user experience and increases the likelihood of repeat purchases. E-commerce websites serve not only as tools to facilitate business transactions but also as channels for companies to interact and communicate with their consumers (Sullivan & Kim, 2018). Key aspects of website quality encompass information quality, website design, shopping convenience, security, and communication. High-quality information fosters consumer trust, while a user-friendly website design smooths navigation and mitigates frustration. Website design is essential for marketing activities aimed at enhancing customer loyalty. Extensive research has demonstrated a significant relationship between website quality and customer satisfaction. According to Kim et al. (2012), satisfaction is perceived as an assertiveness that arises from a psychological comparison of the service and quality that a customer or consumer expects to receive from a transaction after purchase. Customer satisfaction denotes an expected outcome of service that involves assessing whether the service has met the customer's desires and expectations (Mbango, 2018). High-quality websites, characterized by superior information, system, and service quality, enhance customer satisfaction and trust, thereby strengthening customer relationships. Furthermore, Saleem et al. (2022) highlighted that website quality not only boosts customer satisfaction but also encourages electronic word-of-mouth and purchase intentions, with gender differences playing a moderating role in risk-taking behaviors. The following hypothesis was formulated based on the literature review:

**Hypothesis 1.** *Site quality positively impacts customer satisfaction.*

Trust and security are essential for online repurchase intentions. Consumers hesitate to engage in online transactions if they perceive a risk of fraud, identity theft, or data breaches. E-commerce businesses must implement robust security measures to safeguard customer data and foster a sense of trust. Trust can be built through various mechanisms, including clear privacy policies, secure payment gateways, and third-party certifications (Sullivan & Kim, 2018). The quality of a website significantly impacts customer trust in e-commerce. This relationship is examined in several studies, which highlight various dimensions of site quality and its effect on

customer perceptions (Shin et al., 2013; Hong & Cha, 2013; Masturoh & Mugiono, 2020; Guo et al., 2023). E-service quality has been demonstrated to positively influence customer trust. For instance, studies show that higher e-service quality of the site enhances customer satisfaction and trust, both of which are essential for fostering customer loyalty and encouraging repeat purchases (Etha et al., 2024). Hence, this study assumes the following:

**Hypothesis 2.** *Site quality positively impacts customer trust.*

Website quality is crucial for fostering customer commitment in e-commerce. A well-designed, user-friendly website with intuitive navigation and aesthetic appeal enhances commitment and loyalty (Guo et al., 2023). Efficient organization and responsiveness increase perceived value while reducing risk, thereby fostering trust and encouraging repeat purchases. Conversely, poor design and complicated checkout processes deter customers, leading to cart abandonment and diminished trust. According to Kessel (2024), nearly 80% of shoppers abandon purchases due to cumbersome checkout experiences. Therefore, investing in high-quality website design is essential for maintaining customer commitment. Based on that, the following state is developed:

**Hypothesis 3.** *Site quality positively impacts customer commitment.*

In general, online purchasing behavior can be conceptualized as a two-stage process. The first stage involves stimulating customers' initial purchase intentions, while the second stage focuses on fostering the actual realization of these intentions into completed transactions. Both stages are critical in determining the overall success of e-commerce platforms, as they influence not only consumer engagement but also long-term customer retention and business sustainability (Kumar et al., 2024). Customer satisfaction is a crucial factor in the business-to-consumer (B2C) online marketplace, serving as a key measure of success. It is an overall attitude developed from a customer's experience after purchasing a product or utilizing a service. Satisfaction stems from the evaluation of interactions with a service provider and helps customers anticipate future experiences (Mosavi & Ghaedi, 2012). Customer satisfaction reflects the strength of a customer's belief that a service will generate a positive outcome. It is shaped by the purchasing experience and significantly influences future behaviors, including online repurchases and brand loyalty (Rita et al., 2019; Pereira et al., 2017). Satisfied customers are more likely to return for future purchases and recommend the online retailer to others (Pereira et al., 2017), while dissatisfied customers may abandon the retailer without voicing their concerns. Based on these findings, the following hypothesis arises:

**Hypothesis 4.** *Customer satisfaction positively impacts repurchase intention.*

Trust in e-commerce is generally analyzed in two separate phases: before and after the purchase (Kim et al., 2012). Since this study focuses on analyzing the impact of trust on repurchase intention, trust is measured specifically at the post-purchase stage. Unlike initial trust, which is formed before a consumer's first transaction, post-purchase trust develops after consumers have directly experienced the online retailer's service quality, product reliability, and transaction security. At this stage, trust is shaped by prior interactions and plays a crucial role in influencing customers' willingness to engage in repeat purchases (Sullivan & Kim, 2018). Based on the statements provided, a hypothesis can be formulated as follows:

**Hypothesis 5.** *Customer trust positively impacts repurchase intention.*

Keiningham et al. (2015) emphasize that commitment is a lasting desire to uphold a valued relationship. Customer commitment is frequently perceived as a psychological attachment or a dedication to maintaining an ongoing relationship with a brand or organization. Research by Mbango (2018) highlights that commitment enhances cooperation between buyers and sellers, fostering continued engagement and brand loyalty. Mosavi & Ghaedi (2012) have



demonstrated a direct correlation between commitment and repurchase behavior, particularly in banking services and branded products, confirming that committed customers are more likely to remain loyal and continue purchasing from the same provider. Ultimately, commitment cultivates trust, stability, and cooperative behavior, all of which contribute to sustained consumer relationships and increased repurchase intentions. Hence, the following hypothesis is proposed:

**Hypothesis 6.** *Customer commitment positively impacts repurchase intention.*

Based on the literature review and the formulated hypotheses, the conceptual model depicted in Figure 1 was developed.

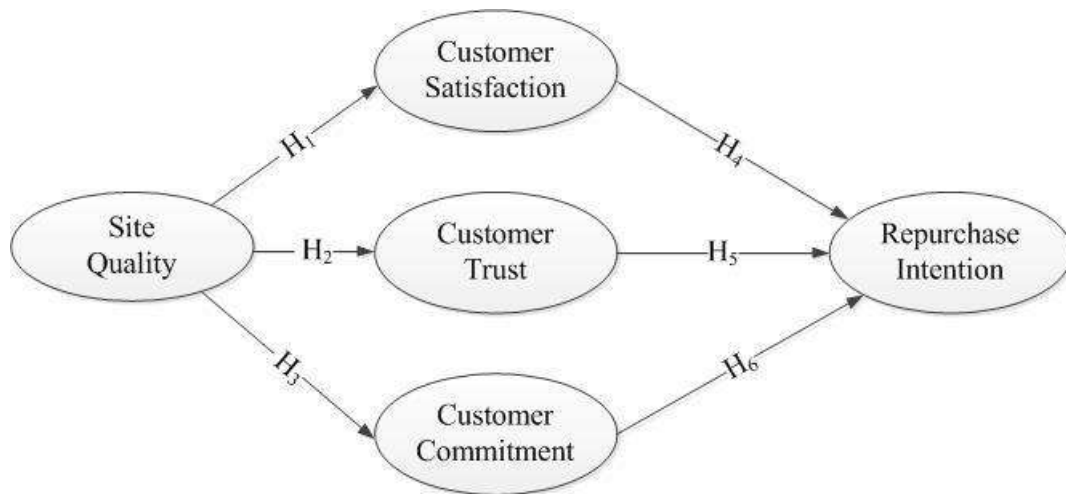


Figure 1. The conceptual model

### 3. METHODOLOGY

This section outlines the research methodology employed to investigate the factors influencing consumers' online repurchase intentions. It describes the data collection methods, measurement scales used, and the statistical techniques applied to analyses the data.

#### 3.1. Sampling and data collection

The study employed a survey questionnaire to collect data from a sample of online consumers in Serbia. A convenience sampling method was applied, and data were collected through both digital survey platforms and printed forms, ensuring accessibility for e-commerce users. The data collection process occurred during 2024. All analyses were conducted using IBM SPSS Statistics v.24.0 and SmartPLS v.4 software packages (Ringle et al., 2024).

The sample consisted of 252 respondents, with 49.2% being female and 50.8% being male. The age distribution of the respondents was as follows: 34.1% were between 18-30 years old, 25.8% were between 31-40 years old, 24.6% were between 41-50 years old, and 15.5% were 51 years old or older. The majority of respondents (47.2%) had a bachelor's degree or higher.

### 3.2. Measuring instrument development

The questionnaire included validated scales to measure the key constructs of interest, including site quality, customer satisfaction, customer trust, customer commitment and repurchase intention.

The primary dependent variable, Repurchase Intention (RI), was measured using the questionnaire proposed by Rita et al. (2019) and Shin et al. (2013) composed of 3 items measured on a 5-point Likert scale. Exploratory factor analysis (KMO = 0.660, Bartlett's test: chi-square = 309.136 with 3 degrees of freedom,  $p < 0.001$ ) revealed that repurchase intention is a one-dimensional construct, and one factor explains roughly 74.2% of the variance of all the items, which is well above the commonly recommended threshold of **60%**.

Site Quality (SQ) was measured using a 6 item long scale developed and tested by Rita et al. (2019) and Shin et al. (2013). Exploratory factor analysis revealed that a single construct explains nearly 61.2% of the cumulative variance of all the items (KMO = 0.874, Bartlett's test: chi-square = 707.924, with 15 degrees of freedom,  $p\text{-value} < 0.001$ ).

Customer Satisfaction (CS) was measured using scales assessing overall satisfaction with the purchase experience and operationalized following the framework proposed by Shin et al. (2013) and Rita et al. (2019). The scale, comprising 3 items constituted a one-dimensional construct (KMO = 0.752; approx. chi-square = 580.059 with 3 degrees of freedom,  $p < 0.001$ ), explaining over 86.7% of the cumulative variance of the items.

Customer Trust (CT) was measured using the scale developed by Hong and Cha (2013), and Shin et al. (2013) composed of 4 items measured on a 5-point Likert scale. Exploratory factor analysis (KMO = 0.834, Bartlett's test: chi-square = 1001.104, with 6 degrees of freedom,  $p < 0.001$ ) showed that organizational unlearning is a unidimensional construct, and one factor explains over 85.8% of the variance of all the items.

Customer Commitment (CC) were measured using a 4 item research tool measured on a 5-point Likert scale, previously developed and tested by Shin et al. (2013) and Masturoh and Mugiono (2020). Exploratory factor analysis (KMO = 0.715, Bartlett's test: chi-square = 501.045, with 6 degrees of freedom, and  $p < 0.001$ ) revealed that one factor explains over 65.4% of the items' variance.

### 3.3. Data analysis techniques

To evaluate the proposed interrelationships among site quality, customer satisfaction, customer trust, customer commitment, and repurchase intention, structural equation modeling (SEM) was utilized with partial least squares (PLS) analysis. The SEM methodology facilitates the examination of causal relationships between the constructs within the model while assessing the model's overall fit with the observed measurement data (Hair et al., 2022). Furthermore, to investigate the mediating roles of customer satisfaction, customer trust, and customer commitment in the relationship between site quality and repurchase intention, this study followed a mediation analysis procedure. In addition to PLS-SEM, this study employed fuzzy set qualitative comparative analysis (fsQCA) to gain deeper insights into the complexity of customer behavior. Unlike PLS-SEM, which focuses on linear relationships and the significance of individual predictors, fsQCA identifies various combinations of factors that lead to high repurchase intentions. FsQCA goes beyond traditional multiple regression analyses (MRAs) and allows for the exploration of multiple pathways to the same outcome, capturing the nuanced and non-linear nature of consumer decision-making (Pappas & Woodside, 2021). By integrating PLS-SEM and fsQCA, this study offers a comprehensive analysis.

## 4. RESULTS

### 4.1. Common method bias

Harman's single-factor test was performed to assess common method bias (CMB). The results revealed that the variance explained by a single factor was 43.7%, which is below the 50% threshold value suggested by Kock (2015), indicating that CMB is unlikely to be a concern. These findings suggest that the study's model is free from common method bias, ensuring the validity and reliability of the data collected. The lack of CMB indicates that the connections between constructs are not overstated due to measurement artifacts, thus enhancing the reliability of the statistical conclusions. Consequently, the results can be regarded as a robust reflection of the actual patterns within the sample, enhancing the credibility of the study's findings and their theoretical and practical implications.

### 4.2. Measurement model evaluation

The measurement model was first assessed through internal consistency reliability, convergent validity, and discriminant validity (Hair et al., 2021). Cronbach's Alpha, Spearman-Brown's coefficient and Composite Reliability (CR) were evaluated to assess the reliability of the variables. The factor loadings, validity, and reliability results are presented in Table 1.

Table 1. Construct reliability and validity

Construct	Items	Loadings	Cronbach halpha ( $C\alpha$ ) <sup>a</sup>	Spearman- Brown Coefficient <sup>b</sup>	Composite reliability ( $\rho_{\alpha}$ ) <sup>c</sup>	Composite reliability ( $\rho_{\alpha}$ ) <sup>c</sup>	(AVE) <sup>d</sup>
Customer Commitment (CC)	CC_1 CC_2 CC_3 CC_4	0.704 0.883 0.910 0.870	0.825	0.864	0.831	0.896	0.741
Customer Satisfaction (CS)	CS_1 CS_2 CS_3	0.914 0.946 0.934	0.923	0.918	0.924	0.951	0.867
Customer Trust (CT)	CT_1 CT_2 CT_3 CT_4	0.932 0.944 0.933 0.898	0.945	0.921	0.945	0.961	0.859
Repurchase Intention (RI)	RI_1 RI_2 RI_3	0.807 0.917 0.857	0.879	0.813	0.896	0.910	0.632
Site Quality (SQ)	SQ_1 SQ_2 SQ_3 SQ_4 SQ_5 SQ_6	0.823 0.852 0.821 0.821 0.777 0.703	0.809	0.845	0.826	0.879	0.651

Notes: <sup>a</sup> $C\alpha \geq 0.70$ ; <sup>b</sup>Spearman-Brown Coefficient  $\geq 0.70$ ; <sup>c</sup> $\rho_{\alpha} \geq 0.70$ ; <sup>d</sup>AVE  $\geq 0.50$ ;

Cronbach's alpha ( $\alpha$ ) coefficients above 0.70 indicate strong internal consistency, as do Spearman-Brown coefficients, whose values range above 0.8 and 0.9. The CRs surpass the recommended threshold of 0.7 and suggest that the measurement model is dependable, which means that the items used to assess the construct are internally consistent and yield reliable results. The average variance extracted (AVE) and factor loadings were utilized to evaluate convergent validity (Fornell & Larker, 1981). As shown in Table 1, all AVE values were above 0.5, with factor loadings exceeding 0.7, confirming convergent validity.

Table 2. Results of discriminant validity using Fornell-Larcker criteria and Heterotrait-Monotrait (HTMT) method

Construct	Mean	STD	Fornell-Larcker Criterion					Heterotrait-Monotrait (HTMT) ratio				
			CC	CS	CT	RI	SQ	CC	CS	CT	RI	SQ
CC	3.96	0.64	<b>0.807</b>					-				
CS	4.17	0.81	0.352	<b>0.931</b>				0.416				
CT	3.82	0.97	0.409	0.660	<b>0.927</b>			0.469	0.706			
RI	3.23	0.94	0.576	0.573	0.544	<b>0.861</b>		0.705	0.648	0.607		
SQ	3.67	1.00	0.430	0.719	0.730	0.559	<b>0.795</b>	0.532	0.792	0.788	0.654	-

Discriminant validity was assessed using the Fornell and Larcker criterion and the Heterotrait-Monotrait (HTMT) method. The results for the Fornell and Larcker criterion and findings from the HTMT matrix are presented in Table 2. The factor loadings exceeded their respective cross-loadings, and all HTMT values remained below 0.9, confirming discriminant validity through both approaches. Consequently, the study established both convergent and discriminant validity while ensuring internal consistency reliability.

#### 4.3. Structural model evaluation

After confirming that each construct has good reliability and validity, this research evaluated the structural model, including evaluating the prediction of the model and the relationship between the constructs. Structural model evaluation was conducted using SmartPLS (Ringle et al., 2024) to examine the relationships among the established constructs and ascertain their statistical significance. The model was tested employing a bootstrapping procedure with 5,000 resamples and 95% bias-corrected confidence intervals, thereby ensuring robust estimation of path coefficients and hypothesis testing. This methodology facilitated the calculation of key model parameters, including the coefficient of determination ( $R^2$ ), effect size ( $f^2$ ), t-values (one-tailed test), standardized beta coefficients ( $\beta$ ), and the  $Q^2$  test of predictive relevance using the blindfolding technique. To evaluate potential collinearity issues, Variance Inflation Factor (VIF) values were assessed for all predictor constructs, following the guidelines of Hair et al. (2019). The results indicated that all VIF values were below the threshold of 5, confirming that this research does not have a collinearity problem. The one-tailed test assumes a t-value of 1.96 or higher at a 5% significance level, indicating statistical significance (Hair & Alamer, 2022). The hypothesized relationships between the variables were examined, with the analysis results shown in Table 3 and Figure 2.

In the first part of the model, the direct impact of the construct site quality on customer satisfaction ( $\beta = 0.719$ ,  $t = 17.666$ ,  $p < 0.01$ ), customer trust ( $\beta = 0.730$ ,  $t = 24.344$ ,  $p < 0.01$ ), and customer commitment ( $\beta = 0.430$ ,  $t = 7.207$ ,  $p < 0.01$ ) was analyzed. The results obtained indicate that all hypothesized relationships are statistically significant and confirmed. Therefore, hypotheses  $H_1$ ,  $H_2$ , and  $H_3$  were accepted. Additionally, three further hypotheses were tested, examining the direct impact of the constructs of customer satisfaction ( $\beta = 0.322$ ,  $t = 4.617$ ,  $p < 0.01$ ), customer trust ( $\beta = 0.170$ ,  $t = 2.100$ ,  $p < 0.01$ ), and customer commitment ( $\beta = 0.393$ ,  $t = 6.052$ ,  $p < 0.01$ ) on customer repurchase intention. The results indicate that hypotheses  $H_4$ ,  $H_5$ , and  $H_6$  are statistically significant and have been confirmed.

Table 3. Results of hypothesis testing

Hypotheses	Path coefficient( $\beta$ )	t-value	p-value	$f^2$	VIF	$R^2$	$Q^2$	Result
H1: SQ $\rightarrow$ CS	0.719	17.666	0.000*	1.068 <sup>c</sup>	1.000	0.516	0.488	Supported
H2: SQ $\rightarrow$ CT	0.730	24.344	0.000*	1.140 <sup>c</sup>	1.000	0.533	0.518	Supported
H3: SQ $\rightarrow$ CC	0.430	7.207	0.000*	0.227 <sup>b</sup>	1.000	0.185	0.176	Supported
H4: CS $\rightarrow$ RI	0.322	4.617	0.000*	0.116 <sup>a</sup>	1.796	0.503	0.295	Supported
H5: CT $\rightarrow$ RI	0.170	2.100	0.036**	0.031 <sup>a</sup>	1.890			Supported
H6: CC $\rightarrow$ RI	0.393	6.052	0.000*	0.255 <sup>b</sup>	1.218			Supported

Note: Path significance: \*  $p < 0.01$ ; \*\*  $p < 0.05$ ;  $f^2$  thresholds:  $a > 0.02$  (weak effect);  $b > 0.15$  (moderate effect);  $c > 0.35$  (strong effect).

The coefficient of determination ( $R^2$ ) quantifies the predictive accuracy of a model by assessing the proportion of variance in the endogenous variables explained by all exogenous variables.  $R^2$  values range from 0 to 1, with higher values indicating greater predictive power. According to Hair and Alamer (2022),  $R^2$  values of 0.75, 0.50, and 0.25 are classified as substantial, moderate, and weak, respectively. In the structural model (Figure 2), the  $R^2$  values for customer satisfaction (0.516), customer trust (0.533), and repurchase intention (0.503) suggest moderate predictive accuracy, while the  $R^2$  for customer commitment (0.185) is weak.

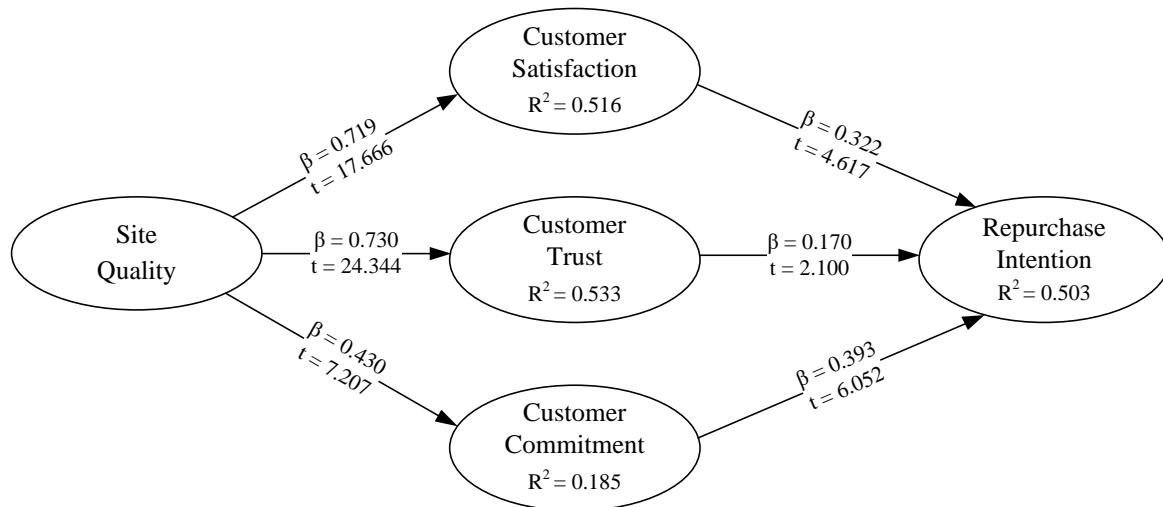


Figure 2. Structural path results

To assess the predictive validity of the structural model,  $Q^2$  predict was examined (Shmueli et al., 2016). When the results are confirmed to have predictive relevance, it indicates that the model can accurately predict the endogenous construct of the reflective measurement model and the indices of the endogenous construct for a single item. In the structural model, the  $Q^2$  value of the reflective endogenous latent constructs exceeded 0, suggesting that both the path models and the construct possess predictive relevance. The  $Q^2$  predict values for all constructs were positive (Table 3), indicating that the model exhibits acceptable predictive relevance (Hair et al., 2021). Notably, customer satisfaction (0.488) and customer trust (0.518) demonstrated the highest predictive power, suggesting that the model can reliably forecast

variations in these constructs. Conversely, customer commitment (0.176) and repurchase intention (0.295) exhibited relatively lower, albeit still acceptable, predictive strength.

Table 4 presents the total indirect effects within the structural model, providing a comprehensive analysis of the relationships between constructs and their influence on repurchase intention. Indirect effects illustrate the extent to which an independent variable affects the dependent variable through one or more mediating variables.

*Table 4. Results of indirect effects*

Influence relation	Original sample	Sample mean	2.50 % LB	97.50 % UB	t-value	p-value	Result
SQ → CS → RI	0.232	0.230	0.127	0.326	4.585	0.000*	Significant
SQ → CT → RI	0.124	0.126	0.011	0.246	2.061	0.039**	Significant
SQ → CC → RI	0.169	0.170	0.104	0.246	4.693	0.000*	Significant

Note: \*significant at the level of 0.01; \*\*significant at the level of 0.05

The results presented in Table 4 indicate that evaluating the influence of site quality on repurchase intention is mediated by customer satisfaction, customer trust, and customer commitment. SQ → CS → RI ( $\beta = 0.232$ ,  $p < 0.001$ ) suggests partial mediation, where CS enhances the impact of site quality on repurchase intention. SQ → CT → RI ( $\beta = 0.124$ ,  $p = 0.039$ ) is significant but weaker, showing that trust plays a role, albeit less pronounced. SQ → CC → RI ( $\beta = 0.169$ ,  $p < 0.001$ ) is also significant, underscoring the importance of customer commitment in driving repurchase behavior.

#### 4.4. Fuzzy set qualitative comparative analysis

Fuzzy set qualitative comparative analysis (fsQCA) analysis was conducted using software fs/QCA 3.0 (Ragin & Davey, 2016). The following section presents the results of the analysis, highlighting the necessary and sufficient conditions that lead to high and low online repurchase intention.

##### 4.4.1. Calibration - transforming data into fuzzy sets

The most important step in configurational analysis is data calibration, which involves transforming all variables into fuzzy set values ranging from 0 to 1 (Ragin, 2008). This process ensures that each case is assigned a degree of membership within a given set, allowing for a more nuanced analysis of causal relationships. Data calibration can be performed using either the direct or indirect method. In the direct method, the researcher establishes three qualitative breakpoints to define full membership, full non-membership, and intermediate membership in a set. Conversely, in the indirect method, data are rescaled based on qualitative assessments rather than predefined thresholds, with the choice of method depending on the nature of the data and the theoretical framework guiding the analysis (Ragin, 2008). For this study, the direct method was applied, with qualitative breakpoints determined using percentiles, as recommended by Pappas and Woodside (2021). The 95<sup>th</sup> percentile was set as the threshold for full-set membership, the 5<sup>th</sup> percentile for full-set non-membership, and the 50<sup>th</sup> percentile for intermediate-set membership. These values were calibrated using a logistic function within the fsQCA software to ensure an appropriate distribution across the three membership levels. The statistics used for data calibration are presented in Table 5.

*Table 5. Percentile chosen for data calibration*

Variable → Thresholds ↓	Customer Commitment (CCc)	Customer Satisfaction (CSc)	Customer Trust (CTc)	Site Quality (SQc)	Repurchase Intention (RIc)
5 <sup>th</sup> percentile	1.75	3.00	2.00	2.87	1.88
50 <sup>th</sup> percentile	3.25	4.00	4.00	4.00	3.67
95 <sup>th</sup> percentile	5.00	5.00	5.00	4.95	5.00

Following the calibration of the fuzzy-set dataset, the next analytical phase involves conducting a Necessary Condition Analysis (NCA). This step aims to determine the extent to which a given causal condition exhibits fuzzy-set scores that meet or fall below a predefined threshold necessary for achieving a particular outcome. Following established methodological guidelines, the necessity analysis assessed whether a condition met the consistency threshold of 0.90 (Ragin, 2008). A condition is classified as necessary if its consistency value exceeds this threshold, signifying that the outcome cannot be achieved without the presence of that condition. Additionally, conditions with consistency values ranging between 0.80 and 0.90 are considered “almost always necessary” provided their coverage score exceeds 0.75.

*Table 6. Results of Necessary Condition Analysis for Repurchase Intention*

Conditions	High RI		Low/ Medium RI	
	Consistency	Coverage	Consistency	Coverage
<b>CSc</b>	0.855	0.750	0.576	0.474
~ CSc	0.400	0.500	0.695	0.819
CTc	0.732	0.791	0.462	0.470
~CTc	0.509	0.502	0.794	0.736
CCc	0.743	0.799	0.482	0.488
~CCc	0.524	0.518	0.801	0.746
SQc	0.749	0.757	0.522	0.497
~SQc	0.502	0.528	0.745	0.736

The results of the necessary condition analysis (Table 6) indicate that customer satisfaction satisfies the criteria for a necessary condition in achieving repurchase intention, with a consistency score exceeding 0.80. Conversely, other examined factors, including customer satisfaction, customer trust, and site quality, did not meet the threshold necessary to influence repurchase intention.

#### 4.4.2. Obtaining the solutions

Following the data calibration process, the next step in fuzzy-set Qualitative Comparative Analysis (fsQCA) involves running the fsQCA algorithm, which generates a truth table. This table consists of  $2^k$  rows, where  $k$  represents the number of predictor variables, and each row corresponds to a unique combination of these predictors (Ragin, 2008). The truth table is then systematically analyzed by sorting rows based on two critical metrics: frequency and consistency. Frequency refers to the number of observations that correspond to each specific combination of conditions. To ensure reliable assessment, a minimum frequency threshold is established. According to Fiss (2011) and Ragin (2008), for datasets with more than 150 cases, the threshold should be set at 3, while for smaller samples, a threshold of 2 may be appropriate. In this study, a threshold of 3 is adopted, and all combinations with lower frequencies are excluded from further analysis. Consistency measures the extent to which cases conform to the set-theoretic relationships defined in a given solution (Fiss, 2011). A recommended consistency threshold of 0.75 is applied (Ragin, 2008), meaning that only combinations meeting or

exceeding this threshold are considered valid explanatory configurations. After filtering the truth table based on these thresholds, combinations that surpass the consistency threshold are classified as those that fully explain the outcome. In such cases, the outcome variable is set to 1, while all remaining combinations are assigned a value of 0.

Finally, the outcomes of the analysis encompass complex, parsimonious, and intermediate combinations of configurations. The complex solution encompasses all possible configurations of conditions derived through traditional logical operations. Complex solutions are refined into parsimonious and intermediate solutions, which are more straightforward and open to interpretation. The parsimonious solution represents a streamlined version of the complex solution, derived through simplifying assumptions (Pappas et al., 2016). It highlights the most essential conditions that must be included in any valid solution, referred to as “core conditions” (Fiss, 2011), which are automatically identified by fsQCA. The key distinction between parsimonious and complex solutions lies in their treatment of counterfactual cases, the complex solution excludes them and applies minimal simplification, whereas the parsimonious solution incorporates counterfactual combinations to achieve a more concise and logically simplified outcome (Pappas & Woodside, 2021). Intermediate solution is a balance between the complex and parsimonious solutions. The intermediate solution uses a subset of those simplifying assumptions used to compute the parsimonious solution, which should be consistent with theoretical and empirical knowledge. Typically, results are presented with intermediate solutions, clearly indicating (often highlighted) the parsimonious components contained within. The parsimonious and intermediate solutions for both high and low levels of repurchase intention are detailed in Table 7. Specifically, black circles (●) indicate the presence of a condition, while crossed-out circles (⊗) signify its absence (Fiss, 2011; Pappas & Woodside, 2021). Blank spaces represent the “do not care” situation. The conditions displayed include both core and peripheral conditions.

*Table 7. Configurations that lead to high and low/medium Repurchase Intention*

Configuration	Solutions for high RI					Solutions for low/medium RI			
	1	2	3	4	5	6	7	8	9
Customer commitment		⊗	●	●	●		⊗	⊗	●
Customer satisfaction	●	●	⊗	●				●	⊗
Customer trust		⊗		●	●	⊗	⊗		
Site quality	⊗		●		●	⊗		⊗	●
Consistency	0.797	0.772	0.872	0.934	0.924	0.801	0.832	0.825	0.818
Raw Coverage	0.417	0.348	0.252	0.572	0.552	0.683	0.659	0.377	0.251
Unique Coverage	0.029	0.019	0.015	0.012	0.003	0.086	0.069	0.031	0.018
Overall Solution Coverage	0.776					0.789			
Overall Solution Consistency	0.811					0.816			

*Note: (●) indicates the presence of a condition, and (⊗) indicates its absence. Large circles represent core conditions; small circles represent peripheral conditions. Blank spaces imply “don’t care” condition.*

Table 7 displays both consistency and coverage for the overall solution and for each individual solution. All values exceed the recommended threshold of 0.75 (Ragin, 2008). Consistency reflects how well a relationship has been approximated, while coverage assesses the empirical relevance of the consistent subset. Therefore, the overall solution coverage indicates how high repurchase intention in e-commerce may be influenced by the configurations



set, which can be compared to the  $R^2$  value (Pappas & Woodside, 2021). The study explores two outcomes: high repurchase intention and low repurchase intention. Solution coverage, representing the degree to which identified solutions explain observed outcome cases, is notably high. This indicates that the recognized combinations of conditions account for a substantial portion of the observed outcomes, specifically reaching coverage rates of 77% and 79%, respectively. That reveals that the five solutions (1-5) and four solutions (6-9) represent a significant portion of high and low/medium repurchase intentions in e-commerce. In contrast, the consistency, which pertains to maintaining uniformity across various cases in the dataset, is also high, at 0.81 and 0.82, respectively. This indicates that the results are reliable and account for the majority of the cases examined. Additionally, fsQCA assesses the empirical relevance of each solution by measuring both raw and unique coverage. Raw coverage refers to the share of the outcome attributed to a specific alternative solution, whereas unique coverage denotes the share of the outcome that only a particular alternative solution can account for. The solutions detailed in Table 7 clarify a considerable amount of high and low/medium repurchases intentions, accounting for 25.1% to 68.3% of the associated cases.

The presence of customer satisfaction leads to high repurchase intentions when site quality is absent, regardless of the other factors (solution 1). Next, when customer satisfaction is present, high purchase intention may be achieved with an absence of customer commitment and trust, regardless of the site quality (solutions 2). Furthermore, the combination of customer commitment and site quality leads to high purchase intention in e-commerce, regardless of customer trust (solution 3). Furthermore, customer commitment, satisfaction, and trust contribute to a high repurchase intention in e-commerce when site quality is deemed to be in a “do not care” state (solution 4). Ultimately, customer commitment and trust, combined with site quality, also result in a high repurchase intention when customer satisfaction beliefs are in a “do not care” state (solution 5). Consistency values of 0.934 (solution 4) and 0.924 (solution 5) indicate that these solutions are highly reliable in predicting high repurchase intention. Raw coverage values of 0.572 and 0.552, respectively, suggest that these are dominant pathways, explaining a large proportion of cases.

The four solutions leading to low/medium repurchase intention (Solutions 6-9) suggest different combinations of conditions that hinder customer repurchase behavior. Solution 6, with a consistency score of 0.801, indicates that the absence of both customer commitment and trust significantly contributes to low repurchase intention in e-commerce. Additionally, when customer commitment and satisfaction beliefs are in a “do not care” state, it reinforces the notion that a lack of trust and commitment plays a crucial role in reducing the likelihood of repurchasing. The absence of customer commitment and trust leads to low repurchase intention regardless of the other factors (solution 7). Further, the absence of customer commitment and site quality with the presence of customer satisfaction, regardless of customer trust, leads to low repurchase intention (solution 8). Finally, the same outcome may be achieved by the presence of customer commitment site quality with the absence of customer satisfaction (solution 9).

## 5. DISCUSSION OF THE RESULTS

Firstly, this paper evaluated six developed hypotheses using the PLS-SEM methodology. The results show that all the analyzed hypotheses proposed in the model have been supported. In the developed research model, the positive and statistically significant influence of site quality on customer satisfaction, customer trust, and customer commitment was analyzed and confirmed. Hypothesis  $H_1$  suggests that site quality positively influences customer satisfaction, a finding supported by the results obtained. This result indicates that a well-designed, user-friendly, and reliable website enhances customers' overall satisfaction,

reinforcing their positive perception of the platform. This finding aligns with previous studies that emphasize the critical role of site quality in shaping customer experiences and behaviors. For instance, Saleem et al. (2022) highlight that key elements such as website usability, visual appeal, and navigation efficiency significantly contribute to customer satisfaction. Similarly, Rita et al. (2019) stress that a seamless and engaging online experience fosters a higher level of satisfaction, ultimately influencing customer retention. Additionally, Shin et al. (2013) demonstrate that security, ease of use, and website performance play a crucial role in ensuring customer satisfaction, further validating the results of this study. The results of hypothesis H<sub>2</sub> indicate a positive relationship between site quality and customer trust. These findings align with previous research highlighting the significance of site quality in fostering customer trust (Shin et al., 2013; Rita et al., 2019). For example, Rita et al. (2019) underscore that intuitive design, quick loading speed, and relevant content positively influence users' perceptions of a website's reliability. Likewise, Shin et al. (2013) emphasize that factors such as security, ease of use, and visual appeal bolster customer trust, further supporting the outcomes of this study. The results confirm hypothesis H<sub>3</sub>, highlighting the positive impact of site quality on customer commitment. A well-structured and user-friendly website fosters a sense of reliability and engagement, encouraging customers to develop long-term relationships with the platform. High-quality websites that offer seamless navigation, security, and appealing design elements enhance user experience, leading to greater emotional and behavioral commitment. This finding is consistent with previous research indicating that a well-designed website fosters customer attachment and loyalty by creating a positive and trustworthy online environment (Shin et al., 2013; Saleem et al., 2022). According to Wijaya et al. (2021), the quality of the website significantly influences customer loyalty in e-commerce, indicating that better website service quality leads to higher customer commitment. Hsu et al. (2018) highlighted that customer satisfaction significantly impacts trust and commitment, indicating that a high-quality website experience fosters stronger relationships with customers. Furthermore, the effects of customer satisfaction, customer trust, and customer commitment on repurchase intention are examined and confirm hypotheses H<sub>4</sub>, H<sub>5</sub>, and H<sub>6</sub>. The obtained results align with prior studies, such as those conducted by Rita et al. (2019) and Chen et al. (2020) which similarly found that customer satisfaction has a significant positive impact on repurchase intention. This relationship suggests that when customers are satisfied with their online shopping experience, they are more inclined to continue purchasing from the same platform. Satisfied customers are not only more likely to make repeat purchases but also to develop brand loyalty, which increases long-term engagement and fosters positive word-of-mouth recommendations. Similarly, Chen et al. (2020) emphasize that customer satisfaction enhances the likelihood of returning to the same e-commerce platform for future transactions, reinforcing the importance of maintaining high service quality and user experience.

Beyond mere satisfaction, trust plays a crucial mediating role in the relationship between various factors and repurchases intention. Shin et al. (2013) indicate that trust significantly affects customers' willingness to make future purchases, as it diminishes perceived risk and strengthens their confidence in the online retailer. This finding is supported by Rita et al. (2019) and Wandoko and Panggati (2022), who show that heightened levels of customer trust are directly associated with an increased likelihood of repeat purchases. When customers regard an online retailer as trustworthy, they are more inclined to engage in long-term transactions, thereby enhancing the platform's sustainability and growth. Moreover, commitment stands out as a key element influencing repurchase behavior. Iqbal et al. (2024) highlight that fostering customer commitment is crucial for marketing strategies designed to build loyalty and promote repeat purchases. When customers feel a strong commitment, their retention rates improve, as those connected to a specific online retailer are more likely to come

back for additional purchases. This suggests that online retailers should focus on tactics that enhance both trust and commitment, as these factors together boost repurchase intention and cultivate enduring customer relationships.

Additionally, in this study, it was confirmed that site quality through the mediating variables of customer satisfaction, customer trust, and customer commitment has a significant effect on repurchase intention, which is in line with the findings of Shin et al. (2013).

The results of the fsQCA analysis reveal that specific combinations of customer commitment, satisfaction, and trust are key contributors to high repurchase intention in the context of e-commerce.

## **6. CONCLUSION**

In the vast digital landscape, e-commerce has emerged as a transformative force, changing the way businesses operate and how consumers engage with commercial activities. Given that repeat purchases are a key driver of long-term business success, understanding consumer expectations is crucial. Consumers' purchasing needs are not static, and each customer may have distinct expectations concerning the terms of purchase. Therefore, e-commerce companies must continually recognize and respond to their customers' changing needs in order to remain competitive. By integrating PLS-SEM and fsQCA methods, this research paper evaluates the factors influencing consumers' online repurchase intentions. The findings indicate that customer satisfaction, customer trust, and customer commitment are important determinants of online consumers' repurchase intentions.

This research offers both theoretical and practical contributions. It builds upon previous scientific studies by exploring the relationship between these factors and their relative significance in influencing repurchases decisions. The research was conducted in Serbia, where similar research is still limited. Consequently, the study fills the gap in the existing literature and provides new insights into this field of study within the Serbian context.

However, despite its contributions, this study has certain limitations. Firstly, the research is geographically limited to Serbia, which may affect the generalizability of the findings to other markets characterized by different consumer behaviors and economic conditions. Additionally, the study concentrated on specific factors influencing consumers' repurchases intentions. Future research could expand the scope by incorporating additional elements such as price, product quality, and social influence, thereby achieving a more comprehensive understanding of the factors driving repurchase decisions.

## **ACKNOWLEDGEMENT**

The research presented in this paper was carried out with the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia within the framework of financing scientific research work at the University of Belgrade, Technical Faculty in Bor, in accordance with the contract with registration number 451-03-137/2025-03/200131. The author would also like to thank Sandra Vasković, English teacher, for proofreading the paper.

## REFERENCES

- Aslam, W., Ham, M., & Farhat, K. (2018). Influencing factors of brand perception on consumers' repurchase intention: An examination of online apparel shopping. *Management: journal of contemporary management issues*, 23(2), 87-102. <https://doi.org/10.30924/mjcmi/2018.23.2.87>
- CAGR (2024). Serbia Country Commercial Guide. Available at: <https://shorturl.at/DSQMv>
- Chen, Y., Lu, F., & Zheng, S. (2020). A study on the influence of e-commerce live streaming on consumer repurchase intentions. *International Journal of Marketing Studies*, 12(4), 1-48. <https://doi.org/10.5539/ijms.v12n4p48>.
- Etha, E., Suciati, P., & Citra, A. N. (2024). Factors Influencing Online Repurchase Intention in Indonesia's E-Commerce Market: A Structural Equation Modeling Approach. *Jurnal Sosial Humaniora Terapan*, 6(2), 8. <https://doi.org/10.7454/jsht.v6i2.1127>
- Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of management journal*, 54(2), 393-420.
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39-50. <https://doi.org/10.1177/002224378101800104>
- Guo, J., Zhang, W., & Xia, T. (2023). Impact of shopping website design on customer satisfaction and loyalty: The mediating role of usability and the moderating role of trust. *Sustainability*, 15(8), 6347. <https://doi.org/10.3390/su15086347>
- Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. SAGE Publications.
- Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1), 2-24. <https://doi.org/10.1108/EBR-11-2018-0203>.
- Hair, J. F., Sarstedt, M., Ringle, C. M., & Gudergan, S. P. (2022). *Advanced Issues in Partial Least Squares Structural Equation Modeling (PLS-SEM)*. SAGE Publications.
- Hong, I. B., & Cha, H. S. (2013). The mediating role of consumer trust in an online merchant in predicting purchase intention. *International Journal of Information Management*, 33(6), 927-939. <https://doi.org/10.1016/j.ijinfomgt.2013.08.007>
- Iqbal, A. I., Ahmed, S., Laila, A., Khan, S. A., & Faizan, M. (2024). E-Commerce Adoption: The Moderating Role of Commitment between Purchase Intention and Customer Purchase Behavior. *Research Journal for Societal Issues*, 6(1), 65-82. <https://doi.org/10.56976/rjsi.v6i1.169>
- Jauhar, S. K., Chakma, B. R., Kamble, S. S., & Belhadi, A. (2024). Digital transformation technologies to analyze product returns in the e-commerce industry. *Journal of Enterprise Information Management*, 37(2), 456-487. <https://doi.org/10.1108/JEIM-09-2022-0315>
- Keiningham, T. L., Frennea, C. M., Aksoy, L., Buoye, A., & Mittal, V. (2015). A five-component customer commitment model: Implications for repurchase intentions in goods and services industries. *Journal of Service Research*, 18(4), 433-450. <https://doi.org/10.1177/1094670515578823>
- Kessel, A. (2024). Clunky Websites Are Costing Companies Money, Scaring Away Shoppers. Available at: <https://shorturl.at/esaap>
- Kim, C., Galliers, R. D., Shin, N., Ryoo, J. H., & Kim, J. (2012). Factors influencing Internet shopping value and customer repurchase intention. *Electronic commerce research and applications*, 11(4), 374-387. <https://doi.org/10.1016/j.elerap.2012.03.003>

- Ljubicic, I., & Štokić, V. (2024). The growth of e-commerce in the Republic of Serbia. *Pravo–teorija i praksa*, 41(2), 122-135. <https://doi.org/10.5937/ptp2402122L>
- Mahesh, K. M., Aithal, P. S., & Sharma, K. R. S. (2022). Open Network for Digital Commerce-ONDC (E-Commerce) Infrastructure: To Promote SME/MSME Sector for Inclusive and Sustainable Digital Economic growth. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, 7(02), 320-340. <https://doi.org/10.47992/IJMTS.2581.6012.0223>
- Masturoh, L. M., & Mugiono, D. (2020). The effect between Customer Satisfaction, Switching Cost, and Customer Experience of Trust to Customer Loyalty, Customer Commitment as a Mediation (Case Study: Customers on Online Shop Tokopedia, Malang City). *South East Asia Journal of Contemporary Business. Economics and Law*, 21(5), 151-162. <https://doi.org/10.5937/SEAJBEL2002151M>
- Mbango, P. (2018). Examining the effects of customer satisfaction on commitment and repurchase intentions of branded products. *Cogent Social Sciences*, 4(1), 1521056. <https://doi.org/10.1080/23311886.2018.1521056>
- Mosavi, S. A., & Ghaedi, M. (2012). A survey on the relationship between trust, customer loyalty, commitment and repurchase intention. *African journal of business management*, 6(36), 10089. <https://doi.org/10.5897/AJBM12.273>
- Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration*, 11(4), 1-10. <https://doi.org/10.4018/ijec.2015100101>
- Pappas, I. O., & Woodside, A. G. (2021). Fuzzy-set Qualitative Comparative Analysis (fsQCA): Guidelines for research practice in Information Systems and marketing. *International journal of information management*, 58, 102310. <https://doi.org/10.1016/j.ijinfomgt.2021.102310>
- Pappas, I. O., Kourouthanassis, P. E., Giannakos, M. N., & Chrissikopoulos, V. (2016). Explaining online shopping behavior with fsQCA: The role of cognitive and affective perceptions. *Journal of Business Research*, 69(2), 794-803. <https://doi.org/10.1016/j.jbusres.2015.07.010>
- Paștiu, C. A., Oncioiu, I., Gârdan, D. A., Maican, S. Ș., Gârdan, I. P., & Muntean, A. C. (2020). The perspective of e-business sustainability and website accessibility of online stores. *Sustainability*, 12(22), 9780. <https://doi.org/10.3390/su12229780>
- Pereira, H. G., de Fátima Salgueiro, M., & Rita, P. (2017). Online determinants of e-customer satisfaction: application to website purchases in tourism. *Service Business*, 11, 375-403. <https://doi.org/10.1007/s11628-016-0313-6>
- Ragin, C. C. (2008). *Redesigning Social Inquiry: Fuzzy Sets and Beyond*. University of Chicago Press. ISBN-13: 978-0-226-70275-9
- Ragin, C. C., & Davey, S. (2016). fs/QCA [Computer Programme], version 3.0. Irvine, CA: University of California. <https://sites.socsci.uci.edu/~cragin/fsQCA/software.shtml>
- Raji, M. A., Olodo, H. B., Oke, T. T., Addy, W. A., Ofodile, O. C., & Oyewole, A. T. (2024). E-commerce and consumer behavior: A review of AI-powered personalization and market trends. *GSC Advanced Research and Reviews*, 18(3), 066-077. <https://doi.org/10.30574/gscarr.2024.18.3.0090>
- Ringle, C. M., Wende, S., and Becker, J.-M. (2024). SmartPLS 4. Bönningstedt: SmartPLS, <https://www.smartpls.com>
- Rita, P., Oliveira, T., & Farisa, A. (2019). The impact of e-service quality and customer satisfaction on customer behavior in online shopping. *Heliyon*, 5(10). <https://doi.org/10.1016/j.heliyon.2019.e02690>

- Saleem, U., Yi, S., Bilal, M., Topor, D. I., & Căpușeanu, S. (2022). The impact of website quality on customer satisfaction and eWOM in online purchase intention: The moderating role of gender in risk-taking. *Frontiers in psychology*, 13, 945707. <https://doi.org/10.3389/fpsyg.2022.945707>
- Sharma, R., Srivastva, S., & Fatima, S. (2023). E-commerce and digital transformation: Trends, challenges, and implications. *International Journal For Multidisciplinary Research*, 5, 1-9. <https://doi.org/10.36948/ijfmr.2023.v05i05.7128>
- Shin, J. I., Chung, K. H., Oh, J. S., & Lee, C. W. (2013). The effect of site quality on repurchase intention in Internet shopping through mediating variables: The case of university students in South Korea. *International Journal of Information Management*, 33(3), 453-463. <https://doi.org/10.1016/j.ijinfomgt.2013.02.003>
- Shmueli, G., Ray, S., Estrada, J. M., & Chatla, S. B. (2016). The elephant in the room: Predictive performance of PLS models. *Journal of Business Research*, 69(10), 4552-4564. <https://doi.org/10.1016/j.jbusres.2016.03.049>
- Sullivan, Y. W., & Kim, D. J. (2018). Assessing the effects of consumers' product evaluations and trust on repurchase intention in e-commerce environments. *International Journal of Information Management*, 39, 199-219. <https://doi.org/10.1016/j.ijinfomgt.2017.12.008>
- Turban, E., Outland, J., King, D., Lee, J. K., Liang, T. P., & Turban, D. C. (2017). *Electronic commerce 2018: a managerial and social networks perspective*. Springer. <https://doi.org/10.1007/978-3-319-58715-8>
- Wijaya, I. G. N. S., Triandini, E., Kabnani, E. T. G., & Arifin, S. (2021). E-commerce website service quality and customer loyalty using WebQual 4.0 with importance performances analysis, and structural equation model: An empirical study in shopee. *Register: Jurnal Ilmiah Teknologi Sistem Informasi*, 7(2), 107-124. <https://doi.org/10.26594/register.v7i2.2266>



## INNOVATION MODELING TRAFFIC AND TRANSPORT

Nataša Pejić \*

*Leget Container Transport d.o.o., Serbia*

**Abstract:** Traffic and transportation are very important for the industry. New way of organizing and optimizing transport can help the development of a country's industry, as well as the preservation of the environment. Railway traffic can be an innovation solution for environmental protection. All types of goods can be transported by rail, with good traffic organization. Modelling of railway infrastructure and timetables is of crucial importance for the renewal of railway infrastructure and for monitoring user requests. Also, passenger railway traffic with timetable which monitor request passenger is very good solution preservation of the environment. Rail traffic with good organization can provide global transport security and a cleaner planet.

**Keywords:** modeling, railway, traffic, innovation transport, timetable.

### 1. INTRODUCTION

The traffic system consists of technological subsystems of different types of traffic. Each individual type of traffic represents a complex technological system, which differs from the others in terms of basic technical, technological and economic properties. Freight transport the supports the economy is characterized by:

- spatial action of the transport process,
- a unique process of production of transport services,
- the integrity of the transport process and means of transport,
- the presence of transport users in the process (production time can't be separated from consumption time).

---

\* Corresponding author: [natasa.p1111@gmail.com](mailto:natasa.p1111@gmail.com)

Nataša Pejić, ORCID: 0009-0001-0812-1259

## **2. CHARACTERISTICS OF TRANSPORT**

### **2.1. Advantages and disadvantages of model of transport**

The features of railway traffic that make this mode more suitable than others are reflected in the following:

- railway traffic is practically independent of climatic conditions, as it is able to transport goods with a high degree of accuracy and regularity throughout the year, night and day, regardless of climatic conditions,
- the railway has a large quantitative transport capacity, because it can transport large quantities of goods, over long distances and overcome large transport irregularities,
- low resistances between rails and points and the transport of heavy trains enable the railway to achieve high productivity of the work of assets and labor with lower transport costs per unit of transport service compared to road traffic,
- the possibility that railway exploitation can be carried out through the application of increasing automation and cybernetics represents a real progressive improvement of railway traffic safety,
- benefits of realizing the development of various forms of combined transport,
- the railway itself can carry out the transport process in the case of transport over industrial tracks, and in other cases it is required to cooperate with other modes of transport, primarily with road transport.

The railway is a complete unit, but at the same time it is "difficult to move" because the railway network is large and territorially distributed. Because of this, it is immobile, inelastic and rigid to a certain degree, so it is often forced to give way to other modes of transport.

The road traffic has advantages, due to transport process can be unfold directly between production and consumption centers. These possibilities make it flexible and adaptable to a wide range of activities, thus creating a number of socio-economic advantages in the organization and implementation of transport services:

- high maneuverability when transporting goods,
- the possibility of "door-to-door" transportation and, in this sense, direct contact with users,
- relative ease of use and great possibilities in providing additional services to clients,
- the variety of forms of transportation that are performed, due to the variety of types of means of transport used, their specialization and carrying capacity,
- relatively small sums of investment required to meet the given volume of goods transportation than with railways,
- in comparison to other types of traffic, it has a small volume of exploitation costs related to initial and final operations,
- faster delivery of goods compared to rail and water transport, which enables the reduction of the needs of the recipient of the goods in working capital and warehouse space,
- a better possibility of ensuring the accommodation of goods during their transport than with other modes of transport.

In addition to advantages, road traffic has a number of disadvantages:

- high consumption of fuel per transport unit (very important in conditions of energy crisis),
- in relation to maritime, river and railway traffic, a high coefficient of the ratio of the vehicle fleet's own weight to the amount of transported goods (tare-net ratio),



- low efficiency of driving power utilization,
- high cost of transport compared to rail, river, pipeline and sea transport, especially on longer distances.

Seen from a general – social aspect, the most suitable sphere of road traffic use is:

- transportation of goods over short distances and delivery (pick-up - pick-up) from the manufacturer to the railway or pier (port),
- long-distance transportation of perishable and expensive goods,
- carrying out transportation by serving intermediate processes in industry.

The most significant technological and economic advantages of river transport are:

- very high, practically unlimited permeability of waterways,
- lower resistances to the movement of ships compared to the resistances to the movement of assets on land roads, which ensures more efficient use and less fuel consumption per transport unit,
- compared to land transport, it has a significantly higher carrying capacity of the vehicle fleet, which results in a smaller number of service personnel per transport unit and the possibility of a wider use of high-production transshipment machinery during loading and unloading,
- compared to rail and road traffic, it has a significantly lower coefficient of ratio between the ship's own weight and its carrying capacity,
- lower consumption of metal per one ton of the ship's carrying capacity.

The main disadvantages of river traffic that limit its application are:

- dependence on the geographical connection of the river network;
- increased transport distances, compared to other modes of transport, due to the unfavorable geographical layout of the river network;
- diversity of exploitation conditions on individual sections and changes in these conditions during navigation;
- lower speed compared to other types of traffic, especially in various climatic conditions;
- the existence of various seasonal downtimes in exploitation (frost, drought, etc.);
- the variability of the water level, which on the Sava river, for example: changes drastically, in just a few days the water level can rise or fall by several meters.

Compared to other modes, maritime transport has the following advantages:

- unlimited throughput capacity, which is practically reduced to the processing capacity of seaports,
- low fuel consumption and low energy costs,
- resistance to movement is significantly lower than in land traffic, which requires a significantly lower traction force per transport unit,
- for long-distance transports, transport costs are lower than for other types of transport,
- the use of ships with a large carrying capacity ensures high work productivity compared to other modes of transport,
- labor productivity in maritime transport is 5 - 6 times higher than in rail and river transport, and transport costs are on average 2 - 3 times lower than in these types of transport,
- on average, one ton of useful load capacity is: in the case of railway traffic from 0.7 to 0.8 t tare, in the case of road traffic 1.2 t, and in maritime traffic about 0.4 t tare (where the hull, power unit, equipment, ship supplies and fuel).

Disadvantages of maritime transport are:

- dependence on natural-geographical and navigational conditions (wind, waves, tides, low tides, mud and other climatic factors),
- the need to build complex and expensive port facilities (ports and terminals).

The previously listed advantages and disadvantages of each type of transport can lead to the conclusion that each type of transport can be suitable depending on the type of goods, delivery terms, transport price, elasticity and the like. Also, important factors that influence the choice of a certain type of transport are: transport capacity, safety as well as reliability and accuracy. It is very important to state that earlier research has shown that water transport has the lowest fixed and variable costs of transport, while rail and air transport have the same share of variable and fixed costs in transport. Road transport has the lowest fixed costs, and the highest variable costs that participate in the formation of the value of the transport price.

### **3. RAILWAY TRAFFIC**

Railway traffic is a large complex dynamic system that has its own structure - elements of the system and connections between elements - it has its own subsystems, hierarchy and environment (Pejić, 2022). The traffic system is a set of roadways, rolling stock and telecommunications devices, commercial, administrative, educational, scientific and other bodies and organizations and their workers, which ensures that the traffic performs its tasks as a purposeful, functionally unified unit.

Traffic tasks are not the same in all areas, countries or regions at the same time. Differences in transportation needs arise due to differences in the structure and number of the population, population density, and people's habits and needs for consumption of goods. Then, there are also regional differences in the economy, in the quantity and type of goods that are produced. Due to all these differences in the environment of the traffic system, the function of the traffic system is different in different areas.

The function of the traffic system also depends on its structure. As with all other large dynamic systems, the structure of the traffic system consists of its elements, as well as the way in which these elements are interconnected in the process of realizing their functions. Since the traffic system is a complex system, there are first connections between elements in lower-order subsystems, and then connections between higher-order subsystems, which is required by the hierarchy of large complex systems (Milanović, 2012).

Also, rail traffic can provide complete and continuous support to both industry and passengers. The needs and requirements of transport users have the characteristic of changing over time and space. Consequently, when the demand changes in the transport market, it occurs changes in the flow of passengers and goods, and carriers must adjust their offer would be competitive. Transport planners, constantly monitor changes on the transport market, and to offer the service in accordance with their own capacities of transportation that is in line with newly emerging needs for transportation.

Changes in the offer and demands for transportation services require planners to constantly reassess the relationship between the volume of traffic and the capacity of the roads on which it takes place. For support planners in the field of adapting the transport offer to the market by monitoring the relationship of traffic and traffic infrastructure and the adoption of various strategic, tactical and various methodologies, methods and sophisticated tools have been developed for operational decisions computer application base (Milanović & Gopčević, 2017).

Based on the transport service market research indicators, it can be determined whether and which elements of the transport service quality require special attention when planning for the next period.

Users can be good consultants when planning the transport offer. Previous research has shown that one satisfied user of the transportation service shares his experience with at least three other people who may become new users, while on the other hand, one unfavorable experience is transmitted to at least ten people, which can lead to a decrease in demand.

The subject and goal of this paper is to show the importance of planning cooperation, as well as how good planning can achieve environmental preservation.

### **3.1. Transport technologies in rail traffic**

Technologies for transporting goods in railway traffic, where only he participates in the entire transport route, can be divided into:

- classical goods transport systems (transportation of individual wagon shipments or groups of wagons),
- transportation of goods by scheduled trains.

The classic system of transporting goods almost doesn't exist, because most of the world's railways do not see the justification of the costs incurred during such shipments. The costs incurred during such shipments can be divided into:

- costs for delivery and removal of cars from loading and unloading tracks,
- collection and transportation costs (collection trains) to marshalling stations,
- costs of processing and formation of trains in shunting stations,
- long and uncompetitive transport time for most types of goods and users.

Shunting stations can function and be profitable and competitive on the transport services market only if:

- well-utilized trains can be formed from incoming flows (according to the number of cars, mass or length),
- arriving trains can form relatively constant flows on the main routes – routes,
- the transport distances are such that the loss of time in the shunting stations can be mitigated at least to some extent compared to the competition's transport time.

Delivery and shipment of goods by route trains is the most efficient way of transporting goods by rail, both for users and for the railway. Routing is increasingly present on today's market, but users of goods transportation by route trains can be divided into several groups:

- a group of users who have constant and large flows of goods, "shipper's route trains",
- users who are not always able to ship sufficient quantities of goods that are necessary for the formation of an ad hoc route train, that is, as needed,
- users of route trains that travel between production and consumer centers, "logistic route trains".

Both loading and unloading have limitations in terms of infrastructure owned by the loading/unloading place. Also, weather conditions can affect exploitation. It is important to draw the conclusion that every company should take care of the infrastructure they need in order for loading/unloading to be done as efficiently as possible, that is, how they improve all other business segments in accordance with them, and the transport sector needs to improve.

## **4. SAFETY AS A QUALITY FACTOR THAT AFFECTS THE QUALITY OF THE TRANSPORT SERVICE**

The railway system is a standardized based on strict rules and a special way of organizing work. As a very complex system, it has numerous rules, procedures, standards and specifications in order to function successfully. In addition to regulating safety, they are also necessary to ensure reliable, orderly and economical operation of the system, the preservation

of human health and the human environment, as well as the mutual compatibility of various parts of the railway system. In addition, technical standards on railways have a great influence on the transport market and its development, as well as the social conditions of employees. The railway traffic safety system consists of institutions competent to define, enact, implement and supervise the implementation of norms in that area (Milanović & Pejić, 2021).

These institutions include classic state bodies such as competent ministries or directorates, independent state bodies, sectoral associations and associations, railway companies, i.e. infrastructure managers and operators, the railway industry as well as international institutions. International institutions can have an interstate character or a professional or business character as international associations. Technical standards affect many areas in the railway sector. They cover issues ranging from the greatest public interest to the business interests of companies to individual social interests. That is why both the authority and the interest in determining technical standards on railways move from the state to local bodies to companies and trade unions. Also, considering the international character of railway traffic, international institutions also participate in it.

Legal norms in the field of security can be classified into two groups:

- laws and by-laws (regulations) that represent a legal obligation and are passed by state bodies,
- standards, specifications and manufacturer's instructions which are voluntary and which are adopted by the sector (companies and associations).

Standards are usually adopted at the level of associations and organizations for standardization, while specifications and instructions are usually adopted by companies. Both essentially represent voluntarily introduced norms by the sector. However, if a legal regulation refers to certain standards or specifications, they also become mandatory for implementation. Technical norms can be introduced through an international agreement or by direct recognition of an international regulation by a country or company. In that case, international agreements and regulations are mandatory and take precedence over national legislation.

Laws and other technical regulations in the field of railway traffic safety, in addition to defining rules, procedures, standards, must also determine the manner of application of the regulations.

Technical regulation is a very complex and multidisciplinary issue with a major impact on the position of the entire railway sector. It is clear that inadequate regulations can threaten safety, as well as cause great economic, social and social damage. Due to its size and complexity, the railway system is divided into subsystems. According to the European concept of interoperability and safety, the railway can be divided into the following subsystems: infrastructure, control, management and signaling on the infrastructure, energy, railway vehicles, traffic regulation and management, maintenance, telematics applications for services in the transport of goods and passengers (Pejić, 2024).

All technical means in the mentioned subsystems can be classified into two basic groups, namely: immovable (stable) and movable (mobile).

The group of immovable assets includes railways and stations with all their facilities, electric traction facilities, stable signaling equipment, depots and workshops. In a word, immovable assets make up the railway network. The group of movable assets includes vehicles, i.e. towing and towed vehicles.

The functional subsystems of the railway system are:

- Traffic regulation and management subsystem,
- Subsystem maintenance,
- Subsystem of the telematics application for the transport of passengers and goods.

## **5. TIMETABLE IN RAILWAY TRAFFIC**

Planning the timetable and building the railway network or improving the existing ones through software has not yet gained importance in the Balkans and if software packages are available.

If it were insisted on a global level that traffic modeling and simulations are done through software before being implemented in a real system, railway traffic would be better organized and would have many more users.

For example, it would exclude Open Track software. For modeling and simulation in this software, should have use methodology phases as follows:

- Phase 1. Definition of the problem,
- Phase 2. Designing the study,
- Phase 3. Designing the conceptual model,
- Phase 4. Formulating inputs, assumptions, and process definition,
- Phase 5. Data collecting, separating, selecting and preparing,
- Phase 6. Choosing the simulation tool, simulation language or simulation software,
- Phase 7. Building and verifying the simulation model,
- Phase 8. Calibrating and validating the simulation model,
- Phase 9. Simulation experiments planning (scenarios planning),
- Phase 10. Exploiting the simulation model (experiment with the model), performing the simulation by defined scenarios,
- Phase 11. Analyzing the simulation results,
- Phase 12. Presenting the simulation results, and
- Phase 13. Defining the model life cycle (Huerlimann & Nash 2017).

Based on the methodology and if we know well all the disadvantages and advantages of the railway system, we can conclude that we could always and at any time get a well-planned timetable and well-suited to users. There are also other software that can give equally good results (Kuzmanović et al., 2019).

## **6. IMPACTS OF TRAFFIC ON THE ENVIRONMENT**

Traffic is the biggest polluter of the environment, if it uses different fuels for its drive, which leave harmful substances when burned. To reduce environmental pollution, the solution can be found in rail traffic, because of that more and more trains use electricity for their propulsion. Also, on more and more parts of the railway line, are provided power supply for electricity.

Water and soil pollution also results from traffic, due to the release of chemical substances and the release of toxic gases. Noise is a growing problem, it is becoming stronger and more unbearable, causing many negative consequences, hormonal and organic disorders in people.

Traffic is the biggest cause of noise, which increases depending on the type and number of means of transport, structure of means of transport, speed, road surface, location of roads and railways, etc. Road traffic, from the aspect of its development, number and basic characteristics, creates significantly more noise than railway traffic. Research has shown that for the same volume of traffic, the noise level in road traffic is about twice as high compared to the noise level in railway traffic. Also, from the aspect of safety, rail traffic is more favorable (Milanović, 2010).

In addition to safety and the impact on the environment, rail traffic, if well good planned, can be more favorable for the population in cities. If the network of railway stations is well developed, as well as if the timetable is adapted to the user's requirements.

## 7. CONCLUSION

Innovations and additional research of user requirements could contribute to the satisfaction of users of the transport service. Investing in the development of institutes that deal with research, planning and designing is of key importance for the development of all types of traffic.

The development of railway traffic would be also affect the reduction of environmental pollution.

## REFERENCES

- Huerlimann, D. & Nash, A., B. (2017). OpenTrack Simulation of Railway Network, Version 1.9. Manual, OpenTrack Railway Technology Ltd. and ETH Zurich Institute for Transport Planning and Systems.
- Kuzmanović, J., Schöbel, A., Malinović, N., Milanović, Z. (2019). Application of OpenTrack at Železnice Republike Srpske. *VII International Symposium: New Horizons 2019 of transport and communications. Book of Abstracts, University of East Sarajevo, Faculty of Transport and Traffic Engineering, Doboј, 29 - 30 November, 2019.*
- Milanović Z. (2010). Traffic simulation to identify "bottlenecks" on part of the Belgrade railway junction. *XIV Scientific-expert conference on railway RAILCON'10, Niš, Serbia, 07-08. October, 2010.* (Simulacije saobraćaja u cilju utvrđivanja „uskih grla“ na delu železničkog čvora. XIV Naučno - stručna konferencija o železnici ŽELKON'10, Niš, Srbija, 07-08. Oktobar, 2010). (In Serbian)
- Milanović Z. (2012). E-business in traffic planning based on modular application of microsimulation models. Megatrend University, Faculty of Business Studies, Belgrade (*doctoral dissertation*). (Elektronsko poslovanje u planiranju saobraćaja zasnovano na modularnoj primeni mikrosimulacionih model. Megatrend Univerzitet, Fakultet za poslovne studije, Beograd (doktorska disertacija) (In Serbian).
- Milanović, Z. & Gopčević, Š. (2017). Digital infrastructure as a basis for railway traffic simulation - Experiences of Serbian Railways. *Fourth BH Congress on Railways, Sarajevo, B&H, 26-27. October 2017 - Proceedings.* (Digitalna infrastruktura kao osnova za simulaciju železničkog saobraćaja - Iskustva železnica Srbije. Četvrti BiH Kongres o željeznicama, Sarajevo, BiH, 26-27. oktobar, 2017 - Zbornik radova). (In Serbian)
- Milanović, Z., & Pejić, N. (2021). Analysis of Tourist Travel Behaviour for the Train/Bus Transport Service Establishment - The Case of Kopaonik. *Transport for Today's Society (TTS 2021). Bitola, 2021.*
- Pejić, N. (2022). Traffic simulation on the part of the railway line from Pančevo main station to Vršac station and Stamora Moravita border. *XX International Scientific-Expert Conference of Railways, 2022, Niš, Serbia.*
- Pejić, N. (2024). Analysis of the timetable from Sremska Mitrovica station to Šid station. *XXI International Scientific-Expert, Conference of Railways, 2024, Niš, Serbia.*



## APPLICATION OF INNOVATIVE SOLUTIONS IN LOCAL GOVERNMENT IN CENTRAL EUROPEAN COUNTRY

Kamil Turčan\*, Ivana Butoracová Šindleryová

*Faculty of Social Sciences, University of St. Cyril and Methodius in Trnava, Slovakia*

**Abstract:** Intelligent mobility is an integral part of the modern world, including Slovak municipalities. The introduction of new transportation options is currently taking place in several cities in the form of various modes of transport. The research part of our contribution addresses the absence of shared vehicles in the municipality of Trnava. The global phenomenon of carsharing has found its place in the developed countries of Europe. In the context of the Slovak Republic, its implementation occurs only in selected cities and is mostly conceptual in nature. The goal of our work is to propose the implementation of shared cars in the municipality of the regional city of Trnava. We employed several methods to assess the potential of carsharing utilization by the citizens of Trnava. The theoretical part is the result of a literature search that had to be selected and summarized. The result of our investigation is defined by situational analysis and the empirical method of observation. We studied the traffic behavior of the city's inhabitants, specifically in the form of a questionnaire. The initial focus is primarily on ensuring ecological forms of transport and reducing the number of cars on the road infrastructure. The conclusion of our work presents recommendations for the implementation of a new transport service in the city of Trnava.

**Keywords:** intelligent mobility, local government, innovation, car sharing

### 1. INTRODUCTION

In the last decade, there has been an increased interest among local governments in utilizing innovative trends from the field of transportation. This mainly concerns environmentally sustainable modes of transport that aim to eliminate negative impacts on infrastructure and reduce adverse effects on the environment (Žárska & Papcunová, 2007). Slovakia is no exception, with various cities gradually becoming more involved in offering new transportation options to their residents. However, before implementing specific smart solutions in the field of mobility, it is crucial to understand the entire system and the individual components of a Smart City, which are interconnected and create a synergistic effect. The

---

\* Corresponding author: [turcan3@ucm.sk](mailto:turcan3@ucm.sk)

Kamil Turčan, ORCID: 0000-0002-1236-0658

Ivana Butoracová Šindleryová, ORCID: 0000-0001-8261-7490

presented paper highlights the importance of applying modern transportation methods and Smart mobility components, the necessity of which for the environment is confirmed by numerous documents from the European Union and the Slovak Republic.

We explore the possibility of introducing Carsharing in the regional city of Trnava, which is gradually evolving towards an eco-friendlier part of Slovakia by building an extensive cycling infrastructure network. This issue is also being addressed within projects in Slovakia. The initiative comes from national representatives, who are conditioned by EU regulations, yet when looking at the competence framework, Slovak local governments are not lagging. The practical part of our work involves a written research method to collect large-scale data. We used a research data collection method in the form of a questionnaire, where we primarily examined the stance of city residents toward the new transportation alternative, carsharing.

## 2. LITERATURE REVIEW

In our work, Carsharing is a part of the Smart City model. The key to its success lies in building a synergistic infrastructure, which reflects the economy of the 21st century. Its foundation primarily involves data processing and sharing, with the gradual increase in the efficiency of the entire advancing project (Pauhofová et al., 2019).

It is important to note that several cities in Nordic EU member states are characterized as Smart Cities, as are most metropolises in Italy, Austria, and the Netherlands, and approximately half of the major cities in Germany, Spain, and France. Poland, as our close neighboring country, has relatively few Smart Cities, despite being considered an advanced region with a large population (Ruengchinda, 2021).

A comparison of Slovakia and other countries in Europe in terms of the use of Smart solutions does not yet seem justified, but it is possible to draw inspiration and examples of good practices. While in other developed countries these solutions are implemented, in Slovakia, the concept is still being introduced, and its application at the local government level is progressing very slowly. In 2019, 112 cities were compared in the global index, with Bratislava ranking 84th (Bubla, 2019).

The slowing effect may be attributed to finances, underdeveloped infrastructure, and numerous other factors, which cause Slovak regions to lag behind European ones. A significant issue in Slovakia is the enormous regional disparities across the entire territory. Smart solutions can help, and in fact, resolve several of the challenges we face, such as waste management, mobility, infrastructure, and air pollution. The question is whether we are willing to change Slovakia for the better and take inspiration from other European regions, or whether we will allow stereotypes to hinder our path to a better life (Stiftung, 2021).

The goal of a Smart City is to significantly reduce emissions, thus preventing environmental pollution. The Smart mobility component, in the context of local governments, is characterized by highly organized transportation systems, intelligent behavior of residents when using new transportation options in the city or municipality, connecting transport services, and intelligently managed traffic (Cohen, 2018). In 2017, the Ministry of Economy of the Slovak Republic (MH SR) developed a document titled "Support for Innovative Solutions in Slovak Cities," which explains the importance of applying Smart solutions in the Slovak urban and municipal context.

It clearly emphasizes good examples from practice in cooperation with private entities. This concept is considered a national document, aiming to assess the current state of city development. The factor that inspired our article is the need to introduce car-sharing in local governments as a necessary trend to reduce the number of vehicles in road infrastructure and to



achieve the goal of permanently reducing emissions in the context of the EU (Hučková & Martin, 2017).

Sehmi and Serreira (2019) consider intelligent mobility to be a new and revolutionary way of thinking about how to move more efficiently, safely, and in an environmentally friendly manner. It plays a key role in local governments in building a city's brand, improving residents' quality of life, reducing emissions, and creating an attractive environment for employment opportunities. Urban mobility is described as the driving force of modern cities, but also as a critical economic factor and intermediary for intelligent and sustainable development.

The planning of a Smart City, which brings efficient and equitable urban mobility solutions, is one of the most pressing issues faced by cities around the world. Innovations and new technologies are increasingly changing the mobility landscape, providing users and providers with broader transportation options (Litman, 2000). Carsharing is a term used worldwide to refer to mobility services where, after registration, a user has access to a vehicle provided by the service without interaction with the previous user. The vehicle is operated in the same way as in a traditional car. Usage is charged in time intervals (minutes or hours) or based on the distance traveled, and vehicles are generally available from distributed locations within the service area. Thanks to shared car services, cars are parked at designated parking spots throughout the city, often in walking distance from dense residential or commercial areas, shopping centers, and other institutions. The vehicles are available 24 hours a day, 7 days a week, at prices specified in the service provider's price list. One-way carsharing is the fastest-growing trend in recent years. This can largely be attributed to the ability to use other means of transport after travelling on a route with a shared vehicle, where it does not have access, such as pedestrian zones and similar locations.

The theoretical definition of the issue of implementing intelligent transportation in the form of shared cars as an innovative element in local government will be further discussed in the subsequent parts of our paper, aiming at the application of Carsharing in the local government of Trnava. In the attached diagram, the data obtained from the portal *intelligentnemesta.sk* shows the current state of Smart City component usage in Slovak municipalities (Figure 1).

The portal creators, researchers from FSV UCM Trnava and the Faculty of Business at EUBA, *intelligentnemesta.sk*, have created a platform called Smart Cities, which serves to compare in detail the implementation of Smart systems in Slovak municipalities. It assesses their level, resulting in the Smart City Index. It helps bring the issue closer to interested citizens, can identify the problems of individual municipalities through various indicators, and assist in finding potential solutions. They aim to help suppliers of Smart solutions in communities through various recommendations. As a result, they actively participate in updating data, graphs, and evaluation tables, providing users with an overview of the current state of Smart solutions in Slovak municipalities.

When we look more closely at the current situation in the city of Trnava, we find positive trends in alternative transportation, as well as predispositions for its further development. One of the new transportation options within the city area is bikesharing. Bikesharing is a relatively new term that has become widely adopted and enjoys enormous popularity. The company Arboria bike, a joint project between the city of Trnava and the company Lucron, donated the bikesharing system to the public. In September 2018, the bikesharing system was launched in a pilot operation. In 2020, the name was changed to Trnava Bikesharing. The service has been operating since 2019, following the construction of a residential complex from 2011 and its continuous expansion. Currently, the service is available to all residents of the city, regardless of their place of residence. The company operates 118 green-and-black electric bicycles and 71 virtual stations, where bikes can be parked after use. Residents of Trnava can, of course, use

their own bikes, supported by the city's-built cycling infrastructure. In recent years, there has been a significant increase in cycling transport in the municipality of Trnava. To date, 22 kilometers of bike lanes are available. This is one of the most supported forms of transportation, not only in Trnava but also in other cities in Slovakia, so the routes will continue to expand (Mohanty et al., 2019).

Other activities to support cycling include the construction of a bike tower near the train station with a capacity of 118 bikes, the expansion of the city's bike rack portfolio, and other supportive activities for the use of alternative transportation (City of Trnava, 2021).

Electromobility is gradually developing, and both the city and its residents have a positive attitude towards the use of environmentally friendly transportation forms. Since 2018, employees of the city office have been using three electric Smart cars within the city area, and in 2020, they purchased two more electric vehicles, the Škoda Citigo-e iV. The city's fully electrified fleet is only missing the replacement of the mayor's vehicle. The city police also uses one electric vehicle, the Nissan e-NV200. However, the residents themselves do not yet have the option to rent an electric car or a fossil-fuel car (Kuník, 2020).

There are only 11 charging stations in the city of Trnava, managed by private companies with varying fees. In Trnava, users can charge their electric vehicles for free at the Kaufland shopping center on Trstínska Street. We personally verified this at the mentioned location.

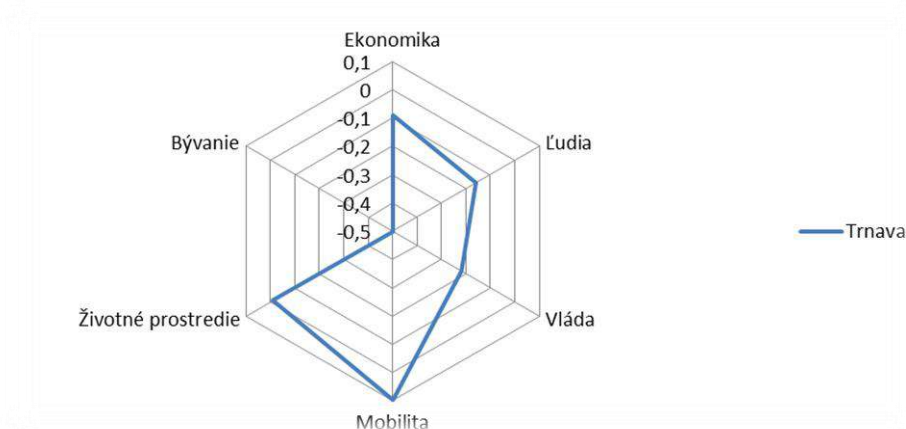


Figure 1. Level of individual pillars in the Smart agenda of the city of Trnava (Own processing according to: <https://intelligentnemesta.sk/smartindex-benchmark-graf-porovnanie-mesta-2020/>, 2020)

### 3. DATA AND METHODOLOGY

To prepare this paper, it was necessary to choose several methods through which we, as authors, can work towards an effective solution to the problem of reducing the number of cars in the regional city. In the basic section of the theoretical framework of our work, we created a concept of smart mobility as one of the components of Smart City through the selection of appropriate domestic and foreign literature, available publications, and documents. From the method of generalization, we move in the theoretical part to the specification of the term Smart Mobility. This is due to the significance of this component for the study in the empirical section.

The continuation of the paper, in the Results section, is the result of an analysis of the transport environment of the city of Trnava, which is part of key road connections to the capital, Bratislava. Through the synthesis of data on the current situation in the city of Trnava, we constructed a questionnaire-based research form to seek outputs for the proposal section of the work. The summary of data and information from the questionnaire survey of the residents of Trnava allowed us to contact a representative from INFOCAR, a.s., a company specializing in

carsharing. A consultation with the leading representative of the organization, an expert on the topic, Mr. Haník, was constructive, and we searched for common paths for implementing shared vehicles in one of the areas of Trnava. We proposed a potentially defined space in which the service would be utilized by residents.

The subject of research in the empirical section of the article is the local government of the regional city of Trnava and its traffic situation using alternative transportation forms. To obtain the necessary data for evaluating new transportation options, we used the previously mentioned questionnaire form with questions aimed at the current attitudes of residents regarding the topic of Smart Mobility. The survey was conducted electronically, which allowed for the quick summarization of data within two months (01.02.2022 - 31.03.2022).

According to the District Traffic Inspectorate of Trnava, as of December 31, 2020, the total number of registered vehicles in the city of Trnava was 69,418 personal motor vehicles and small utility vehicles of category N1 (Temňák, 2019). This data adds value to our survey, as, by December 31, 2021, Trnava recorded a population count of 62,788 inhabitants, of which 38,008 citizens were aged 18 to 64 years. This implies that for every citizen who could potentially be a holder of a driver's license, there are up to two cars (Statistical Office of the Slovak Republic, 2022).

#### **4. RESULTS AND DISCUSSION**

The Sustainable Mobility Plan (SMP) for the regional city of Trnava and its functional area, issued by the Trnava District Office on October 29, 2021, includes a clear goal: to create the necessary conditions for the development of mobility for the city's residents and other entities in the city's functional area (CFA), reduce negative impacts in transport, and focus on the sustainability of the mobility environment. The detailed specification of goals aligns with the objectives of our work, such as the development of new transportation forms using ecological drives in both public and private transportation, as well as increasing the use of shared modes of transport through the support of car-sharing (CS).

To fulfill the goal of our work, which is to apply a new form of transportation in Trnava's self-government, we created a questionnaire survey, which included questions regarding the current behavior of vehicle users and their attitudes toward alternative forms of individual transportation, specifically car-sharing. The aim of the questionnaire was to assess the potential for the development of this new transportation option in Trnava's transport infrastructure and to understand how the service should be structured for its practical implementation and to meet the needs of potential users.

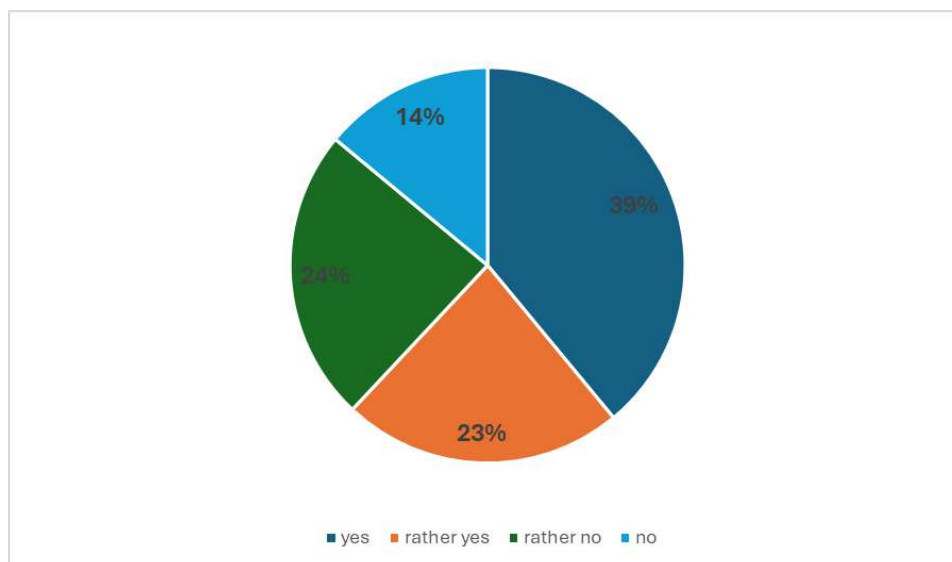
The questionnaires were created electronically using Google Forms. We distributed them via social media to receive quick feedback. The participants in the survey were residents of the different city districts of Trnava, who either have permanent or temporary residence in the area or frequent the surveyed locations. Out of 498 completed questionnaires, we were able to use 457, as the others did not meet the basic requirement of possessing a valid driver's license for category B. The structure of the respondents is specified in the first six questions of the survey. The remaining 22 questions focused on the respondents' transport behavior, awareness, usability, and the parameters of car-sharing.

The survey results were provided to the company INFOCAR, a.s., the provider of the flexiBee service, with whom we collaborated during the research. Based on their feedback, we proposed a new type of transportation in the self-government of Trnava and how to implement the electric car-sharing service in Trnava's conditions.

Since the structure of the survey was extensive, for the purposes of our paper, we selected primary data from its second section, titled "Traffic Behavior of Respondents with a Focus on Individual Automobile Transport." The following is a summary of the responses:

- 90% of respondents own cars in their household, with only 2% using electric or hybrid vehicles.
- For 45% of respondents, the average driving time is only 30 minutes, which shows the potential for introducing electric car-sharing for shorter trips.
- Another positive fact for the usability of the service is the number of cars in households: 60% of respondents own two or more cars. Reducing the number of vehicles by utilizing a shared model would significantly reduce the negative trend of insufficient parking spaces near residential buildings.

The survey questions tended to clarify the area of smart mobility, the concept of car-sharing, and the practical feasibility of its implementation. 44% of respondents could imagine using the proposed new, modern, and ecological form of shared cars. (Graph 1)



*Graph 1. Possibility of car-sharing use by City residents*

The motivation for activating the service would primarily be free parking within designated parts of the city, along with reserved and marked spaces. Since fees are part of the service we are proposing, residents also had the opportunity to comment on this aspect. CS is charged in two ways: based on minutes driven and a monthly fee. 55% of survey participants agreed to a monthly fee of 8 EUR, and they would accept a charge of 0.15 EUR per minute of travel.

We provided the processed questionnaire survey to Mr. Haník from INFOCAR, a.s., a company specializing in shared vehicle services in Bratislava. Together, we concluded how to apply car-sharing in Trnava for maximum benefit. The results of our empirical study were also submitted to the Trnava City Hall based on the recommendations of our consultant, Mgr. Andrej Kóňa, PhD., and the CEO of INFOCAR, a.s., Mr. Haník.

## 5. CONCLUSION

The essence of community car-sharing in the flexiBee service lies in the sharing of the same car among multiple users. Primarily, the service is intended for anyone registered within the community who uses their car minimally or owns two or more cars, one of which remains

unused for most of the time. Our survey in Trnava confirmed this fact, as 60% of respondents own two or more cars.

Electric driving has a positive impact on the environment as it produces almost no emissions. The justification for car-sharing is also supported by low user costs compared to car ownership, which can be several times higher. In practice, car-sharing users only pay for the time they reserve the vehicle, and the distance traveled is less important to them. The cost per minute of driving is 0.25 EUR, depending on the specific time of use. Reservation time intervals range from 30 to 240 minutes. The system operates through a reservation process, payment, and the return of the vehicle to the rental point. Users register through a simple and user-friendly mobile app.

Based on the results of the questionnaire survey, which we provided to the co-founder of the flexiBee service, Mr. Haník, we jointly set the potential functioning of car-sharing in Trnava as follows:

- The use of compact 5-seat electric vehicles, such as the Renault ZOE, as 77% of respondents indicated that they would use this type of vehicle. The vehicles would be distributed as follows: 4 vehicles at the Arboria housing estate (Východná Street), 3 vehicles in the city center (Pekárska Street), and 2 vehicles placed in the underground parking lot of the City Arena shopping center, with up to 5 parking spaces with charging stations for CS to ensure parking for users from other parts of the city.
- Building charging stations along with reserved parking spaces for the flexiBee service in the city center, near institutions, shopping centers, and residential areas to increase visibility and utilization of this new mode of transportation. Part of the funding for the construction of charging stations could be provided by the self-government and the flexiBee service provider through a call for applications for subsidies for the construction of publicly accessible electric charging stations within the 2021–2027 Mobility Support Program. The minimum grant is 2,500 EUR, which corresponds to one station with two charging ports. (MH SR, 2022).

The suggested pilot area for implementing the car-sharing service is Arboria, as 184 respondents from that estate responded positively to the idea of using car-sharing. The first four vehicles and designated parking spaces in the Arboria residential area would be placed on Východná Street, located between Veterna and Novomestská Streets, thus covering several residential buildings within a 500-meter radius (Figure 2).



*Figure 2.* Proposed location for car-sharing on Východná Street, Arboria housing estate, Trnava (Trnava North District map, car-sharing point location).  
<https://mapa.zoznam.sk/?search=+Trnava%2C+V%C3%BDchodn%C3%A1+ulica>)

In this paper, we emphasized the need to introduce new transportation forms in local governments as an effective tool for mitigating negative environmental impacts and improving community coexistence by using ecological transportation modes within closed communities. The potential for implementing car-sharing is confirmed by the majority of our respondents who expressed a positive attitude toward this concept. This area has not been sufficiently studied, and we aimed to apply the concept of car-sharing in the conditions of the Slovak Republic, specifically in the city of Trnava, by analyzing the smart mobility environment of Trnava and conducting a questionnaire survey to assess residents' attitudes toward transportation, alongside consultations with Mr. Haník, the executive director of INFOCAR, a.s.

Alternative modes of transportation are becoming increasingly relevant not only abroad but also in Slovakia, especially in the context of worsening climate conditions and insufficient infrastructure capacity. Individual automobile transportation plays a crucial role in mobility, but it is necessary to optimize it and create conditions for further development. Our proposal is the implementation of car-sharing as a daily service for residents, which would help limit car concentration in traffic. From an economic standpoint, depending on how the vehicle is used, opting for car-sharing can result in savings by eliminating the fixed costs associated with owning a vehicle, including maintenance, repairs, fuel, taxes, and insurance. Car-sharing offers a sustainable, flexible, and innovative transportation option for local governments, not only in Trnava but also in other Slovak cities.

Despite the negative environmental impacts, the use of individual automobile transportation is increasing. It is therefore more necessary than ever to adopt new mobility forms based on examples from other municipalities, and we found community car-sharing to be a suitable and acceptable model for Trnava. International practices show that car-sharing has the potential to reduce the adverse effects of individual automobile transport by improving vehicle utilization and providing better emission standards for shared vehicles. This can be seen, for example, in the introduction of low-emission zones in European cities, which restrict vehicle access to certain urban areas.

Car-sharing also contributes to fulfilling the EU's strategic goal of intelligent and sustainable mobility for 2021, which includes changing consumer attitudes toward vehicle ownership. In Slovakia, the trend is to own a private car, with fewer economical and ecological alternatives available. An essential factor for the successful implementation of car-sharing is building the necessary infrastructure and providing financial assistance to local governments and car-sharing companies.

To assess the feasibility of introducing a new form of transportation in the regional city of Trnava, we used a questionnaire focused on transportation behavior and residents' attitudes toward car-sharing. The results revealed that 90% of respondents own a car in their household, with a majority owning more than one car, which predisposes them to use new alternative transportation forms.

In conclusion, we believe that car-sharing in Trnava can develop into a real service if the right provider is chosen, the local government supports it, and the necessary infrastructure is built, along with the proper setting of vehicle usage fees and user benefits. Based on the statements of Mr. Haník and the evaluation of the survey and Trnava's situation, we believe that community car-sharing among Trnava residents can be implemented in the near future, with active cooperation from the local government to establish acceptable conditions for the service from the perspective of the users.

## REFERENCES

- Bubla, P. (2019, October 10). Bratislava is not among the smart cities, people criticized traffic jams and the acceptance of foreigners. SITA. <https://www.webnoviny.sk>
- City of Trnava (2021). Sustainable Mobility Plan of the City of Trnava. [https://portal.trnava-vuc.sk/documents/10180/3848338/PUM\\_Trnava\\_Zber\\_final/eeb8cb64-1221-4e0d-9aaf-98667bfc1ef7?version=1.0](https://portal.trnava-vuc.sk/documents/10180/3848338/PUM_Trnava_Zber_final/eeb8cb64-1221-4e0d-9aaf-98667bfc1ef7?version=1.0)
- Cohen, B. (2018, May 1). Blockchain Cities and the Smart Cities Wheel. <https://boydcohen.medium.com/blockchain-cities-and-the-smart-cities-wheel-9f65c2f32c36>
- Hučková, M., & Martin, S. (2017). Support for innovative solutions in Slovak cities. Bratislava.
- Kuník, T. (2020, August 19). The city of Trnava has almost completely electrified its vehicle fleet. Môjelektromobil.sk. <https://www.mojelektromobil.sk/mesto-trnava-elektrifikovany-vozovy-park/>
- Litman, T. (2000). Evaluating carsharing benefits. *Transportation Research Record*, 1702(1), 31-35. <https://doi.org/10.3141/1702-04>
- Mohanty, S. P., Choppali, U., & Kougianos, E. (2016). Everything you wanted to know about smart cities: The Internet of things is the backbone. *IEEE Consumer Electronics Magazine*, 5(3), 60-70. <https://doi.org/10.1109/MCE.2016.2556879>
- Pauhofová, I., Staněk, P., & Stehlíková, B. (2019). SMART REGIONS in the Slovak Republic: Possibilities and Reality. Wolters Kluwer: Prague. ISBN 978-80-7598-418-0
- Ruengchinda, Z. (2021, April 29). Nordic cities amongst top 50 Smart City Governments. SCANDASIA. <https://scandasia.com/nordic-countries-are-amongst-top-50-smart-city-governments-ranking/>
- Sehmi, G. S., & Serriera, J. M. (2019, October 10). Sustainable mobility in cities: No way forward without public transport. <https://blogs.worldbank.org/transport/sustainable-mobility-cities-no-way-forward-without-public-transport>
- Stiftung, H. B. (2021). Facts and Figures about Transport and Mobility in Europe. European mobility atlas. [https://eu.boell.org/sites/default/files/2021-02/EUMobilityatlas2021\\_FINAL\\_WEB.pdf](https://eu.boell.org/sites/default/files/2021-02/EUMobilityatlas2021_FINAL_WEB.pdf)
- Stiftung, R. (2019, September 24). The number of registered vehicles in the Trnava district has almost doubled since 2000. Trnava-live.sk. <https://www.trnava-live.sk/2019/09/24/pocet-evidovanych-vozidiel-v-okrese-trnava-sa-od-roku-2000-takmer-zdvojnasil/>
- Smart City Index (2021). Evaluation of the municipality of Trnava. <https://intelligentnemesta.sk/meet-the-team-kontakt/>
- Statistical Office of the Slovak Republic (2022, October 11). [http://datacube.statistics.sk/#!/view/sk/vbd\\_dem/om7007rr/v\\_om7007rr\\_00\\_00\\_00\\_sk](http://datacube.statistics.sk/#!/view/sk/vbd_dem/om7007rr/v_om7007rr_00_00_00_sk)
- Žárska, E., & Papcunová, V. (2007). Municipal Economy and Policy. Bratislava: Ekonóm. ISBN 978-80-225-2293-9.





## THE RELATIONSHIP BETWEEN BURNOUT AND MENTAL WELL-BEING OF OLDER PEOPLE

Rita Remeikienė\*, Rusnė Katerina Jančaitytė, Beatričė Rūškienė

*Mykolas Romeris University, Lithuania*

**Abstract:** The risk of burnout in older people is increased by various factors, such as chronic diseases, their treatment, emotional stress, loss of a loved one, loss of mobility and independence, and financial problems. In addition, personal habits, such as lack of sleep and poor nutrition, as well as stress at work or social isolation, can lead to the development of burnout. Aging is often associated with poorer mental well-being of older adults who tend to lose their life purpose, autonomy, and disregard personal growth. Nevertheless, positive emotions, a sense of happiness, and social support can help maintain or even improve the well-being of older people. In order to improve mental well-being, it is important to promote social support, lifelong learning, and self-compassion. These factors can reduce the risk of burnout and improve the quality of life of older people. The purpose of this article is to examine the relationship between burnout and mental well-being of people aged 60 and older.

**Keywords:** older people, burnout, mental well-being, healthy aging, stress.

### 1. INTRODUCTION

Longer life expectancy is a great achievement of humanity. The number of older people is growing, and this part of population is becoming increasingly important both for the economy and communities. The major demographic indicator representing aging trends is the share of older people in society (Gustainienė & Banevičienė, 2014). The well-being of older people is becoming an extremely relevant topic in the context of modern life. The vast majority of developed countries are encountering the problem of population aging. This process is particularly rapid in Lithuania (Eurostat, 2019). The radical demographic developments prompt the adoption of social policy measures aimed at improving the well-being of older people (STRATA, 2020).

The annual report by the National Health Council (Gurevičius & Jaselionienė, 2012, p. 14) proposes that the pursuit of healthy aging should be the major objective. Healthy aging is defined as a state in which a person's mental, social, and physical functions are optimally maintained.

---

\* Corresponding author: [rita.remeikiene@mruni.eu](mailto:rita.remeikiene@mruni.eu)

Rita Remeikienė, ORCID: 0000-0002-3369-485X  
Rusnė Katerina Jančaitytė, ORCID: 0009-0006-6390-9758  
Beatričė Rūškienė, ORCID: 0009-0005-6884-3383



The experience of burnout, which attracted the attention of researchers and practitioners as early as the 1970s, is now recognized as a significant social problem. Over the past decade, various theoretical models have been developed and studies have been conducted to better understand the causes and consequences of this dysphoria. Many previous studies analysed the situation in the public sector, especially the fields of health care and education, i.e. the ones characterised by the intense personal and emotional contact between participating subjects. Nevertheless, researchers note that the stressors which lead to burnout may vary among individuals of different occupations and ages.

In aging society, older people are likely to face different challenges, such as the generation gap, digital divide, fast pace of life, the need to work after retirement age to earn higher income, health problems, etc. (Mikulionienė et al., 2018). These factors can increase the risk of burnout in older people, and therefore reduce their mental well-being. Batsis et al. (2021) and Lee (2000) note that mental health problems, which tend to worsen with a person's age, deserve close attention from scientists and researchers, as they are significantly correlated with mortality rates.

Burnout, accompanied by constant stress and exhaustion, can greatly damage a person's mental well-being, making this person feel isolated, frustrated, restless, and depressed. The ignorance of the symptoms of burnout can lead to serious mental health problems, such as anxiety, depression, or even eating disorders. Therefore, it is very important to understand what burnout refers to, reduce its risk, and take measures to promote mental well-being.

When it comes to older people, it is usually assumed that older age is accompanied by the activation of destructive processes and a decrease in adaptive abilities (Kovalenko & Spivak, 2018). However, according to Ryff (2013), when conducting interdisciplinary scientific research, it is appropriate to treat individuals of mature age as striving, value delivering, proactive, able to deal with life challenges. Many scientific studies (Ong et al., 2011; Ong & Mroczek, 2010; Lee, 2020; Smith, 2023; Sun, 2023, etc.) confirm the influence of mental well-being on a person's physical health.

Earlier scientific studies, addressing the problems of burnout, were largely focused on burnout at work (Bakker & Schaufeli, 2000; Johnson et al., 2017) and society (Hobfoll & Freedy, 1993; Farber, 2000; Maslach & Leiter, 2016, etc.), as well as the links between burnout and a person's age (Hochschild, 1983; Urry & Gross, 2010; Scheibe & Zacher, 2013; Doerwald et al., 2016, etc.), while studies in the field of well-being of older people mainly examined the elements of hedonic (Ermolayeva, 2002; Clark et al., 2012; Kumar, 2015; Tavares, 2022; Sun, 2023) and eudaimonic (Ryff & Keyes, 1995; Lachman et al., 2008; Siedlecki et al., 2008; Ward, 2010; Keyes & Westerhof, 2012; Vazonienė, 2014; Homan, 2016; Moilanen et al., 2020; Lee, 2020; Heide, 2022; Smith, 2023, etc.) well-being which can affect the mental well-being of older adults. Nevertheless, scientific literature lacks the studies that would reveal the relationship between burnout experienced by older people and their mental well-being, given that mental well-being is particularly important in reducing the risk of chronic diseases and extending life expectancy. In other words, previous studies mainly focus on analysing the problems of older people in the labour market, but the problem of burnout remains under researched.

**The major purpose** of this research is to examine the relationship between burnout and mental well-being of people aged 60 and older.

The research is based on the method of *comparative literature analysis*. An older person is defined by the United Nations (2019) as a person who is over 60 years of age. In Lithuania, persons who are over 60 years of age are categorized as the target group of older people, to whom healthy lifestyle services and other preventive health care services are directed (Office

of the Equal Opportunities Ombudsperson, 2023). In accordance with the categorizations provided above, this research considers older people to be those aged 60 years and older.

## 2. LITERATURE REVIEW

### 2.1. The relationship between burnout and a person's age

Burnout is an important problem from both an individual and organisational perspective (in the case of working older people) since it has been found to cause physical and mental health problems (Ahola et al., 2005; Honkonen et al., 2006) (an individual aspect) and lead to a lower capacity to work (if a person is still working, the number of days of sick leave tends to increase) (an organizational aspect) (Ahola et al., 2008).

The literature analysis revealed that the major elements related to older age that can increase the risk of burnout in older people are diseases and their treatments, emotional stressors, personal habits, stress at work (for working older people), and being in a group (see Table 1).

*Table 1.* Analysis of the relationship between burnout elements and older age

Elements	Research results	References
Diseases	Burnout in older age can be caused by medical problems and their treatments	“Vinmec”, 2019; Corretge, 2023; National Institute on Aging, 2023
Emotional stressors	Worries about health, caregiving, loss of a loved one, loss of mobility and independence, stress due to financial and personal problems, and a sense of losing control over one’s life raise the risk of burnout	“Vinmec”, 2019; National Institute on Aging, 2023
Personal habits	Lack of sleep, excessive consumption of caffeine, chocolate, alcohol, fatty and sugary foods, low physical activity, and avoidance of social and productive activities can lead to a constant feeling of lack of energy, and thus increase the risk of burnout.	Freudenberger, 1974; “Vinmec”, 2019; Malik et al., 2022; National Institute on Aging, 2023
Stress at work	The need to adapt to rapidly changing technologies and work environments, reduced stamina, long hours, physically demanding tasks, inflexible schedules, isolation from retired peers can lead to exhaustion, physical health problems, and burnout	Nubling et al., 2010; Vinstrup et al., 2021; Malik et al., 2022; Williams, 2023
Being in a group	Indirect influence on a person’s burnout made by a team manifests itself through autonomy, support, and response to the person’s needs.	Bakker et al., 2003

Source: compiled by the authors.

**Diseases.** When an elderly person becomes tired, this tiredness is usually attributed solely to the aging process. Indeed, it is important to accept the aging process, since an older person will never be as energetic as a young one. However, exhaustion and burnout can be caused not only by the natural course of the aging process, but also by diseases and their treatments (Corretge, 2023). According to the National Institute on Aging (2023), exhaustion and burnout in older people can be caused by medical problems and their treatments. Medical problems include various infections, chronic diseases (diabetes, heart, kidney, liver, thyroid diseases, rheumatoid arthritis, chronic obstructive pulmonary disease, cancer, fibromyalgia, anaemia, stroke, Parkinson's disease), sleep apnoea and other sleep disorders, intractable pain, etc. Treatments include chemotherapy and radiation, recovery from major surgery, antidepressants, antihistamines, anti-nausea and pain medications, etc. (Vinmec, 2019; National

Institute on Aging, 2023). Due to the factors mentioned above, a person may stop being active, become apathetic, have a bad mood, and lose appetite (Corrette, 2023).

**Emotional stressors.** Exhaustion and burnout in older people can be caused by worries and doubts, concerns about health and caregiving, loss of a loved one, loss of mobility and independence, stress due to financial and personal problems, and a sense of loss of control over one's life. These stressors can lead to anxiety, depression, and grief, which tend to increase the risk of burnout (Vinmec, 2019; National Institute on Aging, 2023).

**Personal habits.** As noted by Freudenberg (1974), individual characteristics are also explanatory factors of burnout. Some individuals have expectations and habits that generate greater activity load; thus, these individuals are at greater risk of burnout (Malik et al., 2022). Personal habits, such as little sleep, intensive consumption of caffeine, chocolate, alcohol, fatty, sugary foods, lack of physical activity, avoidance of social and productive occupations (boredom, laziness) can lead to a constant feeling of fatigue, lack of energy, and thus increase the risk of burnout (National Institute on Aging, 2023).

**Stress at work.** Stress at work can have a significant negative impact on the mental well-being of vulnerable groups, such as older people. As people tend to live longer and retirement ages are increasing, a significant proportion of people are working into their later years. While this can be a significant economic support, working into older age can be associated with a number of challenges, including burnout. One of the direct drivers of such burnout is the need to adapt to rapidly changing technologies and work environments. This leads to frustration and stress. In addition, older people may no longer have the same resilience as their younger colleagues. Long working hours, demanding tasks, and inflexible schedules can lead to exhaustion and physical health problems, which, in their turn, raise the risk of burnout (Williams, 2023). Social isolation is another significant factor. When older people's peers retire and they continue working, this can lead to the feelings of isolation, loneliness, and emotional exhaustion (Williams, 2023). Malik et al. (2022) researched the relationship between work-related stress, health and mental well-being among working older people. By following the multivariate modelling approach, the authors found that work-related stress is significantly associated with social, economic, physical, and mental health risks in working older people. Their study also disclosed that women are at higher risk of work-related stress than men, and affluent individuals experience less work-related stress. Stress at work was found to be a common problem, which is exacerbated by the work-related, health, and socio-economic vulnerability of older people. The authors also argue that work-related stress affects the mental well-being of older people through its negative impact on productivity and job opportunities. The effects of age as a factor of the mental well-being of working people were also confirmed by Nubling et al. (2010), Vinstrup et al. (2021), and other researchers.

**Being in a group.** Bakker et al. (2003) examined how burnout is affected by being in a team (socialisation). Taking into account the direct and indirect factors which can cause burnout, the authors propose a model based on the hypothesis that burnout is directly affected by the constant presence in the same group of people (a team). A team can indirectly affect the risk of burnout through a person's autonomy, support, and response to personal needs. If a person has sufficient autonomy, receives support, and his or her needs are recognised, then the risk of burnout is very low, and vice versa. If burnout develops, the person is likely to dissocialise and leave the team (absenteeism).

Nevertheless, the results of many previous studies, focused on the relationship between a person's age and burnout, are conflicting. Schaufeli and Enzmann (1998), and Maslach et al. (2001), who analysed the relationship between a person's age and burnout in the service sector, found that burnout tends to decrease with age, while some general population studies on the relationship between burnout and age show opposite trends. For instance, the studies by

Kalimo (2000) and Ahola et al. (2006), who examined the Finnish population samples (young adults were not included in the study samples), revealed the positive correlation between a person's age and burnout, i.e. the results propose that burnout levels tend to increase with a person's age. The investigation by Lindblom et al. (2006) of the population in one region of Sweden disclosed that older but still employed individuals had higher burnout rates than middle-aged employed individuals. This trend was not observed among young workers, which led to the conclusion that the relationship between a person's age and burnout is not linear (Lindblom et al., 2006).

Hochschild (1983), however, noticed that a person's age is positively related to emotion management, i.e. the author suggests that older individuals are better able to manage their emotions. They are able to use various emotion regulation strategies which can help preserve available mental resources. These insights were confirmed by Doerwald et al. (2016), whose literature review implies that age provides a small but noticeable advantage in the area of a person's emotional competencies. Scheibe and Zacher (2013) explain that emotional competencies motivate to avoid extremely stressful situations or at least limit the number of such situations, since constant deep stress can harm a person's physiological flexibility and cognitive abilities. According to the Socioemotional Selectivity Theory (SST), when a person realizes that his/her life expectancy is getting shorter, the points of concentration change: instead of concentrating on acquiring the knowledge and information which may affect the future, the person focuses on his/her emotional state and the meaning of phenomena. Aging tends to strengthen a person's emotional control and provides the variety of control measures (Urry & Gross, 2010). All of this reduces the risk of mental burnout in older people.

In summary, the major age-related factors which can increase the risk of burnout in older people are chronic illnesses and their treatments, emotional stressors (worries and doubts, loss of a loved one, loss of mobility and independence, stress due to financial and personal problems, and a sense of loss of control over one's life), personal habits leading to lack of sleep and poor nutrition, stress at work (for working older people), and being in a group which can indirectly affect the risk of burnout through a person's autonomy, support, and response to personal needs. However, the results of previous scientific studies on the relationship between a person's age and burnout are contradictory: some studies find a positive correlation between a person's age and the level of burnout, while others emphasize the decreasing risk of burnout due to stronger emotional control in older age.

## **2.2. The relationship between mental well-being and a person's age**

There is a wide range of factors which can affect the mental well-being of older people. Not all scientific studies confirm that older age is associated with lower mental well-being, as is often stereotypically believed. For instance, Keyes (2002) found that mental well-being can increase with a person's age, education, extraversion, and conscientiousness, but can decrease with neuroticism. The findings that the problems of mental well-being are often observed in people of all ages experiencing depression, neurosis, and hopelessness were also confirmed by Korniyenko (2014) (see Table 2).

*Happiness.* Sun (2023) found a positive relationship between happiness and mental well-being in older people. Kumar (2015) conducted a survey of 60 respondents over the age of 60 which revealed that there is a significant positive relationship between subjective happiness and mental well-being, and the results of the regression analysis disclosed that happiness is one of the predictors of mental well-being. According to Zeidner et al. (2016), happiness is even a necessary condition for mental well-being of individuals. Happiness as a personal feeling is an essential component of the daily life of older people. It affects a person's

choices, actions, and the ability to exploit opportunities (Sun, 2023). Having conducted the analysis of 63 scientific studies, Mhaske (2017) concluded that highly successful older people are characterised by high levels of happiness, a positive attitude towards life, and life satisfaction.

Table 2. Analysis of the relationship between mental well-being elements and older age

Elements	Research results	References
<b>Hedonistic well-being</b>		
Happiness	Significantly directly correlates with mental well-being and is its predictive factor; an important component of daily life	Kumar, 2015; Zeidner et al., 2016; Mhaske, 2017; Sun, 2023
Positive emotions	Has a significant positive impact on a person's health throughout adulthood and beyond; is one of the factors for predicting life expectancy and mortality	Charles et al., 2001; Ong and Mroczek, 2010; Carstensen et al., 2011; Ong et al., 2011
Life satisfaction	Can increase with age under particular external and internal conditions, and with hope	Clark et al., 2012; Ermolayeva, 2002; Tavares, 2022; Ozdemir et al., 2023
<b>Eudaemonic well-being</b>		
Self-acceptance	It is driven by crystallized intelligence, self-compassion, and acceptance of imperfection; the influence of subjective aging is debatable	Ryff and Keyes, 1995; Lachman et al., 2008; Siedlecki, 2008; Ward, 2010; Keyes and Westerhof, 2012; Kozmina, 2013; Melekhin, 2015; Homan, 2016
Environment management	A highly sensitive dimension of mental well-being; helps develop coping strategies for current and future challenges; can increase with age	Ryff and Keyes, 1995; Knight et al., 2011; Bar-Tur, 2021; Buratta et al., 2023
Having positive relationships	The ability to maintain trust-based, constructive relationships, use adaptive behavioural strategies; the importance of family support; altruistic activity on the Internet	Ryff and Keyes, 1995; Kostenko, 2005; Pavlotskaya, 2014; Vazonienė, 2014; Kovalenko and Spivak, 2018; Zheng et al. 2018
Personal growth	It is slow in older age, but can be stimulated by autobiographical memoirs, stories of life changes and the most important life goals, education, and involvement in favourite/desired activities	Ryff, 1991; Clarke et al., 2000; Bauer and McAdams, 2004; Kostenko, 2005; Gladman, 2019
Life purpose	The sense of purpose in life tends to weaken with age; maintaining life goals and preventing their loss tend to increase mental well-being, and vice versa	Ermolayeva, 2002; Ebner et al., 2006; Bel'sky, 2010; Irving, 2024
Autonomy	The ability to make choices and decisions; it enhances mental well-being through the promotion of health and quality of life	Moilanen et al., 2020; Lee, 2020; Heide, 2022; Smith, 2023

Source: compiled by the authors.

*Positive emotions.* In a general sense, positive emotions are defined as a state of pleasant feeling (Fredrickson, 2004). The study by Charles et al. (2001) disclosed that despite the decline of cognitive resources in older age, the ability to experience positive emotions remains relatively stable throughout a person's life. Ong et al. (2011) found that positive emotions have a positive impact on a person's health throughout adulthood. Only the physiological expression and the optimal level of positive emotions may vary. Carstensen et al. (2011) found that a person's net positive emotional experience, obtained by subtracting the average of negative emotions from the average of positive emotions, is one of the predictors of life expectancy. Ong and Mroczek (2010) estimated that individuals with a net positive emotional experience rate of 2 or higher live longer and have lower mortality rates than individuals with a correspondingly lower rate.

*Life satisfaction.* Clark et al. (2012) note that the relationship between life satisfaction and age is best represented by an inverted U-shaped curve, which indicates that young and older adults have the highest levels of mental well-being compared to middle-aged adults. Tavares (2022) agrees with this finding only if adjusting factors – a person's health, income, and lifestyle – are taken into account. Having surveyed 1,383 people aged 65 and over, Ozdemir et al. (2023) found that mental well-being of the respondents was significantly correlated with their life satisfaction and hope. Ermolayeva (2002) indicates the determinants of life satisfaction in older people: life satisfaction is associated with the meaning of life for others (reflection on the meaning of life), the seniors' own assessment of the meaning of life, having a life goal, and the time perspective to connect the past, present, and future. The second group of life satisfaction determinants includes external and internal life conditions of a person. External conditions include physical living conditions, (in)sufficiency of resources, (absence of) physical and moral support, while internal life conditions include anxiety (e.g. anxiety about health, deterioration of appearance), nervous state, etc.

*Self-acceptance.* Siedlecki et al. (2008) links the mental well-being of seniors to crystallized intelligence, which is contrasted with fluid intelligence, observed in young people. Crystallized intelligence means that an older person's thoughts and opinions are already clear and established, and the person accepts many aspects of their personality, which has a positive impact on their mental well-being. Kristin J. Homan (2016) emphasises the importance of the self-compassion factor in the situations where a person's adequacy is threatened, as well as the importance of the imperfection acceptance factor, when a person realizes that imperfection is part of being human. The author's survey of 121 older people in a community library and a senior day centre revealed that the abovementioned factors have a positive impact on the mental well-being of seniors. Keyes and Westerhof (2012) investigated how older adults feel and how they would ideally like to feel. Their study found that greater well-being in older adults can be associated with feeling younger, but not with expecting to become younger. Similar results were obtained by Ward (2010): greater mental well-being is observed in older adults who feel younger than they actually are (subjective aging). This view is supported by Melekhin (2015), who argues that individuals who identify themselves as younger (positive cognitive age illusion) are more prosperous and happier in old age. According to Kozmina (2013), subjective aging affects a person's mental well-being, as it is part of self-concept.

However, the finding that subjective aging affects the social well-being of older individuals contradicts the results of the study by Lachman et al. (2008), who state that greater realism and fewer illusions lead to better functioning of an individual, including their mental well-being. The results of the study by Ryff and Keyes (1995) are neutral: they show that self-acceptance is constant across all age periods, so there is no evidence that it could significantly affect the mental well-being of older individuals.

*Environment management.* Bar-Tur (2021) treats environment management as a positive factor in aging (this approach is proposed for improving the skills and strategies used by older people to cope with current and future challenges). According to Buratta et al. (2023), environment management and self-acceptance are the most sensitive dimensions of mental well-being in older age. The study by Ryff and Keyes (1995) implies that environment management and self-reliance tend to improve with age.

Conversely, after surveying 96 people aged 64-98, Knight et al. (2011) found that 49 percent of the identified cases of depression among respondents were associated with a low level of environment management. The survey of 243 adults by Buratta et al. (2023) showed that education, self-esteem, and self-control can strengthen environment management skills.

*Having positive relationships.* The results by Ryff and Keyes (1995) show that positive relationships with other people are constant across all age groups. Pavlotskaya (2014) confirms

that the ability to maintain trust-based, constructive relationships with others and use adaptive communication strategies are the factors that are important for the mental well-being of older people, and conversely, an increasing level of communication control negatively affects their mental well-being. Similar results were obtained by Kovalenko and Spivak (2018) who surveyed 325 persons (an average age of 67.2): the survey revealed that socially active seniors tend to have a higher level of mental well-being than lonely seniors who lack communication. Vazonienė (2014) emphasises the importance of strong social ties and family support, especially in the context of personal care. Meanwhile, the study by Kostenko (2005) shows that close relationships with other people are significant even for people living in nursing homes. Zheng et al. (2018) find that altruistic activity on the Internet positively affects the mental well-being of seniors.

The "Silver Line", active in Lithuania, promotes communication among lonely and elderly people. In May 2024 alone, volunteers responded to 3,082 calls, which helped reduce the feeling of loneliness in older people through communication.

*Personal growth.* Clarke et al.'s (2000) research revealed that older adults tend to report higher levels of purposefulness, personal growth, and vulnerability compared to younger and middle-aged adults. Personal growth is usually intense in young people, but tends to slow with aging. Having surveyed respondents of different age, Ryff (1991) found that younger and middle-aged adults believed they would improve over time, while older adults expected their mental well-being to deteriorate in the coming years. Ryff and Keyes (1995) imply that the intensity of personal growth among older adults tends to decrease, while Kostenko (2005) reports a positive effect of education and engagement in desirable activities on the mental well-being of seniors living in nursing homes. In addition, autobiographical memoirs, life transition stories (Bauer & McAdams, 2004), and stories about major life goals (Bauer & McAdams, 2004) can promote greater mental well-being in older adults through the personal growth factor. Gladman (2019) believes that personal growth is possible even in the face of physical and social losses (e.g. physical and mental disabilities) since it includes not only the initiation of new activities, but also the acceptance of experienced losses and illness, and the development of a sense of life achievement.

*Life purpose.* Ebner et al. (2006) researched the changes in a person's goal orientation from early to late adulthood and found that maintaining goals and preventing loss of goals are associated with greater mental well-being, and vice versa. Nevertheless, according to Ermolayeva (2002), the belief that they are implementing their life plans and receiving the results of their efforts raises the satisfaction with life in older people, and therefore promotes their mental well-being. Irving (2024) argues that the purpose of life includes the desire to live, assumption of certain roles and responsibilities, carrying out a chosen routine, as well as personal activeness, independence, faith, and spirituality. The researcher's qualitative survey of 40 people, aged 68-96, showed that having a life purpose can lead to significant positive modifications of a person's mental well-being through stimulating the sense of awareness and usefulness. The study by Bel'sky (2010) revealed that those seniors who, in their opinion, are engaged in meaningful activities, i.e. the activities that have value for them, tend to maintain a higher level of mental well-being and often retain their professional identity.

*Autonomy.* Moilanen et al. (2020) treat the autonomy perceived by an older person as the ability to make his or her own choices. Autonomy is associated with individual capabilities, independence, physical and mental competence, personal characteristics, and support from relatives. The researchers found that autonomy positively contributes to a person's mental well-being by promoting health and quality of life. Smith (2023) notes that maintaining the sense of autonomy is a significant factor in life satisfaction for older people since people feel that they can make decisions, choose how, where, when and with whom they want to spend time. Lee

(2020) argues that the autonomy of an older person includes the recognition of their wishes and decision-making abilities. This view is supported by Heide (2022) who adds that autonomy also means leaving a person the chance to make mistakes (e.g. fall).

In summary, the literature analysis revealed that all elements of hedonic and eudaimonic well-being are significantly correlated with mental well-being in older adults. Aging is often associated with a decline in life purpose, environment management skills, personal growth, and autonomy, which leads to poorer mental well-being in older adults. Since these factors are most problematic, the targeted intervention strategies should be directed at their positive change. Meanwhile, the sense of happiness, satisfaction with life, the ability to have positive emotions, self-acceptance through crystallized intelligence, and having positive relationships can remain constant at all stages of a person's life, which significantly contributes to mental well-being. Those individuals who feel younger, but do not aspire to be younger, are characterised by greater mental well-being, although realism rather than illusory self-assessment is also a determinant of greater mental well-being of older people. The level of mental well-being tends to change when a person overcomes life challenges and has a flexible self-perception. Kovalenko and Spivak (2018) note that when pursuing mental well-being, it is important to neutralize the influence of destructive factors, and ensure harmonious and optimal activeness for seniors.

### **3. CONCLUSION**

The main older-age related elements which can increase the risk of burnout are as follows: chronic illnesses and their treatments; emotional stressors, such as worries and doubts, loss of a loved one, loss of mobility and independence, stress due to financial and personal problems, a sense of loss of control over one's life; personal habits leading to a lack of sleep and poor nutrition; stress at work (for working older people); being in a group, which can indirectly affect burnout through autonomy, support, and responsiveness to one's needs.

All elements of hedonic and eudaimonic well-being are significantly correlated with the mental well-being of older people. Aging is often associated with a decline in one's life purpose, environment management skills, personal growth, and autonomy, which leads to poorer mental well-being of older adults. Meanwhile, a sense of happiness, life satisfaction, the ability to have positive emotions, self-acceptance through crystallized intelligence, and having positive relationships under optimal conditions can remain constant at all stages of a person's age, which promotes mental well-being. When pursuing mental well-being, it is important to neutralize the influence of destructive factors, and ensure harmonious and optimal activeness for seniors. The major factors which can affect the direction of the relationship between burnout and mental well-being in older persons are social support, lifelong learning, self-compassion, organisational justice, health, and stable, sufficiently high income. This means that the factors mentioned above can reduce burnout in older people, and thus improve their mental well-being.



## REFERENCES

- Ahola, K., Honkonen, T., Isometsä, E., Kalimo, R., Nykyri, E., Aromaa, A., & Lönnqvist, J. (2005). The relationship between job-related burnout and depressive disorders - results from the Finnish Health 2000 Study. *Journal of Affective Disorders*, 88, 55–62. <https://doi.org/10.1016/j.jad.2005.06.004>
- Ahola, K., Honkonen, T., Isometsä, E., Kalimo, R., Nykyri, E., Koskinen, S., Aromaa, A., & Lönnqvist, J. (2006). Burnout in the general population. Results from the Finnish Health 2000 Study. *Social Psychiatry and Psychiatric Epidemiology*, 41, 11–17. [10.1007/s00127-005-0011-5](https://doi.org/10.1007/s00127-005-0011-5)
- Ahola, K., Honkonen, T., Virtanen, M., Aromaa, A., & Lönnqvist, J. (2008). Burnout in relation to age in the adult working population. *Journal of Occupational Health*, 50(4), 362–365. <https://doi.org/10.1539/joh.M8002>
- Bakker, A. B., & Schaufeli, W. B. (2000). Burnout contagion process among teachers. *Journal of Applied Social Psychology*, 30, 2289–2308. <https://doi.org/10.1111/j.1559-1816.2000.tb02437.x>
- Bakker, A. B., Demerouti, E., & Schaufeli, W. B. (2003). The socially induced burnout model. In S. P. Shohov (Eds.), *Advances in Psychology Research* (pp. 45–62). Nova Science Publishers. <https://www.wilmarschaufeli.nl/publications/Schaufeli/205.pdf>
- Bar-Tur, L. (2021). Fostering well-being in the elderly: Translating theories on positive aging to practical approaches. *Frontiers in Medicine*, 8, 517226. <https://doi.org/10.3389/fmed.2021.517226>
- Batsis, J. A., Daniel, K., Eckstrom, E., Goldlist, K., Kusz, H., Lane, D., Loewenthal, J., Coll, P. P., & Fiendman, S. M. (2021). Promoting healthy aging during COVID-19. *Journal of the American Geriatrics Society*, 69, 572–580. <https://doi.org/10.1111/jgs.17035>
- Bauer, J. J. & McAdams, D. P. (2004). Personal Growth in Adults' Stories of Life Transitions. *Journal of Personality*, 72(3), 573–602. <https://doi.org/10.1111/j.0022-3506.2004.00273.x>
- Bel'sky, M. (2010). Sotsialno-psikhologicheskiye faktory udovletvorennosti zhiznyu russkoyazychnykh pozhilykh emigrantov (na primere Germanii). [Socio-psychological factors of life satisfaction of Russian-speaking elderly immigrants (on the example of Germany)]. (Unpublished PhD thesis, St. Petersburg State University)
- Buratta, L., Delvecchio, L., Mazzeschi, C. (2023). Environmental Mastery and Self-Acceptance during Emerging Adulthood: A Study of the Determinant Factors in College Students. *Journal of Positive Psychology & Wellbeing* 7 (4), 407–418.
- Carstensen, L. L., Turan, B., Scheibe, S., Ram, N., Ersner-Hershfield, H., Samanez-Larkin, R., Brooks, K. P., & Nesselroade, J. R. (2011). Emotional experience improves with age: evidence based on over 10 years of experience sampling. *Psychology and Aging*, 26, 21–33. <https://doi.org/10.1037/a0021285>
- Charles, S. T., Reynolds, C. A., & Gatz, M. (2001). Age-related differences and change in positive and negative affect over 23 years. *Journal of Personality and Social Psychology*, 80, 136–151. <https://doi.org/10.1037/0022-3514.80.1.136>
- Clark, A. E., Layard, R., & Senik, A. E. (2012). The causes of happiness and misery. In J. Helliwell, R. Layard & J. Sachs (Eds.), *World Happiness Report* (pp. 59–89). The Earth Institute. <https://www.earth.columbia.edu/sitefiles/file/Sachs%20Writing/2012/World%20Happiness%20Report.pdf>
- Clarke, P. J., Marshall, V. W., Ryff, C. D., & Rosenthal, C. J. (2000). Well-being in Canadian seniors: findings from the Canadian study of health and aging. *Canadian Journal on Aging*, 19, 139–159. <https://doi.org/10.1017%2FS0714980800013982>
- Corretge, M. (2023). What are the causes of fatigue in older adults? <https://www.topdoctors.co.uk/medical-articles/what-are-the-causes-of-fatigue-in-older-adults>
- Doerwald, F., Scheibe, S., Zacher, H., & Van Yperen, N. W. (2016). Emotional competences across adulthood: state of knowledge and implications for the work context. *Work, Aging and Retirement*, 2(2), 159–216. <https://doi.org/10.1093/workar/waw013>

- Ebner, N. C., Freund, A. M., Baltes, P. B. (2006). Developmental changes in personal goal orientation from young to late adulthood: from striving for gains to maintenance and prevention of losses. *Psychol Aging*, 21(4), 664-78. <https://doi.org/10.1037/0882-7974.21.4.664>
- Ermolayeva, M. (2002). *Prakticheskaya psikhologiya starosti* [Practical psychology of old age]. Moscow: EKSMO-Press.
- Eurostat. (2019). Ageing Europe – 2019 edition. Looking at the lives of older people in the EU. Publications Office of the European Union. <https://ec.europa.eu/eurostat/documents/3217494/10166544/KS-02-19-681-EN-N.pdf/c701972f-6b4e-b432-57d2-91898ca94893?t=1631631350686>
- Farber, B. A. (2000). Introduction: understanding and treating burnout in a changing culture. *Psychotherapy in Practice*, 56, 589-594. [https://doi.org/10.1002/\(SICI\)1097-4679\(200005\)56:5<589::AID-JCLPI>3.0.CO;2-S](https://doi.org/10.1002/(SICI)1097-4679(200005)56:5<589::AID-JCLPI>3.0.CO;2-S)
- Fredrickson, B. L. (2004). The broaden-and-build theory of positive emotions. *Philosophical Transactions of the Royal Society of London: Biological Sciences*, 359, 1367–1377. <https://doi.org/10.1098/rstb.2004.1512>
- Freudenberger, H. J. (1974). Staff burnout. *Journal of Social Issues*, 30, 159-165. <https://doi.org/10.1111/j.1540-4560.1974.tb00706.x>
- Gladman, J. R. F. (2019). Personal growth and development in old age—a clinician’s perspective. *Age and Aging*, 48(1), 8-10. <https://doi.org/10.1093/ageing/afy130>
- Gurevičius, R., & Jaselionienė, J. (2012). Lietuvos gyventojų sveikatos rodikliai ir senstančios visuomenės įtaka jų raidai [Health indicators of the Lithuanian population and the impact of the aging population on their development]. Nacionalinės sveikatos tarybos metinis pranešimas 2012. Sveikas senėjimas – nauji iššūkiai Lietuvai [Annual report of the National Health Council 2012. Healthy aging – new challenges for Lithuania]. <http://sveikatostaryba.lt/wp-content/uploads/2017/01/2012.pdf>
- Gustainienė, L. Banevičienė, V. (2014). Peculiarities of psychosocial factors and psychosocial adjustment in relation to sociodemographic factors among elderly people. *Social work*, 13 (2), 248-262.
- Heide, S. K. (2022). Autonomy, identity and health: defining quality of life in older age. *Journal of Medical Ethics*, 48(8), 353-356. <https://doi.org/10.1136/medethics-2020-107185>
- Hobfoll, S. E., & Freedy, J. R. (1993). Conservations of resources: a general stress theory applied to burnout. In W. B. Schaufeli, C. Maslach, & T. Marek (Eds.), *Professional burnout: recent development in theory and research* (pp. 115-129). London: Taylor & Francis.
- Hochschild, A. R. (1983). *The managed heart: the commercialization of feeling*. Berkeley: University of California Press.
- Homan, K. J. (2016). Self-compassion and psychological well-being in older adults. *Journal of Adult Development*, 23(4), 111-119. <https://link.springer.com/article/10.1007/s10804-016-9227-8>
- Honkonen, T., Ahola, K., Pertovaara, M., Isometsä, E., Kalimo, R., Nykyri, E., Aromaa, A., & Lönnqvist, J. (2006). The association between burnout and physical illness in the general population - results from the Finnish Health 2000 Study. *Journal of Psychosomatic Research*, 61, 59–66. <https://doi.org/10.1016/j.jpsychores.2005.10.002>
- Irving, J. (2024). Just Get Up and Get on. Purpose in Later Life. *Activities, Adaptation & Aging*, 1–23. <https://doi.org/10.1080/01924788.2024.2317013>
- Johnson, S. J., Machowski, S., Holdsworth, L., Kern, M., & Zapf, D. (2017). Age, emotion regulation strategies, burnout, and engagement in the service sector: advantages of older workers. *Revista de Psicología del Trabajo y de las Organizaciones*, 33(3), 205-216. <https://doi.org/10.1016/j.rpto.2017.09.001>
- Kalimo, R. (2000). The challenge of changing work and stress for human resources. The case of Finland. *Journal of Tokyo Medical University*, 58, 349–356.
- Keyes, C. L., & Westerhof, G. J. (2012). Chronological and subjective age differences in flourishing mental health and major depressive episode. *Aging & Mental Health*, 16, 67-74. & <https://doi.org/10.1080%2F13607863.2011.596811>

- Keyes, C. L., Shmotkin D., Ryff, C. D. (2002). Optimizing well-being: the empirical encounter of two traditions. *J Pers Soc Psychol.* 82(6), 1007-22.
- Knight, T., Davison, T. E., McCabe, M. P., & Melor, D. (2011). Environmental mastery and depression in older adults in residential care. Cambridge: Cambridge University Press.
- Korniienko, D. S. (2014). Lichnostnyye prediktory psikhologicheskogo blagopoluchiya. [Personal predictors of psychological well-being]. *Fundamentalnyye issledovaniya [Basic research]*, 11(2), 429-432.
- Kostenko, K. V. (2005). Subyektivnaya kartina zhiznennogo puti i udovletvorennost zhiznyu v pozdnem vozraste (na materiale prozhivayushchikh v domakh-internatakh). [The subjective picture of the life course and satisfaction with life in later life (on the material of those who live in boarding houses)]. (Unpublished PhD thesis, Kuban State University)
- Kovalenko, O. H., & Spivak, L. M. (2018). Psychological well-being of elderly people: the social factors. *Social Welfare Interdisciplinary Approach*, 1(8), 163-176. <https://doi.org/10.21277/sw.v1i8.323>
- Kozmina, L. B. (2013). Samootnosheniye i samootsenka kak prediktory psikhologicheskogo blagopoluchiya lichnosti studentov-psikhologov. [Self-attitude and self-evaluation as predictors of the psychological wellbeing of the personality of psychological students]. *Istoricheskaya i sotsialno-obrazovatel'naya mysl [Historical and social-educational thought]*, 1(17), 193-197.
- Kumar, M. V. (2015). Emotional expressivity, loneliness and subjective happiness as predictors of psychological wellbeing among the elderly. *Indian Journal of Health & Wellbeing*, 6(12), 1169-1173.
- Lachman, M. E., Röcke, C., Rosnick, C., & Ryff, C. D. (2008). Realism and illusion in Americans' temporal views of their life satisfaction: age differences in reconstructing the past and anticipating the future. *Psychological Science*, 19, 889-897. <https://doi.org/10.1111%2Fj.1467-9280.2008.02173.x>
- Lee, Y. (2000). The predictive value of self-assessed general, physical, and mental health on functional decline and mortality in older adults. *Journal of Epidemiology and Community Health*, 54, 23–129. <https://doi.org/10.1136/jech.54.2.123>
- Lee, J. (2020). Autonomy and Quality of Life for Elderly Patients. <https://journalofethics.ama-assn.org/article/autonomy-and-quality-life-elderly-patients/2008-06>
- Lindblom K.M., Linton S.J., Fedeli C., Bryngelsson I. L. (2006). Burnout in the working population: relations to psychosocial work factors. *Int J Behav Med.* 13(1), 51-59. [https://doi.org/10.1207/s15327558ijbm1301\\_7](https://doi.org/10.1207/s15327558ijbm1301_7)
- Malik, M. A., Singh, S. P., Jyoti, J., & Pattanaik, F., (2022, June 16). Work stress, health and wellbeing: evidence from the older adults labor market in India. *Humanities & Social Sciences Communications.* <https://www.nature.com/articles/s41599-022-01192-7>
- Maslach, C., & Leiter, M. P. (2016). Understanding the burnout experience: recent research and its implications for psychiatry. *World Psychiatry*, 15(2), 103-111. <https://doi.org/10.1002/wps.20311>
- Melekhin, A. I. (2015). Vospriyatiye i poznaniye vremeni v pozhilom i starcheskom vozraste [Perception and knowledge of time in elderly and senile age]. *Elektronnyy zhurnal Sovremennaya zarubezhnaya psikhologiya [Electronic Journal Modern Foreign Psychology]*, 4(2), 11-19.
- Mhaske, R. (2017). Happiness and Aging. *Journal of Psychosocial Research*, 12(1), 71-79.
- Mikulionienė, S., Rapolienė, G., & Valavičienė, N. (2018). Vyresnio amžiaus žmonės, gyvenimas po vieną ir socialinė atskirtis [Older people, living alone and social exclusion]. Lithuanian Social Research Centre. <https://www.lstc.lt/wp-content/uploads/2019/04/VIENAS1.pdf>
- Moilanen, T., Kangasniemi, M., Suhonen, R., Papinaho, O., Mynttinen, M., Siipi, H., & Suominen, S. (2020). Older people's perceived autonomy in residential care: an integrative review. *Nursing Ethics*, 28(3), 414-434. <https://doi.org/10.1177/0969733020948115>
- National Institute on Aging. (2023). Fatigue in older adults. <https://www.nia.nih.gov/health/fatigue/fatigue-older-adults>

- Nubling, M., Vomstein, M., Schmidt, S. G., Gregersen, S., Dulon, M., & Nienhaus, A. (2010). Psychosocial workload and stress in the geriatric care. *BMC Public Health*, 10(1), 1–12. <https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-10-428>
- Office of the Equal Opportunities Ombudsperson. (2023). Vyresnio amžiaus asmenų diskriminacija darbe [Discrimination against older people at work]. <https://lygybe.lt/wp-content/uploads/2023/12/Vyresnio-amziaus-asmenu-diskriminacija-darbe.pdf>
- Ong, A. D., & Mroczek, D. K. (2010). Aging, positivity, and mortality. (unpublished manuscript)
- Ong, A. D., Mroczek, D. K., & Riffin, C. (2011). The health significance of positive emotions in adulthood and later life. *Social and Personality Psychology Compass*, 5(8), 538–551. <https://doi.org/10.1111/j.1751-9004.2011.00370.x>
- Özdemir AA, Kavak Buda F, Dural G, Gültekin A. (2023). The Relationship Between Spiritual Well-Being, Life Satisfaction and Hope in Elderly Individuals in Turkey. *J Relig Health*, 62(5), 3123–3136. <https://doi.org/10.1007/s10943-022-01517-5>
- Pavlotskaya, Ya. I. (2014). Model psichologicheskogo blagopoluchiya lichnosti: sotsialnyy kontekst. [Model of psychological well-being of a person: the social context]. In P. M. Shamionov (Ed.), *Sotsialnaya psikhologiya lichnosti i akmeologiya*. [Social psychology of personality and acmeology], 122–128.
- Ryff, C. D., & Keyes, C. L. M. (1995). The structure of psychological well-being revisited. *Journal of Personality and Social Psychology*, 69, 719–727. <https://doi.org/10.1037/0022-3514.69.4.719>
- Ryff, C. D. (1991). Possible selves in adulthood and old age: a tale of shifting horizons. *Psychology and Aging*, 6, 286–295. <https://doi.org/10.1037%2F0882-7974.6.2.286>
- Ryff, C. D. (2013). Psychological well-being revisited: Advances in the science and practice of eudaimonia. *Psychiatry and Psychology*, 83(1), 10–28. <https://doi.org/10.1159/000353263>
- Schaufeli, W. B., & Enzmann, D. (1998). *The burnout companion to study and practice: a critical analysis*. London: Taylor & Francis.
- Scheibe, S., & Zacher, H. (2013). A lifespan perspective on emotion regulation, stress, and well-being in the workplace. In P. L. Perrewé, C. C. Rosen, & J. R. B. Halbesleben (Eds.), *The role of emotion and emotion regulation in job stress and wellbeing* (pp. 163–193). Emerald Group Publishing. [https://doi.org/10.1108/S1479-3555\(2013\)0000011010](https://doi.org/10.1108/S1479-3555(2013)0000011010)
- Siedlecki, K. L., Tucker-Drob, E. M., Oishi, S., & Salthouse, A. (2008). Life satisfaction across adulthood: different determinants at different ages. *The Journal of Positive Psychology*, 3(3), 153–164. <https://doi.org/10.1080/17439760701834602>
- Smith, L. (2023). The Importance of Autonomy in the Well-Being of the Older Adult. <https://www.elderoptionsca.com/the-importance-of-autonomy-in-the-well-being-of-the-older-adult/>
- Strata. (2020). Senstanti Lietuvos visuomenė – analitinė apžvalga [Lithuania's aging society – an analytical review]. Government strategic analysis centre. <https://strata.gov.lt/images/tyrimai/2020-metai/zmogiskojo-kapitalo-politika/20200924-senstanti-lietuvos-visuomene.pdf>
- Sun, Y. (2023). Happiness and mental health of older adults: multiple mediation analysis. *Frontiers in Psychology*, 14, 1108678. <https://doi.org/10.3389/fpsyg.2023.1108678>
- Tavares, A. I. (2022). Health and life satisfaction factors of Portuguese older adults. *Archives of Gerontology and Geriatrics*, 99, 104600. <https://doi.org/10.1016/j.archger.2021.104600>
- United Nations (2019). New Measures of Population Ageing. [https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/unpd\\_e\\_gm\\_201902\\_s1\\_sergeischerbov.pdf](https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/unpd_e_gm_201902_s1_sergeischerbov.pdf)
- Urry, H. L., & Gross, J. J. (2010). Emotion regulation in older age. *Current Directions in Psychological Science*, 19(6), 352–357. <https://doi.org/10.1177/0963721410388395>
- Vazonienė, G. (2014). Subjective wellbeing of elderly people: social domain aspect. *Social Welfare: Interdisciplinary Approach*, 4(1), 129–144. <https://doi.org/10.15388/SW.2014.28239>
- Vinmec (2019). Avoid burning in aging. <https://www.vinmec.com/en/news/health-news/general-health-check/avoid-burnout-during-aging/>

- Vinstrup, J., Meng, A., Sundstrup, E., & Andersen, L. L. (2021) The psychosocial work environment and perceived stress among seniors with physically demanding jobs: the senior working life study. *International Journal of Environmental Research and Public Health*, 18(14), 7437. <https://doi.org/10.3390/ijerph18147437>
- Ward, R. A. (2010). How old am I? Perceived age in middle and later life. *The International Journal of Aging and Human Development*, 71, 167-184. <https://doi.org/10.2190%2FAG.71.3.a>
- Williams, L. L. (2023). Senior burnout in the workforce: a silent struggle. <https://www.linkedin.com/pulse/senior-burnout-workforce-silent-struggle-williams-ph-d-cbcp>
- Zeidner, M., Matthews, G., & Shemesh, D. O. (2016). Cognitive-social sources of wellbeing: differentiating the roles of coping style, social support and emotional intelligence. *Journal of Happiness Studies*, 17, 2481-2501. <https://doi.org/10.1007/s10902-015-9703-z>
- Zheng, X., Xie, F., & Ding, L. (2018). Mediating role of self-concordance on the relationship between internet altruistic behaviour and subjective wellbeing. *Journal of Pacific Rim Psychology*, 12(e1), 1-7. <https://doi.org/10.1017/prp.2017.14>





## VIOLENCE AGAINST WOMEN WITHIN THE CONTEXT OF DOMESTIC ABUSE IN BALTIC STATES AND ITS IMPACT ON LABOUR MARKET

Ligita Gaspareniene, Ilona Michailovič, Rita Remeikienė\*

*Vilnius university, Law faculty, Lithuania*

**Abstract:** Domestic violence is a serious problem which is particularly difficult to solve because the cases of domestic abuse often occur at home, and because it requires deep socio-cultural changes in society. This article aims at identifying which types of domestic violence are prevalent in the Baltic States and how their prevalence affects the labour market. The main types of domestic violence include physical and sexual violence (the statistical data on the cases of this violence are available), while the cases of economic and psychological violence are more difficult to detect. Thus, this article focuses on physical and sexual violence against women in domestic environment in the Baltic States. The surveys carried out in the Baltic States reveal that physical injuries are the most common consequence of domestic violence, with a significant number of women feeling that their lives are in danger. Traumas and physical injuries lead to women leaving the labour market or reducing their working time.

**Keywords:** domestic violence, women, Baltic states, domestic abuse, labour market.

### 1. INTRODUCTION

One of the key objectives in the Gender Equality Strategy 2020-2025 is ending gender-based violence. Domestic violence, defined as a pattern of behaviour in any relationship that is used to gain or maintain power and control over an intimate partner and which can manifest as physical, sexual, emotional, economic or psychological actions or threats of actions that influence another person (United Nations, 2024), is a critical health and human rights concern. Although it can affect both genders, the results of previous studies show that the proportion of women experiencing domestic violence is significantly higher than that of men (81 against 19 percent, according to Wathen et al. (2015)), and 27 percent of women of reproductive age (15-

---

\* Corresponding author: [rita.remeikiene@tf.vu.lt](mailto:rita.remeikiene@tf.vu.lt)

Ligita Gaspareniene, ORCID: 0000-0002-5535-6552  
Ilona Michailovič, ORCID: 0000-0001-6292-1508  
Rita Remeikienė, ORCID: 0000-0002-3369-485X

49 years of age) have been subjected to some form of physical and/or sexual violence by their intimate partner (World Health Organisation, 2024).

According to Purvaneckienė et al. (2019), intimate partner violence is patterned behaviour aimed at controlling another person and abusing one's own power. Most often, it is a man's behaviour with a woman in the context of an intimate relationship. It can take many forms, including but not limited to physical, sexual, psychological, economic violence and social isolation. In most cases, it is a combination of all these forms. All forms of violence are as serious as sexual violence. Domestic violence is one of the leading causes of injury and death among women.

Despite the United Nations General Assembly's 1993 declaration on the “Elimination of Violence against Women” (United Nations, 1993), it continues to be a significant global issue. More than a quarter (27%) of women aged 15–49 years who have been in a relationship report experiencing physical and/or sexual violence at the hands of their intimate partner (White, et. al., 2024). The social and economic costs of domestic violence against women are huge and have ripple effects throughout society. Women experiencing domestic violence can suffer from isolation, they do not participate in regular activities and have limited abilities to take care for themselves and their children (World Health Organisation, 2024).

When women experience domestic violence, their participation in the labour market is also affected: domestic violence reduces their ability to work, undermines work performance, and can lead to loss of wages or loss of job (Docherty, 2022; The Center for Domestic Peace, 2024).

Research on the impact of violence in the workplace is usually focused on 'worker-on-worker' violence, but the impact of domestic violence remains overlooked because it is assumed that domestic and work areas are separate, and domestic problems are not brought to work. Nevertheless, domestic violence as a form of workplace violence is increasingly being recognised and causes scientific interest. Thus far, some authors (Zhang et al., 2012; Ouedraogo & Stenzel, 2021, etc.) have investigated the economic impact of domestic violence, and their estimations include some labour market related findings, but literature on this socially sensitive issue is still scarce.

The major purpose of this research is to identify which types of domestic violence are prevalent in the Baltic States and how their prevalence affects the labour market. To the best of our knowledge, “Eurostat” conducted the first research of this kind in the EU Member States, including the Baltic States. The objectives of the research are as follows: 1) to discuss the potential impact of domestic violence against women on the labour market by analysing the theoretical and empirical findings regarding the relationship between domestic violence against women and employment outcomes, and provide the estimations of the labour-market related economic impact of domestic violence against women; 2) to present a statistical descriptive analysis of the prevalence of different types of domestic violence in the Baltic States; 3) to reveal the reasons why particular Baltic States have a lower level of domestic violence than the others. The methods of the research include systematic and comparative literature analysis, statistical data analysis, statistical descriptive analysis.

## **2. LITERATURE REVIEW: IMPACT OF DOMESTIC VIOLENCE AGAINST WOMEN ON THE LABOUR MARKET**

The situation of women in the labour market is an extremely relevant topic in the context of the European model of social cohesion since the balanced economic development is impossible without the proper use of female human resources. With the increasing efforts to employ women from socially vulnerable population groups (by age, disability, nationality, etc),

the women who experience domestic violence still receive too little attention (Jirsa, 2015). Victims of domestic violence usually sustain costly and long-lasting physical, emotional, and financial consequences, which cannot be compartmentalised or separated from victims' work area, i.e. everything what happens at home is brought to work. Thus, domestic violence against women can marginalize and exclude women from full-fledged labour market participation.

Statistical data show that the main victims in domestic abuse-related crimes recorded by the police are women (73.5% of women vs 26.5% of men as of March 2023) ("Women's Aid", 2024). Due to the limitations of the available data and underreporting of the cases of domestic violence (according to The Center for Domestic Peace (2024), only 1 in 4 cases of domestic violence is officially reported), it is reasonable to suggest that the estimations related to this issue are quite conservative.

### **2.1. The relationship between domestic violence against women and employment outcomes**

The potential relationships between women's employment and domestic violence are explained by invoking some theories which reflect both positive and negative links between the phenomena under consideration. For instance, the theory of social capital suggests that working women get involved in non-household networks, which raises their social capital and decreases the risk of domestic violence (Sanyal, 2009). The household bargaining model proposes that women's employment allows them to acquire social resources and power, which reduce the risk of domestic violence by decreasing the cost of relationship exit and increasing women's bargaining power in their households (Strenio, 2022). Employment is one of the ways for women to leave a violent relationship. Financial security provided by employment can help women escape isolation and maintain standard of living (Rothman et al., 2007). Having conducted the research based on the questionnaire survey and covariation analysis in Turkey, Gedikli et al. (2023) found that intimate partner violence (physical, sexual and psychological) promotes women's participation in the labour market since women exposed to violence see employment as an opportunity to reduce the time spent at home. The positive relationship between domestic violence and women's participation in the labour market was identified for all kinds of paid employment (wage workers and the self-employed).

However, according to the resource theory, women's employment tends to increase the risk of domestic violence by disbalancing the key resources in households, i.e. women's employment distorts traditional resource allocation by gender, and when men feel that their available resources are decreasing, they can use violence to reestablish resource ownership (Goode, 1971).

The results of the previous empirical studies provide evidence that women who experience domestic violence tend to have a disrupted work history, often change jobs, more often undertake casual and part-time work and earn lower income compared to women who do not experience domestic violence (Adams et al., 2012; Jirsa, 2015; Lelebina & Lemiere, 2024). The major negative effects of domestic violence on women's employment, commonly highlighted by previous empirical studies, are discussed below.

Ability to get to work. Galvez et al. (2011) and Wathen et al. (2015) provide empirical evidence that domestic violence can affect a victim's ability to get to work (e.g. through physical restraint) (as noted by more than a third of the respondents experiencing domestic violence). Wathen et al.'s (2015) survey revealed that 12.5 percent of those whose ability to get to work was affected by domestic violence had been late for work, 30 percent were forced to miss work, and 51.4 percent experienced both situations. Docherty's (2022) literature review suggests that an abuse can undertake employment sabotage, for example, an abuser can hide a survivor's



keys, start an argument before work or refuse to care for children, which restricts access to alternative childcare.

**Work performance.** Swanberg et al.'s (2005) study revealed that domestic violence against women can have a direct negative impact on women's productivity in the workplace (for example, if an abuser calls to work). Wathen et al. (2015) conducted a survey of 8,429 respondents in Canada and found that domestic violence continued at or near the respondents' workplace (usually it manifested itself in the forms of abusive phone calls or text messages). The empirical findings show that an abuser's calls to work and threats to the victim's colleagues can have a negative impact on their work performance (Trades Union Congress, 2014). Work performance of the victims of domestic violence tends to be negatively affected due to distraction and the feeling of being tired or sick (Wathen et al., 2015).

**Employment (in)stability.** Employment stability is referred to as “the amount of time a woman has been employed throughout several months or years” (Showalter, 2016, p. 40). The review of 20 previous studies by Showalter (2016) revealed that domestic violence not always has an impact on women's employment stability: it can remain unchanged (Beck et al., 2014), and sometimes can cause employment overtime (Adams et al., 2012). Nevertheless, the literature review by Docherty (2022) suggests that trauma from violence (manifesting as anxiety and depression) can affect a survivors' ability to sustain employment, achieve advancement at work, and can potentially affect a survivor's employment stability or career progression for a number of years.

**Working time.** Showalter's (2016) findings indicate that domestic violence may lead to workplace time reductions (women tend to work fewer hours), which is in line with the results provided by Swanberg et al. (2005) (domestic violence tends to prolong victims' time off, as reported by 5 percent of the respondents). Wathen et al. (2015) found that 39.5 percent of the respondents took time off because they were dealing with health/medical issues related to domestic violence or attended counselling. The estimations by The Center for Domestic Peace (2024) show that the survivors of intimate partner violence lose a total of 8.0 million days of paid work each year.

**Job loss.** Seven studies in Showalter's (2016) literature review confirm that domestic violence can be associated with women losing their jobs: women report unemployment as a result of abuse. 27 percent of female victims in Swanberg et al.'s survey (2005) and 8.5 percent of the respondents in Wathen et al.'s (2015) survey reported having lost a job due to domestic violence. As noted by Docherty (2022), victims of domestic abuse can quit employment because of constant disruption, stress and harassments, the feelings of shame or because of the number of missed days or the poor productivity and performance. Jirsa's (2015) survey in Serbia disclosed that 75 percent of the female victims of domestic violence had been legally employed, but were dismissed after the decision of an employer (as indicated by 28.6 percent of the respondents), left employment because of worsening health or suffering violence for many years (as noted by 28.6 percent of the survey participants). Gedikli et al. (2023) found that women who have lost their jobs and become unpaid family workers, tend to involve into working in small scale family farms with other family members in rural areas, which generates personal income for self-reliance.

**Loss of life.** The Center for Domestic Peace (2024) provide the statistical data from The Center for Disease Control 2003, U.S. General Accounting Office, which indicate that 142 women were murdered in their workplace by their abuser between 2003 and 2008. 78 percent of women were killed in the workplace during this timeframe.

## 2.2. Estimations of the labour-market related economic impact

Estimations of the economic impact of domestic violence (e.g. spousal violence) is a way to measure tangible and intangible effects of this phenomenon.

Day et al. (2005) present the results of the national survey used by the Institute for Women of Andalusia, Spain (2003) to compile over 100 indicators which represent the effects of violence against women and children. 25 of the indicators represented the health, judicial, social, educational, employment, and psychological components. The total cost, including pain and suffering, were estimated at approximately US\$ 2.9 billion.

The Center for Domestic Peace (2024) provides the estimations which indicate that the cost of intimate partner violence exceeds \$8.3 billion per year in the United States.

Zhang et al. (2012) estimated tangible and intangible costs of domestic violence (domestic violence in their study included crimes defined in the criminal code, such as murder, sexual assault, assault, robbery and criminal harassment, and other equivalent violent acts, such as being threatened, pushed, grabbed, beaten, choked, threatened with a gun or knife, or forced into sexual activity) in Canada in 2009. The authors estimated that the total economic impact of domestic violence was \$7.4 billion, or \$220 per capita. The most direct economic impact was found to be borne by primary victims and estimated at \$6.0 billion (this amount covers the costs of medical attention, hospitalizations, lost wages, missed school days, and stolen/damaged property). The intangible costs, including pain, suffering and loss of life, accounted for 91.2% of the total victim costs. The remaining tangible costs were estimated at \$525.0 million. When analysing the costs related to the labour market, it can be noted that work loss costs due to domestic violence against women were estimated at \$98,178,631, productivity loss costs - at \$37,125,687, lost wage costs - at \$20,943,599, lost education costs - at \$259,081. The estimations also indicate that employers tend to lose nearly \$52,123,343 every year as a direct result of domestic violence against women.

The results provided by Ouedraogo and Stenzel (2021) (their research covered 18 sub-Saharan African countries and more than 440,000 women representing sub-Saharan Africa's female population) suggest that an increase in domestic violence against women by 1 percentage point tends to reduce the level of economic activity by 9 percent. The lower economic activity is considered to be determined by a significant drop in female employment due to physical, psychological, and emotional violence. The authors also present the data from previous studies which indicate that domestic violence leads to a 1-2 percent decrease in GDP in a given economy. They note that this drop in economic potential in the short term is associated with shorter working hours and lower productivity generated by women experiencing domestic violence. In the long term, domestic violence can have a negative impact on women's education and the acquisition of skills and lead to a decrease in the number of women in the workforce.

## 3. DATA AND METHODOLOGY

The data on violence against women at the global level are very limited because they are not accumulated on a regular basis. Some gender data are accumulated by the Australian Bureau of Statistics, World Bank Group. The Eurostat database provides the statistical information on violence against women only for 2021, which did not allow to analyse the

dynamic trends of this phenomenon<sup>†</sup>. The EU authorities and Member States could confirm their commitment to regularly collect data on different types of violence against women. The data could be useful when developing national and regional policies and actions. The *Eurostat* and its expert groups could contribute to this process; in addition, the *Eurostat* could provide the data to the specialised monitoring bodies of the UN and the Council of Europe, as well as the European Institute for Gender Equality (European Union Agency for Fundamental Rights, 2014).

This article considers the following domestic violence-related data representing the situation in three Baltic States (according to the Eurostat):

Prevalence of Violence by a Domestic Perpetrator Among Women by Type of Violence;  
Type and Frequency of Intimate Partner Violence Experienced by Ever-Partnered Women;

Ever-Partnered Women Who Have Experienced Intimate Partner Violence, by Person or Support Service to Whom Violence Was Reported;

Consequences of Intimate Partner Violence Among Ever-Partnered Women;

When analysing the Prevalence of Violence by a Domestic Perpetrator Among Women by Type of Violence (see Fig. 1), it can be seen that physical violence (including threats) was the most common in all Baltic States in the period under consideration. Physical violence is followed by sexual violence. The greatest number of the cases of physical violence against women was recorded in Estonia - 14.5 percent, in Latvia - 12.3 percent, and in Lithuania - 11.5 percent. Estonia also had the greatest number of the cases of sexual violence (11.8 percent), followed by Lithuania (5.5 percent) and Latvia (4.6 percent).

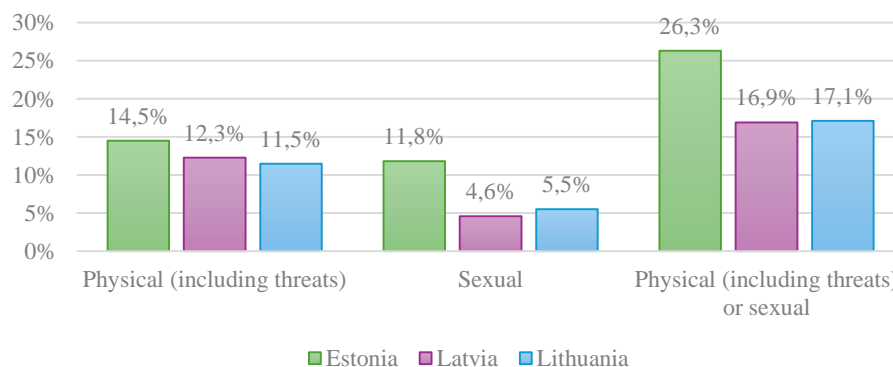


Figure 1. Prevalence of Violence by a Domestic Perpetrator Among Women by Type of Violence, in percent (Eurostat)

The data on the frequency of the crimes under consideration (see Table 1) indicate that an intimate partner tends to repeat his violent actions, and this tendency is observed in all Baltic States, so violence is not a one-time act.

Table 1. Type and Frequency of Intimate Partner Violence Experienced by Ever-Partnered Women

Country	One time	Repeated
Estonia	1.4%	9.3%
Latvia	1.1%	10.4%
Lithuania	1.0%	9.1%

<sup>†</sup> No score is provided to the Baltic States regarding the domain of violence due to the lack of the comparable EU-wide data.

The women experiencing domestic violence in the Baltic States usually turn for help to close people (71.4 percent in Estonia, 68.9 percent in Latvia, and 66.9 percent in Lithuania) or to any other person or service (75.6 percent in Estonia, 76.5 percent in Latvia, and 73.1 percent in Lithuania) (see Fig. 2). The smallest number of women turn for help to the support service (9.1 percent in Estonia, 7.0 percent in Latvia, and 6.9 percent in Lithuania).

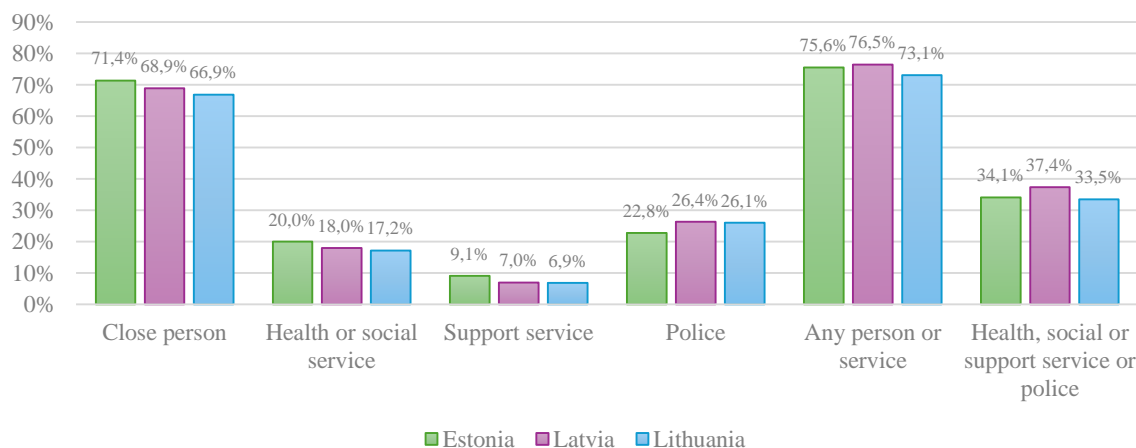


Figure 2. Ever-Partnered Women Who Have Experienced Intimate Partner Violence, by Person or Support Service to Whom Violence Was Reported, percent (Eurostat)

The more frequent consequences of domestic violence against women were physical injuries, with a slightly lower percentage of women feeling that their lives were becoming dangerous (see Fig. 3).

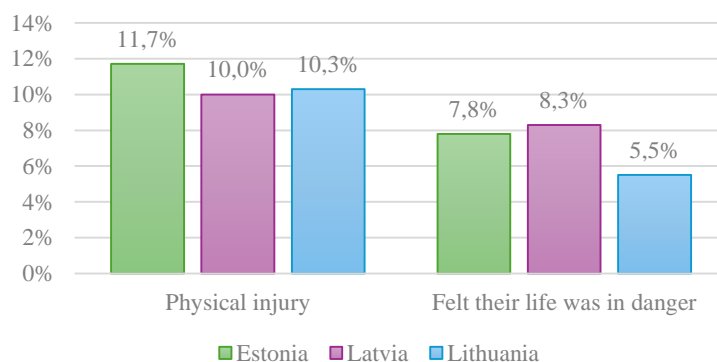


Figure 3. Consequences of Intimate Partner Violence Among Ever-Partnered Women, percent (Eurostat)

The reasons why certain types of violence are more common in one of the Baltic States are discussed in the following subsection to reveal the plausible impact of domestic violence on women's participation in the labour market.

#### 4. RESULTS AND DISCUSSION

Lithuania is the European Union country that has signed the Istanbul Convention on June 6, 2013, but not ratified it yet in the Parliament. Estonia ratified the Istanbul Convention on 26 October 2017, and the Latvian Saeima ratified the Istanbul Convention on 30 November 2023.

According to the Population and Social Statistics Department of Statistics Estonia (2024), the survey results indicate that 39 percent of women have experienced psychological violence, 13 percent have faced physical violence (including threats), and 9 percent have been subjected to sexual violence. Younger women, aged 18–29, are the most likely to have encountered violence, while older women, aged 65–74, are the least likely to have experienced it. The current data show that physical violence against women in Estonia decreased by 1.5 percent, sexual violence – by 1.8 percent. The major cause of these two types of violence is the consumption of alcohol.

In 2021, the Lithuanian Parliament adopted a new version of the Law on Protection from Domestic Violence, which established the warrant for protection against domestic violence. These amendments entered into force on July 1, 2023. According to the law, if there is a risk of domestic violence, an adult who poses a risk of violent behaviour may be obliged to temporarily move out of the place of residence, not to visit a victim's place of residence, not to approach this person and other people living together. A domestic violence protection warrant would be issued by a police officer for a period of 15 days, when, after receiving a report of possible domestic violence and carrying out a risk assessment, a risk of domestic violence has been identified.

According to Human Rights Monitoring Institute (2023) in the first weekend when the warrant was in effect, the police received 353 reports of possible domestic violence. In 91 cases, a pre-trial investigation or a material clarification procedure has been initiated. In another 262 cases, the police assessed the situation individually and issued 147 warrants obliging the potential perpetrator to move out of the residence and not to seek contact with the person at risk of violence.

Domestic and intimate partner violence was criminalised in Latvia and considered an aggravating factor in certain criminal offenses. There were penalties for causing “minor” bodily harm when the survivor and perpetrator were spouses, former spouses, or civil partners. Penalties ranged from fines to imprisonment. The law allowed the police to investigate domestic violence without a survivor's prior approval and criminalised stalking. The law allowed survivors of domestic violence to request that police officers issue an order for the eviction of the perpetrator for eight days. Upon receiving such a request, police had to react immediately. Only courts could issue restraining orders and were required to respond to such requests within one business day. Once a restraining order was issued, it remained in force until a court revoked it (Latvian Human Rights Report, 2023, pp. 16-17).

Women who experience domestic violence often face significant barriers to entering or remaining in the labour market. The literature analysis suggests that physical and sexual violence can result in injuries or trauma that require time off work and potentially lead to job loss or decreased productivity. The implementation of domestic violence protection laws, such as those in Latvia and Lithuania, plays a critical role in stabilising the labour market participation of women. By ensuring that abusers can be removed from the home, these laws help survivors maintain a safe environment, which is crucial for their ability to work and earn a livelihood. In Latvia, for instance, the criminalisation of intimate partner violence and the ability to request immediate eviction of the abuser helps protect women from the effects of violence on their employment. The reduction of violence, as seen in Estonia where physical and sexual violence against women decreased by 1.5% and 1.8% respectively, may correlate with increased labour market participation among women. Fewer instances of violence can lead to fewer work absences, higher productivity, and greater overall economic participation by women, thus contributing to economic growth.

## 5. CONCLUSION

The relationship between women's employment and domestic violence is complex, with theories suggesting both protective and risk-enhancing effects. On one hand, employment can empower women by increasing their social capital and bargaining power, thereby reducing the risk of domestic violence. However, the resource theory suggests that women's employment might provoke violence by disrupting traditional gender roles and resource distribution within households. Empirical studies show that domestic violence negatively impacts women's work performance, stability, and ability to maintain employment, often leading to job loss. Additionally, domestic violence can result in severe consequences, including loss of life, which highlights the critical need for supportive interventions.

Estimations of the economic impact of domestic violence reveal significant tangible and intangible costs, including billions in lost productivity, wages, and societal costs. Domestic violence not only directly affects victims through health and economic losses but also has broader economic consequences, such as reduced female employment and slower GDP growth. Addressing domestic violence is essential not only for the well-being of individuals but also for sustaining economic stability and growth.

The analysis of domestic violence against women in the Baltic States reveals that physical violence, including threats, is the most prevalent form of this type of violence, with Estonia having the highest rates of both physical and sexual violence. The data also show that domestic violence is recurrent rather than a one-time act across all three countries. While many women seek help from close contacts or other services, few turn to formal support services. Physical injuries are the most common consequence of domestic violence, with a significant number of women feeling that their lives are in danger.

The implementation of domestic violence protection laws in Latvia and Lithuania, along with the observed reduction in violence in Estonia, plays a crucial role in stabilising and enhancing women's labour market participation. By ensuring a safer environment, these legal measures help women maintain employment, which contributes to fewer work absences and a greater economic input. Consequently, addressing domestic violence against women is essential for individual well-being, sustainable economic growth and societal resilience.

## REFERENCES

- Adams, A. E., Tolman, R. M., Byee, D., Sullivan, C. M., & Kennedy, A. C. (2012). The impact of intimate partner violence on low-income women's economic well-being: the mediating role of job stability. *Violence Against Women*, 18(12), 1345–1367. <https://doi.org/10.1177/1077801212474294>
- Beck, G. J., Clapp, J. D., Jacobs-Lentz, J., McNiff, J., Avery, M., & Olsen, S. A. (2014). The association of mental health conditions with employment interpersonal and subjective functioning after intimate partner violence. *Violence Against Women*, 20(11), 1321–1337. <https://doi.org/10.1177/1077801214552855>
- Day, T., McKenna, K., & Bowlus, A. (2005). The Economic Costs of Violence Against Women: An Evaluation of the Literature. <https://www.un.org/womenwatch/daw/vaw/expert%20brief%20costs.pdf>
- Docherty, L. (2022). The impact of intimate partner violence on employment. <https://womanact.ca/the-impact-of-intimate-partner-violence-on-employment/>
- Eurostat. (2021). Gender-based violence: capturing accurate data. <https://ec.europa.eu/eurostat/web/equality-non-discrimination/database>

- Galvez, G., Mankowski, E. S., McGlade, M. S., Ruiz, M. E., & Glass, N. (2011). Work-related intimate partner violence among employed immigrants from Mexico. *Psychology of Men & Masculinity*, 12(3), 230–246. <https://doi.org/10.1037/a0022690>
- Gedikli, C., Popli, G., & Yilmaz, O. (2023). The impact of intimate partner violence on women's labour market outcomes. *World Development*, 164, 106166. <https://doi.org/10.1016/j.worlddev.2022.106166>
- Goode, W. J. (1971). Force and violence in the family. *Journal of Marriage and the Family*, 624-636. <https://doi.org/10.2307/349435>
- Human Rights Monitoring Institute. (2023). Lithuania Introduces New Tool to Prevent Domestic Violence. <https://www.liberties.eu/en/stories/lithuania-introduces-new-tool-to-prevent-domestic-violence/44862>
- Jirsa, K. (2015). Competitiveness of Women Victims of Domestic Violence on Labour Market – Problems and Perspectives. <https://www.eurofound.europa.eu/system/files/2015-08/06irec.pdf>
- Latvian Human Right Report. (2023). [https://www.state.gov/wp-content/uploads/2024/02/528267\\_LATVIA-2023-HUMAN-RIGHTS-REPORT.pdf](https://www.state.gov/wp-content/uploads/2024/02/528267_LATVIA-2023-HUMAN-RIGHTS-REPORT.pdf)
- Lelebina, O., & Lemièrre, S. (2024). “When things aren't going well at home and at work, it is hard”: What can companies do about domestic violence?. *European Management Journal*, 42(2), 154-160. <https://doi.org/10.1016/j.emj.2023.11.005>
- Ouedraogo, R., & Stenzel, D. (2021). How Domestic Violence is a Threat to Economic Development. <https://www.imf.org/en/Blogs/Articles/2021/11/24/how-domestic-violence-is-a-threat-to-economic-development>
- Purvaneckienė, G., Venslovaitė, V., Stonkuvienė, I., & Žiliukaitė, R. (2019). Smurtas artimoje aplinkoje: prevencija, apsauga, pagalba, bendradarbiavimas. [https://socmin.lrv.lt/uploads/socmin/documents/files/Ataskaita\\_Smurtas\\_artimoje\\_aplinkoje%20-%20kokybinio%20tyrimo%20ataskaita\\_docx%20\(5\).pdf](https://socmin.lrv.lt/uploads/socmin/documents/files/Ataskaita_Smurtas_artimoje_aplinkoje%20-%20kokybinio%20tyrimo%20ataskaita_docx%20(5).pdf)
- Rothman, E. F., Hathaway, J., Stidsen, A., & de Vries, H. F. (2007). How employment helps female victims of intimate partner violence: a qualitative study. *Journal of occupational health psychology*, 12(2), 136. <https://psycnet.apa.org/doi/10.1037/1076-8998.12.2.136>
- Sanyal, P. (2009). From credit to collective action: The role of microfinance in promoting women's social capital and normative influence. *American sociological review*, 74(4), 529-550. <https://doi.org/10.1177/000312240907400402>
- Showalter, K. (2016). Women's employment and domestic violence: A review of the literature. *Aggression and violent behavior*, 31, 37-47. <https://doi.org/10.1016/j.avb.2016.06.017>
- Strenio, J. (2022). Economic considerations of intimate partner violence. In *Handbook of interpersonal violence and abuse across the lifespan: A project of the national partnership to end interpersonal violence across the lifespan (NPEIV)* (pp. 2865-2884). Cham: Springer International Publishing. [https://doi.org/10.1007/978-3-319-89999-2\\_167](https://doi.org/10.1007/978-3-319-89999-2_167)
- Swanberg, J. E., Logan, T. K., & Macke, C. (2005). Intimate partner violence, employment, and the workplace: Consequences and future directions. *Trauma, Violence, & Abuse*, 6(4), 286-312. <https://doi.org/10.1177/1524838005280506>
- The Center for Domestic Peace (2024). Economic Impact of Domestic Violence. <https://centerfordomesticpeace.org/economic-impact-of-domestic-violence/>
- The Population and Social Statistics Department of Statistics Estonia (2024). 41% of women in Estonia experience intimate partner violence. <https://www.stat.ee/en/news/41-women-estonia-experience-intimate-partner-violence>
- Trades Union Congress. (2014). Domestic Violence and the Workplace: A TUC Survey Report. <https://www.tuc.org.uk/research-analysis/reports/domestic-violence-and-workplace>

- U.S. Department of State. (2024). Latvia 2023 Human Rights Report. [https://www.state.gov/wp-content/uploads/2024/02/528267\\_LATVIA-2023-HUMAN-RIGHTS-REPORT.pdf](https://www.state.gov/wp-content/uploads/2024/02/528267_LATVIA-2023-HUMAN-RIGHTS-REPORT.pdf)
- United Nations (1993). Declaration on the elimination of violence against women. New York: UN. <https://digitallibrary.un.org/record/179739?v=pdf>
- United Nations. (2024). What is domestic abuse? <https://www.un.org/en/coronavirus/what-is-domestic-abuse>
- Wathen, C. N., MacGregor, J. C., & MacQuarrie, B. J. (2015). The impact of domestic violence in the workplace: Results from a pan-Canadian survey. *Journal of occupational and environmental medicine*, 57(7), e65-e71. <https://doi.org/10.1097/jom.0000000000000499>
- Women's Aid. (2024). Why do we say domestic abuse is gendered? <https://www.womensaid.org.uk/information-support/what-is-domestic-abuse/domestic-abuse-is-a-gendered-crime/>
- World Health Organisation. (2024). Violence against women. <https://www.who.int/news-room/fact-sheets/detail/violence-against-women>
- Zhang, T., Hoddenbagh, J., McDonald, S., & Scrim, K. (2012). An Estimation of the Economic Impact of Spousal Violence in Canada, 2009. [https://www.justice.gc.ca/eng/rp-pr/cj-jp/fv-vf/rr12\\_7/rr12\\_7.pdf](https://www.justice.gc.ca/eng/rp-pr/cj-jp/fv-vf/rr12_7/rr12_7.pdf)





## ALIGNING DIGITAL TRANSFORMATION WITH STRATEGIC MANAGEMENT IN LOGISTICS

**Diana Daskevic\*, Aurelija Burinskiene**

*Vilnius Gediminas Technical University,  
Department of Business technologies and entrepreneurship, Lithuania*

**Abstract:** Digital transformation plays a vital role in enhancing competitiveness within the logistics sector, yet many organizations struggle to align technological innovation with strategic goals. To address this gap, the study examines how decision making enhances the adoption of digital technologies to strengthen competitive advantage. A five-stage methodology, including case study analysis and expert evaluation, ensures analytical depth and practical relevance. Using a mixed-methods approach, the research integrates qualitative insights from logistics professionals with ordinal logistic regression analysis to evaluate their impact on competitiveness. Findings confirm a positive and statistically significant relationship between digital implementation and performance outcomes, emphasizing the importance of strategic foresight and implementation planning. The study underscores the need to assess technological investments through a long-term strategic lens. These findings offer both academic and managerial value, providing a roadmap for logistics firms seeking to enhance resilience, efficiency, competitive advantage, and strategic alignment in a rapidly evolving digital environment.

**Keywords:** strategic decision making, integrated framework, digital technologies, logistics sector, competitiveness.

### 1. INTRODUCTION

Strategic management in the logistics sector is a critical component of organizational operations, driving efficient project management, optimizing supply chains, and ensuring a competitive advantage. Organizations increasingly rely on advanced technologies to maintain competitiveness and efficiency in today's fast-paced and dynamic global markets. As a complex and multifaceted domain, logistics management demands continuous decision making and the ability to rapidly adapt to shifting market conditions (Chandler, 1969; Porter, 1980, 1985). A key element of modern logistics management is integrating technology, which enhances supply chain planning, monitoring, and management while promoting transparency, operational speed,

---

\* Corresponding author: [diana.daskevic@vilniustech.lt](mailto:diana.daskevic@vilniustech.lt)

Diana Daskevic, ORCID ID: 0009-0009-7451-6177

Aurelija Burinskiene, ORCID ID: 0000-0002-4369-8870

and cost reduction (Gunasekaran & Ngai, 2003; Wamba & Chatfield, 2009). Adopting digital solutions and information systems allows organizations to analyze data better, optimize transport routes, and manage inventories, enhancing overall supply chain resilience and enabling agile responses to market changes (Christopher, 2016; Meijer, 2000). Despite these clear advantages, the integration of digital technologies often faces significant challenges. According to Garner (2024), 52% of companies fail to achieve the expected outcomes from their digital technology adoption efforts. These failures often lead to inefficiencies, missed opportunities, and an inability to realize the potential of technological investments fully. This highlights a critical research gap—a lack of structured frameworks or decision support tools that guide organizations through the complexities of technology adoption and integration in logistics operations. Previous studies have explored various aspects of technology adoption in logistics (Christopher, 2016; Meijer, 2000), but few have specifically addressed how structured project management methodologies can support the effective integration of these technologies. This gap underscores the urgent need for a more strategic and systematic approach to managing digital transformations in logistics.

This research addresses the gap in understanding how decision making can enhance the successful adoption of digital technologies in logistics operations to increase competitiveness. The hypothesis examined in this study is: *"The implementation of digital technologies (IDT) in logistics positively impacts competitive advantage (CC)."* Specifically, the study investigates the role of decision making in facilitating the adoption of digital technologies within the logistics sector. The study employs a mixed-methods approach to support this hypothesis, combining qualitative research (semi-structured interviews with logistics executives and technology experts) with ordinal logistic regression analysis of technology adoption trends derived from case studies and industry data. This approach provides valuable insights into how decision-making influences the successful implementation of digital technologies in logistics. The results section primarily focuses on identifying key factors contributing to the success or failure of digital transformations in logistics through ordinal logistic regression analysis. The paper is structured as follows: Section 2 provides a literature review on the theoretical foundation of strategic management, the importance of technology implementation in strengthening logistics ecosystems, and the role of technology in decision-making. Section 3 outlines the research methodology, detailing the mixed-methods approach used to analyze trends in technology adoption. Section 4 presents the research findings, drawing insights from expert interviews and data analysis. Section 5 offers a discussion and concludes with the implications of the findings.

## **2. LITERATURE REVIEW**

This section offers a comprehensive review of academic literature concerning strategic management, technological advancement, and decision-making processes within the logistics domain. In light of increasing market complexity and competitiveness, the integration of strategic planning and technological innovation has emerged as a critical enabler of robust and efficient logistics ecosystems. The review is organized into three main subsections, each addressing a core thematic area.

### **2.1. Theoretical Foundations of Strategic Management**

The concept of strategic management has evolved over the decades, drawing on diverse theoretical frameworks that emphasize its multifaceted nature. Strategic management is a systematic process that enables organizations to define long-term objectives, align resources,

and navigate complex and dynamic market environments. Classical strategic management theories, such as those proposed by Chandler (1969), highlight the alignment between structure and strategy, suggesting that a firm's organizational architecture must support its strategic intent. Similarly, Porter's (1980, 1985) competitive strategy frameworks underscore the role of industry structure and positioning in determining competitive advantage, which laid the foundation for market-based strategic thinking. White (2017) and Rahman (2019) further expanded these ideas, conceptualizing strategic management as an integrative process involving environmental analysis, goal setting, implementation, and control, all within a feedback-driven loop. They assert that effective strategy is dynamic—requiring continuous evaluation and refinement to respond to environmental volatility. Similarly, Ansoff (1987) and Saloner et al. (2005) emphasized the strategic importance of decision making in resource allocation, competitive positioning, and innovation. In particular, Ansoff (1987) was among the first to emphasize technology management as a strategic driver, arguing that the ability to assimilate and leverage new technologies offers a sustainable competitive edge. With the growing importance of digital transformation, scholars have introduced new dimensions to strategic thinking. Henry (2021) notes that organizations embracing digitalization are better positioned to anticipate and shape market trends, thus sustaining long-term leadership. Parnell (2013) supports this by highlighting technology-driven strategic models that optimize internal processes such as logistics and supply chain efficiency. From a decision-making perspective, strategic management involves making high-stakes choices under uncertainty, synthesizing data, forecasting trends, and balancing short-term trade-offs with long-term vision. This aligns with Mintzberg's (1994) view that strategy is a blend of deliberate planning and emergent adaptation. In the context of logistics, strategic decision making is critical for strengthening the logistics ecosystem. As Gregson (1976) noted, logistics management must be approached systemically, integrating decisions across the entire supply chain. Lewis et al. (2018) highlighted the effectiveness of multi-criteria decision making (MCDM) methods in optimizing logistics performance, enabling firms to make informed and balanced operational choices. Apak et al. (2013) further developed a decision-making model for evaluating supply chain execution, emphasizing that structured decision frameworks improve efficiency and responsiveness. Additionally, Chałampowicz et al. (2024) stressed the importance of integrating sustainability into strategic logistics decisions. They argue that this approach enhances both ecological outcomes and the resilience of the logistics network. An example of strategic decision making in logistics can be seen in Zara's logistics model, which integrates rapid decision-making processes to align supply chain activities with market trends. This allows the company to minimize inventory waste and maximize product availability—key enablers of Zara's sustained market advantage.

## **2.2. The Importance of Technology Implementation in Strengthening Logistics Ecosystems**

In modern logistics management, the integration of technology has become essential for ensuring efficiency, agility, and long-term competitiveness. Digital tools, information systems, and real-time data processing capabilities allow logistics organizations to dynamically respond to demand changes, streamline operations, and improve customer service levels. Jurczak (2020) highlights that information technology enables companies to analyze data more effectively, optimize transport routes, and ensure operational transparency. Meijer (2000) introduced the concept of knowledge logistics, emphasizing that organizations with effective knowledge management systems are better equipped to reduce uncertainty and coordinate complex operations. Gunasekaran and Ngai (2003) investigated management strategies in small and

medium-sized logistics enterprises, showing that technological adoption reduces operational costs while simultaneously enhancing service quality. Varella and Buss Gonçalves (2013) also demonstrated that integrating IT into strategic planning enhances flexibility and adaptability in logistics. Christopher (2016) emphasizes the importance of real-time data exchange and digital tracking systems, which enhance supply chain visibility and resilience by predicting disruptions, improving inventory accuracy, and enabling proactive decision making. Further advancing these concepts, Wamba and Chatfield (2009) introduced an integrated framework for Big Data analytics in logistics, demonstrating how real-time analytics tools can enhance strategic alignment and decision making. Their study suggests that firms leveraging advanced analytics achieve superior demand forecasting, inventory optimization, and transportation management performance. Huo et al. (2014) examined the mediating role of IT capability in the relationship between supply chain integration and firm performance, concluding that IT acts as a critical enabler of cross-functional coordination, particularly within logistics operations. Donald et al. (2020) also developed a framework for logistics information systems, emphasizing that technology integration should be aligned with strategic goals such as responsiveness, cost leadership, and customer service enhancement. From a systems design perspective, Melnyk et al. (2010) proposed a framework for "designing for supply chain resiliency," emphasizing the role of technology in building agile logistics networks capable of withstanding disruptions. Their work demonstrates that firms with stronger technological infrastructures are more resilient and adaptive. Despite these benefits, implementing technology presents challenges. High initial investment costs, data security concerns, and the need for specialized workforce training can impede effective adoption (Zhao et al., 2024; Wamba & Chatfield, 2009). Nonetheless, aligning technological capabilities with business objectives is crucial for sustaining competitive advantage in an increasingly volatile global market.

### **2.3. The role of technology in decision making in logistics**

Technology's role in logistics decision making is essential for optimizing operational performance and maintaining a competitive advantage. When decision making frameworks are combined with the strategic application of technology, logistics companies are empowered to make more informed, efficient, and agile decisions. Several scholars have examined the intersection of technology and decision making in logistics, contributing significantly to the development of decision-making frameworks that guide technology adoption and integration. A significant contribution to understanding decision making frameworks in logistics technology comes from Christopher (2016), who discusses how technological innovations in logistics, such as automation, AI, and data analytics, have profoundly impacted supply chain and logistics decision making. Christopher suggests that digital technologies facilitate data-driven decision making, enabling logistics managers to respond more effectively to real-time changes in demand, inventory levels, and supply chain disruptions. This results in more precise and timely decision making, which enhances efficiency and reduces costs. Another key perspective is provided by Klaus and Krieger (2013), who propose a conceptual framework for decision making in logistics that integrates both traditional and digital technologies. They emphasize the importance of aligning technology adoption with business strategy, arguing that decision making frameworks must account for technological capabilities and their potential to provide operational flexibility. This alignment ensures that logistics companies can adapt swiftly to changing environments while fully capitalizing on the benefits of new technologies. Moghaddam et al., (2025) explore the impact of artificial intelligence (AI) on decision making frameworks in logistics, particularly regarding route optimization and inventory management. The authors argue that AI technologies provide logistics companies with advanced decision-

making tools that automate processes, reduce human error, and improve forecasting accuracy. Moreover, Wang et al., (2016) analyze the role of big data in logistics decision making, proposing a decision-making framework that incorporates the use of big data analytics to enhance supply chain visibility. They highlight big data's potential to offer decision makers valuable insights into demand forecasting, inventory management, and transportation planning. By leveraging big data, logistics companies can make more accurate and timely decisions, improving overall performance. Zhang et al. (2023) extend this discussion by focusing on decision making frameworks within the context of digital transformation and Industry 4.0 technologies in logistics. Their integration into decision making frameworks helps logistics companies improve operational efficiency and increase transparency. Despite these advancements, integrating advanced technologies presents several challenges, as highlighted by Trstenjak et al. (2022). Their findings suggest that a well-structured decision-making framework, combined with the right technology and change management strategies, can significantly improve decision making processes in logistics. Ultimately, successful technology integration within logistics requires a well-structured decision-making framework, backed by strategic planning and change management strategies, to capitalize on the benefits of innovation and maintain long-term competitiveness in an evolving market.

### **3. DATA AND METHODOLOGY**

This research aims to bridge the gap in understanding how decision-making can enhance the successful adoption of digital technologies in logistics operations to boost competitiveness. The hypothesis it examines is: "The implementation of digital technologies (IDT) in logistics positively impacts competitive advantage (CC)." The study particularly investigates the role of decision-making in facilitating the adoption of digital technologies within the logistics sector. Employing a mixed-methods approach, the research combines qualitative insights from semi-structured interviews with logistics executives and technology experts, along with ordinal logistic regression analysis of technology adoption trends derived from case studies and industry data. This methodology provides valuable insights into how decision-making influences the successful implementation of digital technologies in logistics.

The research continues by analyzing data from a survey conducted in EU countries in 2025. This study employs a five-stage methodology systematically designed to achieve the defined research objectives.

In the first stage, a structured questionnaire is developed to guide semi-structured interviews to evaluate the impact of digital technology implementation in logistics.

The second stage involves the selection of experts for the semi-structured interviews. These experts are C-level executives, senior managers, and project and process managers with over 10 years of experience in the field. Their extensive knowledge and experience provide critical insights into the challenges and strategies associated with adopting digital technologies, ensuring the validity and relevance of the gathered data.

The third stage consists of conducting the semi-structured interviews with the selected participants. Their responses are carefully recorded and analyzed to extract meaningful insights for further research.

In the fourth stage of this study, ordinal logistic regression analysis is employed to address the research questions by examining the relationships between the ordinal dependent variable and one or more independent variables. This technique allows researchers to estimate the odds of a particular outcome in the dependent variable based on the values of the independent variables, while controlling for other factors. Ordinal logistic regression is particularly useful when the dependent variable is categorical with ordered levels, as it models

and quantifies the relationship between the dependent and independent variables (Hair et al., 2010). Regression analysis has been widely applied in logistics research to understand the dynamic interactions between technological advancements and performance metrics. For instance, Yu et al., (2021) used regression models to explore the impact of technology adoption on logistics performance, focusing on how information technologies affect operational efficiencies in supply chains. Zhang et al., (2023) examined the influence of digital transformation on the performance of logistics service providers, highlighting how advanced technologies affect service quality and cost efficiency. Lu et al. (2020) investigated the relationship between big data adoption and logistics performance, identifying how data-driven decisions enhance logistics effectiveness and improve responsiveness to market changes.

Furthermore, Shee et al. (2018) studied the effect of cloud-based logistics platforms on inventory management and supply chain coordination, while Yuan et al. (2023) assessed the role of digitalization in reducing supply chain disruptions and its impact on operational resilience. These studies illustrate the widespread application of regression analysis in logistics, particularly in understanding how digital technologies influence various performance outcomes, such as efficiency, sustainability, and resilience. This study employs ordinal logistic regression analysis to examine how the implementation of digital technologies in logistics influences competitiveness. Additionally, ordinal logistic regression enables the estimation of outcome probabilities across ordered categories based on identified relationships, offering valuable insights into technology adoption patterns and their strategic implications for logistics management (Eq. (1)).

$$Y = c_1 + c_2 * X \quad (1)$$

Y– competitive advantage (CC); X– implementation of digital technologies (IDT);  $c_1$  – intercept;  $c_2$  – coefficient for X

The use of EViews facilitated a more precise and efficient execution of the ordinal logistic regression techniques, enabling a systematic approach to identifying meaningful relationships between competitive advantage (CC) and decision-making processes in the implementation of digital technologies (IDT).

The hypothesis examined in this study is: "The implementation of digital technologies (IDT) in logistics positively impacts competitive advantage (CC)."

Table 1 below provides a comprehensive overview of various technological areas, their operational purposes, and the corresponding technologies used in different operational domains. It also includes the Web of Science citation counts for each technology, which indicates the level of academic recognition and relevance within the field.

Table 1. Technologies in Operations and Their Academic Recognition

Technological Area	Technology	Web of Science number of citations for authors
Warehousing	Warehouse Management System (WMS)	120
	Intralogistic Automation	1
	Coreless Stretch Film	9
	Inventory Automatization	2
Automation / Material Handling	AGV/AMR	391
Safety and Security	SLAM/Lidar	102
Picking and Packing	Artificial Intelligence	1069
	RPA	15
	Omni	78
	Inventory Control System	38
	ERP	94
	Inventory Management	242
Picking and Packing / Data Analysis	SAP	56
Transport Management	C3 Computed Tomography Scanners	65
	MyDello	-
	Ortec	2
	TPS ABM Cloud	120
	Routing Solution	218
	Cargo Tracking System	86
Data Analysis, Interpretation and Exploration	DVS	322
	ESRI/ArcGIS	20
	Web Self-Invoice	4
	Digital Integration	630
	Operations Time Tracking Software	310
	IFS	78
	CRM	215
	Qlik	-

In the fifth and final stage, the descriptive and ordinal logistic regression analysis results were assessed for the chosen technologies, providing robust evidence to support the research criteria.

#### 4. RESULTS

The results section is divided into two parts: the descriptive and ordinal logistic regression analyses, each providing valuable insights into the relationships and differences among the variables under study.

*Descriptive analysis results.* The descriptive analysis evaluates various digital technology implementation cases within business operations, highlighting successful integrations and notable challenges in decision making and deployment strategies.

One of the most prominent success cases is implementing the MyDello platform, which enables clients to access optimal international shipping options instantly. The platform provides immediate multi-modal transport solutions, significantly reducing proposal waiting times and enhancing customer satisfaction. This solution also contributes to internal process optimization by minimizing manual involvement in logistics planning. Another positive example is the deployment of the TPS ABM cloud solution, which successfully optimized routing processes and resulted in a 20% reduction in logistics costs. Similarly, the inventory automation system, implemented following a successful pilot in Europe, proved the effectiveness of automated inventory management. It aimed to minimize manual errors, enhance stock visibility, and

improve fulfillment speed—successfully achieved objectives. Implementing the Warehouse Management System (WMS) in two operational warehouses also yielded positive outcomes. A strategic approach was taken by aligning the system rollout with the annual inventory process, ensuring minimal disruption to operations. As a result, a higher volume of order lines was processed with the same number of employees, leading to faster delivery times and improved service levels. However, several cases highlighted the complexities and risks associated with digital transformation. WMS migration from the legacy system to a new solution failed to adhere to a structured implementation plan. Consequently, order processing was halted for an entire week. This case underscores the importance of phased rollouts and the presence of in-house IT expertise. A similar scenario occurred during the deployment of a routing solution, where decisions were made without a detailed operational framework. The implementation process lacked coordination and revealed gaps in internal technological competencies, resulting in suboptimal performance.

In contrast, a tracking system proved a strategic advantage, enabling process optimization and reinforcing customer-centric flexibility. This technology differentiated the company in a competitive market and paved the way for further digital process innovations. Respondents emphasized the critical role of structured decision-making methods in successfully adopting digital technologies. Approximately 45% of respondents rated decision making in digital transformation as very important, 36% as high importance, 15% as moderately important, and only 3% considered it of low importance. These findings highlight a broad recognition of the strategic value of well-grounded decisions during technological change. Overall, the implementation of technologies such as MyDello, DVS, ESRI/ArcGIS, third-generation (C3) computed tomography scanners, routing systems, WMS, inventory automation, digital integration, RPA, SAP, and IFS was largely perceived as well-executed and effectively integrated. However, other solutions—particularly ERP, inventory management systems, AI, AGV/AMR, and Ortec—revealed a need for improved decision-making processes and more structured implementation strategies. Ultimately, the findings demonstrate that technological success is not solely determined by the tools adopted but by the quality of decisions and the adaptability of implementation strategies.

*Ordinal logistic regression analysis results.* To analyze decision-making in the context of competitiveness, statistical data were processed using the EViewer statistical package. The data were analyzed using an ordered logistic regression model, where the dependent variable, CC, consists of three ordered categories. The independent variable included in the model was IDT. The estimated model equations are presented in Equations (2) and (3).

$$\text{logit}(P(Y \leq 1)) = 4.84 - 1.4 * X \quad (2)$$

$$\text{logit}(P(Y \leq 2)) = 6.88 - 1.4 * X \quad (3)$$

X represents the independent variable; lowest 4.84 and middle 6.88 are the threshold parameters (cutpoints) that define the boundaries between the ordinal categories; -1.40 is the estimated coefficient for IDT (note that the ordered logit formulation subtracts the linear predictor from each threshold)

The results indicate that higher values of IDT are associated with a decreased likelihood of being in the lower categories of CC, and thus increase the probability of falling into higher outcome categories. The IDT coefficient is statistically significant ( $p = 0.012$ ), suggesting a meaningful relationship between IDT and the ordering of the dependent variable. Model fit statistics support the adequacy of the model, with a pseudo  $R^2$  value of 0.30, and a statistically significant likelihood ratio test (LR statistic = 20.86,  $p < 0.001$ ). These indicators suggest that the model explains a substantial proportion of the variance in outcomes. Furthermore, the model



includes two statistically significant threshold points—LIMIT\_4:  $C(2) = 4.84$  ( $p = 0.035$ ) and LIMIT\_5:  $C(3) = 6.88$  ( $p = 0.005$ )—which delineate the three ordinal categories and define the latent scale underlying respondents' transitions between levels of perceived competitive advantage.

Dependent Variable: CC				
Method: ML - Ordered Logit (Newton-Raphson / Marquardt steps)				
Date: 04/13/25 Time: 17:25				
Sample: 1 33				
Included observations: 33				
Number of ordered indicator values: 3				
Convergence achieved after 7 iterations				
Coefficient covariance computed using observed Hessian				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
IDT	1.408221	0.561960	2.505910	0.0122
Limit Points				
LIMIT_4:C(2)	4.843998	2.304195	2.102252	0.0355
LIMIT_5:C(3)	6.888062	2.457820	2.802508	0.0051
Pseudo R-squared	0.303363	Akaike info criterion	1.633191	
Schwarz criterion	1.769237	Log likelihood	-23.94765	
Hannan-Quinn criter.	1.678966	Restr. log likelihood	-34.37611	
LR statistic	20.85691	Avg. log likelihood	-0.725686	
Prob(LR statistic)	0.000005			

Figure 1. Results of ordinal logistic regression Analysis

Figure 1 presents the results of the ordinal logistic regression model that was employed to investigate the effect of digital technology implementation (IDT) on the perceived level of competitive advantage (CC) within the logistics sector. The dependent variable, CC, represents an ordinal measure of competitive advantage, categorized into three ordered levels ranging from low to high. The model was estimated using the maximum likelihood method and achieved convergence after seven iterations, based on a sample of 33 observations. The estimated coefficient for IDT is 1.40 (standard error = 0.5620,  $z = 2.506$ ,  $p = 0.0122$ ), indicating a statistically significant positive effect. This suggests that higher levels of digital technology implementation are associated with an increased likelihood of reporting stronger competitive advantage. Overall, the findings provide empirical evidence that the implementation of digital technologies significantly contributes to enhancing competitive advantage in the logistics sector, underscoring the strategic importance of digital transformation in modern logistics operations.

Figure 2 presents the histogram and descriptive statistics of the residuals from the regression model. The distribution is centered around zero, with a mean of approximately  $3.64 \times 10^{-13}$  and a median of 0.007, suggesting no systematic bias. The residuals range from  $-0.77$  to  $0.89$ , indicating a moderate spread, as further confirmed by the standard deviation of 0.44.

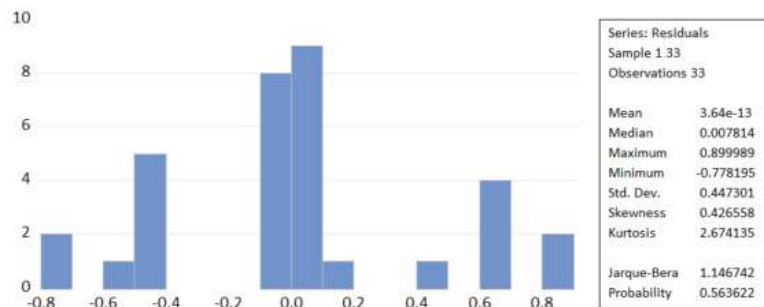


Figure 2. Histogram and descriptive statistics of model residuals

The residuals exhibit slight positive skewness (0.43) and a kurtosis of 2.67—both values reasonably close to those of a normal distribution. The Jarque-Bera statistic of 1.15 and its associated p-value of 0.56 indicate that the null hypothesis of normality cannot be rejected, thus supporting the assumption of normally distributed residuals. These diagnostic results confirm that the error terms behave in accordance with the assumptions of the regression model, reinforcing the reliability and validity of the estimated results.

## 5. DISCUSSIONS

This study makes a significant contribution to the existing literature on the strategic implementation of digital technologies in logistics by addressing several research gaps identified in prior academic works. While numerous scholars have emphasized the theoretical foundations of strategic management (e.g., Chandler, 1969; Porter, 1980; Mintzberg, 1994; Ansoff, 1987), there has been a lack of empirical research exploring how these principles are operationalized in the context of real-world digital technology implementation within logistics systems. This research bridges that gap by combining theoretical insights with field-based evidence drawn from semi-structured interviews and regression analysis, offering a more nuanced understanding of how technology implementation decisions translate into competitive advantage. Importantly, this research also offers methodological originality by applying a replicable regression model that incorporates industry-specific variables and decision-making dimensions rarely captured in previous studies. The integration of qualitative and quantitative data sources—namely, semi-structured interviews triangulated with organizational performance metrics—provides a multi-dimensional approach that enhances both analytical robustness and practical relevance. The uniqueness of the sample, drawn from diverse logistics firms across the EU, and the inclusion of variables, strategic alignment, and implementation quality make this model a valuable tool for future academic and managerial application. Building upon the methodological foundation, this study further explores the strategic implications of technology adoption in logistics. Several existing studies (e.g., Gunasekaran & Ngai, 2003; Christopher, 2016; Wamba & Chatfield, 2009) have highlighted the role of technology in enhancing logistics performance, particularly through automation, data analytics, and real-time information systems. However, relatively few have examined how structured decision-making frameworks influence the successful adoption and integration of these technologies. This article responds to that gap by demonstrating that decision quality and implementation strategy are equally important, or potentially more influential, than the technologies themselves. Furthermore, while Moghaddam et al., (2025) and Zhang et al., (2023) have explored the influence of AI and Industry 4.0 technologies on logistics decision-making,

they have largely focused on conceptual frameworks without empirical validation. This study extends their work by presenting statistically significant evidence ( $\beta = 0.4552$ ,  $p = 0.0293$ ) supporting the relationship between the implementation of digital technologies (IDT) and competitive advantage (CC), using real-world data from logistics firms operating in the EU. By empirically validating a regression model that quantifies this relationship, the study provides a concrete framework for assessing the direct impact of digital technologies on competitive advantage in logistics. This study also addresses a notable gap in the literature concerning failed or suboptimal technology implementations. While most existing research emphasizes success stories (e.g., Donald et al., 2020; Varella et al., 2013), this article presents counterexamples—such as failed WMS migrations and routing system deployments—that underscore the consequences of poor planning and insufficient decision support. These findings contribute to the underexplored discussion on risk management and strategic preparedness in logistics transformations. In addition, although authors such as Apak et al., (2013) and Faulin et al., (2018) have discussed decision-making models in logistics, they do not fully integrate sustainability or resilience as strategic dimensions. This study builds on the recent findings of Charłampowicz et al. (2024), emphasizing that integrating sustainability into decision-making is not merely an ethical imperative but also a strategic one. Our results confirm that well-structured digital transformation initiatives can simultaneously support environmental objectives and enhance systemic resilience. Lastly, while Zhou et al., (2024) and Melnyk et al., (2010) have emphasized the importance of IT capability and supply chain resilience, they stop short of providing concrete frameworks for assessing technology's direct influence on competitive advantage. This study fills that gap by empirically validating a regression model that quantifies this relationship, offering a practical tool for both academics and practitioners to assess the strategic value of digital transformation initiatives.

Despite the breadth of these insights, several limitations merit consideration. The geographic focus on EU-based logistics firms may constrain the generalizability of findings to other regions with different regulatory or operational environments. Additionally, although triangulation was employed, the reliance on self-reported data from interviews introduces a degree of subjectivity that may influence interpretation. However, the study did not delve into the full complexity of each technology, nor did it encompass all digital solutions currently utilized in the logistics sector. Additionally, experts did not identify specific success factors for every technology, which may restrict the broader applicability of the results.

Future research could benefit from longitudinal studies or in-depth case analyses to address these limitations and assess the lasting effects of digital transformation strategies. Expanding the investigation to include a broader range of decision-making factors would also contribute to a deeper and more nuanced understanding of how companies can effectively harness digital technologies to maintain a competitive edge. Such inquiries could help refine strategic frameworks and guide evidence-based technology investments.

## 6. CONCLUSION

Strategic management in the logistics sector is undergoing a profound transformation driven by digital technologies, data analytics, and dynamic project management frameworks. Successful digital transformation requires integrating technological capabilities with strategic foresight, robust project management, and a culture of continuous learning and adaptation.

This multi-stage research provides a rigorous and structured approach to evaluating the strategic impact of digital technology implementation in the logistics sector. The study offers a comprehensive understanding of how digital transformation shapes competitive advantage by integrating qualitative insights from experienced professionals and quantitative analysis via

regression modeling. The five-stage methodology ensured a thorough examination of both expert perspectives and empirical data. The research maintains methodological robustness and practical relevance, from developing a targeted questionnaire and engaging seasoned logistics professionals to applying advanced statistical tools like ordinal logistic regression analysis using EViews.

Theoretical insights and empirical findings jointly reveal that effective strategic management is not limited to adopting advanced technologies—it also demands well-structured decision-making processes, organizational readiness, and alignment between technological initiatives and business objectives. The analysis of results provides a comprehensive overview of how digital technology implementation influences competitiveness in the logistics sector. The descriptive analysis reveals that while many digital transformation initiatives—such as MyDello, TPS ABM, inventory automation, and WMS systems—led to clear operational and strategic benefits, success was largely contingent upon structured decision making and careful implementation planning. Conversely, failed or problematic cases, particularly those involving ERP, routing systems, or AI integration, highlight the risks associated with insufficient preparation, lack of internal expertise, and inadequate project coordination. Respondent feedback confirms the central role of decision-making quality, with over 80% rating it as highly or very important in the context of digital transformation. Furthermore, the research validates that decision making is central to technology-driven transformation. Respondents overwhelmingly recognized structured and informed decision making as a critical success factor.

The hypothesis that "digital technology implementation (IDT) in logistics positively impacts competitive advantage (CC)" was supported by ordinal logistic regression analysis. Based on a sample of 33 observations, the results show that higher levels of IDT significantly increase the likelihood of stronger competitive advantage. Two significant threshold points delineate the ordinal categories of CC, and model fit statistics confirm adequate specification. The findings underscore the strategic importance of digital transformation in enhancing competitiveness within logistics operations. The results also emphasize the need for informed decision-making, structured implementation, and adaptability to context-specific challenges. Additionally, the analysis of residuals confirms that the model accurately captures the relationship between IDT and competitive advantage, with no significant bias or skewness. Overall, the regression model is well-specified and appropriate for examining the impact of digital technology in logistics.

Moreover, the descriptive and ordinal logistic regression analyses further validated these findings' consistency across different technological domains. Incorporating citation metrics from the Web of Science reinforces the selected technologies' academic relevance, bridging the gap between theory and practice.

Based on these findings, it is recommended that logistics companies conduct a strategic impact assessment before implementing new technologies. This assessment should evaluate not only the technological but also the long-term business impact. Such an approach would allow for better anticipation of the threats and opportunities associated with adopting innovations.

Ultimately, this study offers a roadmap for logistics firms seeking to enhance competitiveness and resilience by strategically embedding digital transformation into the heart of their decision making and management practices.

## REFERENCES

- Ansoff, H. I. (1987). Strategic management of technology. *Journal of Business Strategy*, 7(3), 28-39.

- Apak, S., Vayvay, Ö., & Feyzioğlu, O. (2013). A decision making model for the evaluation of supply chain execution and management systems. *International Journal of Computational Intelligence Systems*, 6(2), 293-306.
- Chandler Jr, A. D. (1969). *Strategy and structure: Chapters in the history of the American industrial enterprise* (Vol. 461). MIT press.
- Charłampowicz, J., Mańkowski, C., & Saikouk, T. (2024). Strategic integration of environmental sustainability in inland logistics: A multi-criteria decision-making approach. *Business Strategy and the Environment*, 33(7), 7544-7561
- Christopher, M. (2016). *Logistics and supply chain management: logistics & supply chain management*. Pearson UK.
- Donald, J. B., David, J. C., M Bixby, C., & John, C. B. (2020). *Supply chain logistics management*. McGraw-Hill Education.
- Faulin, J., Grasman, S., Juan, A., & Hirsch, P. (Eds.). (2018). *Sustainable transportation and smart logistics: Decision-making models and solutions*. Elsevier.
- Garner (2024). *Strategic Planning: The Importance of Building Up From the basis*. Retrieved from <https://www.inc.com/louise-allen/strategic-planning-the-importance-of-building-up-from-the-basics/91065348>
- Gregson, R. (1976). The development of a decision making framework for logistics management: I. The systems approach. *International Journal of Physical Distribution*, 7(3), 150-158.
- Gunasekaran, A., & Ngai, E. W. (2003). The successful management of a small logistics company. *International Journal of Physical Distribution & Logistics Management*, 33(9), 825-842
- Hair Jr, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis*. In *Multivariate data analysis* (pp. 785-785).
- Huo, B., Qi, Y., Wang, Z., & Zhao, X. (2014). The impact of supply chain integration on firm performance: The moderating role of competitive strategy. *Supply Chain Management: An International Journal*, 19(4), 369-384.
- Jurczak, M. (2020). The role of IT systems in strategic management and building competitive advantage of companies in the logistics industry. *Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Ekonomia i Organizacja Logistyki*, 5(1), 29-40.
- Klaus, P., & Krieger, W. (Eds.). (2013). *Gabler lexikon logistik: management logistischer netzwerke und flüsse*. Springer-Verlag.
- Lewis, A. O., Helm-Stevens, R., & Ansoff, R. (2018). *Implanting strategic management*. Springer.
- Meijer, B. R. (2000, August). Strategic management of technology, the logic of knowledge logistics. In *Proceedings of the 2000 IEEE Engineering Management Society. EMS-2000* (Cat. No. 00CH37139) (pp. 111-116). IEEE.
- Melnyk, S. A., Davis, E. W., Spekman, R. E., & Sandor, J. (2010). *Outcome-driven supply chains*. MIT Sloan management review.
- Mintzberg, H. (1994). *Rise and fall of strategic planning*. Simon and Schuster.
- Moghaddam, G. K., & Karimzadeh, M. (2025). *AI-Driven Digital Transformation and Sustainable Logistics: Innovations in Global Supply Chain Management*.
- Porter, M. E., & Strategy, C. (1980). *Techniques for analyzing industries and competitors. Competitive Strategy*. New York: Free, 1.
- Porter, M. E. (1985). Technology and competitive advantage. *Journal of business strategy*, 5(3), 60-78.

- Rahman, A. (2019). The impact of strategic planning on enhancing the strategic performance of banks: Evidence from Bahrain. *Banks and Bank systems*, 14(2), 140-151
- Shee, H., Miah, S. J., Fairfield, L., & Pujawan, N. (2018). The impact of cloud-enabled process integration on supply chain performance and firm sustainability: the moderating role of top management. *Supply Chain Management: An International Journal*, 23(6), 500-517.
- Trstenjak, M., Opetuk, T., Đukić, G., & Cajner, H. (2022). Logistics 5.0 implementation model based on decision support systems. *Sustainability*, 14(11), 6514.
- Varella, L., & Buss Gonçalves, M. (2013). Information technology as the main competence in the design of the strategic planning of logistics platforms. *Journal of technology management & innovation*, 8(3), 160-172.
- Wamba, S. F., & Chatfield, A. T. (2009). A contingency model for creating value from RFID supply chain network projects in logistics and manufacturing environments. *European Journal of Information Systems*, 18(6), 615-636.
- Wang, G., Gunasekaran, A., Ngai, E. W., & Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. *International journal of production economics*, 176, 98-110.
- White, C. (2017). *Strategic management*. Bloomsbury Publishing.
- Zhang, Y., Ma, X., Pang, J., Xing, H., & Wang, J. (2023). The impact of digital transformation of manufacturing on corporate performance—The mediating effect of business model innovation and the moderating effect of innovation capability. *Research in International Business and Finance*, 64, 101890.
- Zhao, G., Ye, C., Dennehy, D., Liu, S., Harfouche, A., & Olan, F. (2024). Analysis of barriers to adopting Industry 4.0 to achieve agri-food supply chain sustainability: A group-based fuzzy analytic hierarchy process. *Business Strategy and the Environment*, 33(8), 8559-8586.
- Zhou, J., Hu, L., Yu, Y., Zhang, J. Z., & Zheng, L. J. (2024). Impacts of IT capability and supply chain collaboration on supply chain resilience: empirical evidence from China in COVID-19 pandemic. *Journal of Enterprise Information Management*, 37(2), 777-803.
- Yu, Y., Huo, B., & Zhang, Z. J. (2021). Impact of information technology on supply chain integration and company performance: evidence from cross-border e-commerce companies in China. *Journal of Enterprise Information Management*, 34(1), 460-489.
- Yuan, Y., Tan, H., & Liu, L. (2023). The effects of digital transformation on supply chain resilience: a moderated and mediated model. *Journal of Enterprise Information Management*, 37(2), 488-510.



## RANKING OF THE MOST IMPORTANT GROUPS OF CRITERIA FOR THE SELECTION OF THE UNDERGROUND MINING METHOD FOR COAL DEPOSITS

Mohsen Jamshidi<sup>1</sup>, Dejan Bogdanović<sup>2\*</sup>, Hesam Dehghani<sup>3</sup>

<sup>1</sup> Arya Kani Jouyan Engineering Company, Iran

<sup>2</sup> University of Belgrade, Technical Faculty in Bor

<sup>3</sup> Hamedan University of Technology – Department of Mining Engineering, Iran

**Abstract:** The selection of the mining method for coal deposits is a very complex process that leads to the most important decision for future exploitation. This process is now implemented as a multi-criteria decision problem in which the best mining method is selected from many alternatives. In this paper, the most important groups of factors (groups of criteria) are considered to determine their influence on the mining method selection process. Six groups of criteria were considered: natural – geological conditions, technical conditions, economic conditions, technological (organisational) conditions, safety conditions and environmental protection. These criteria were ranked using the AHP method. The group decision method for ranking was applied by mining experts and managers of various underground mines in Serbia and Iran. The results show the importance of each group of criteria for selecting the best mining method for coal deposits and the differences between them. It also shows how important the process of ranking groups of criteria is for the selection of the best mining method.

**Keywords:** Group of Criteria Ranking, Mining Method, AHP, Coal Deposits.

### 1. INTRODUCTION

The selection of an appropriate mining method is a complex and time-consuming process that requires a high level of expertise and experience. This decision-making process is a major challenge for mining engineers and managers. To ensure an accurate and effective evaluation, decision makers must analyze extensive data sets and consider multiple criteria that influence the selection process.

The groups of criteria that influence the selection of a mining method for coal deposits vary in importance and reliability; some are dynamic, while others remain constant. Certain

---

\* Corresponding author: [dbogdanovic@tfbor.bg.ac.rs](mailto:dbogdanovic@tfbor.bg.ac.rs)

Mohsen Jamshidi, ORCID: 0000-0002-9518-3991

Dejan Bogdanovic, ORCID: 0000-0002-4871-4366

Hesam Dehghani, ORCID: 0000-0003-2029-9540

parameters may exclude certain methods or technologies, making some criteria irrelevant in certain contexts.

This emphasises that the optimal selection of an underground mining method is primarily determined by influencing factors — groups of criteria. Therefore, the identification and evaluation of these groups of criteria is of crucial importance. In order to quantify their influence on mining method selection, a ranking process as presented in this paper is required. In particular, the ranking for coal deposits was carried out using a group decision approach. When selecting mining methods on a case-by-case basis, the ranking should be adapted to the specific conditions of the particular mine or coal deposit.

## **2. LITERATURE REVIEW**

Numerous methods have been developed in the past for the selection of mining methods. The most relevant scientific literature on this topic goes back to the first qualitative classification systems for the selection of mining methods proposed by Boshkov and Wright (1973). Later studies introduced classification systems that categorize underground mining into three groups based on ground conditions and assign appropriate support types accordingly (Morrison, 1976). Laubscher (1981) proposed a selection methodology for underground mining methods based on the Rock Mass Rating (RMR) system.

The first numerical approach to the selection of mining methods was proposed by Nicholas (1981, 1992). In this method, different mining techniques are evaluated based on the ranking of specific input parameters. The method with the highest overall score is selected.

Miller et al. (1995) further refined the Nicholas method by developing the UBC method as an extension. However, a major limitation of these approaches is that they do not take into account the relative importance of the individual selection criteria. Later Hartman (1987) developed a qualitative selection framework that takes into account the geometry of the reservoir and the ground conditions to determine the optimal mining method.

Within the framework of multi-criteria decision analysis (MCDA), various approaches have been used for the selection of mining methods. These include scoring models, the Analytic Hierarchy Process (AHP), the Analytic Network Process (ANP) and methods such as TOPSIS, ELECTRE, PROMETHEE, MAUT, MACBETH, VIKOR, TODIM, Gray, MULTIMOORA and MAHP. In addition, multi-criteria decision making methods (MCDM) such as AHP and Fuzzy AHP enable evaluations based on standardized rating scales and preference functions. These methods often incorporate fuzzy logic (Bitarafan & Ataei, 2004) and are largely based on the Analytic Hierarchy Process (AHP) (Alpay & Yavuz, 2009; Azadeh et al., 2010; Bogdanovic et al., 2012).

Saki et al. (2020) proposed a novel method for selecting the optimal underground mining method by first identifying the most suitable MCDA techniques. For this purpose, a list of fifty parameters including geomechanical, geometrical, technical, economic, environmental and social factors was compiled. Subsequently, the most influential parameters — such as thickness, hanging wall RMR and production rate — were identified as critical selection criteria based on expert evaluations.

## **3. DATA AND METHODOLOGY**

The studies are being carried out in various underground mines in Serbia and Iran. Serbia has nine underground coal mines. The annual production is up to 400,000 tons. The introduction of more modern mining methods is being considered in several mines. Iran, on the



other hand, has a larger number of mines. Total coal production amounts to around 1.8 million tons and consumption to over 3.5 million tons. Coal reserves in Iran amount to several billion tons. Consequently, there is a constant need for the application of modern mining methods in existing mines and the opening of new mines.

In general, different mining methods are used in these mines. The conditions are also very different, from the ore geometry, ore type and reserves to the mechanical properties of the rock, market conditions and safe working conditions. In addition, many mining experts and managers were involved in this study, which provides a very good basis for obtaining high-quality results.

### 3.1. AHP method

The Analytic Hierarchy Process (AHP) is a quantitative decision-making technique developed by Saaty (1980). It is used to solve complex problems. It uses a multidimensional hierarchical structure of objectives, criteria and alternatives. It consists of nine steps: Defining the decision objective, structuring the hierarchy, defining the objective, defining the criteria, alternative options, comparing the criteria and alternatives by pairwise comparisons using the Saaty scale (Table 1), calculating the priorities where the matrices are normalized and the weighting coefficients are calculated, checking the consistency and selecting the best alternative (the alternative with the highest weighting coefficient).

Accordingly, only the first step is carried out in this work, with the aim of evaluating the most important group of criteria for the selection of the mining method for coal deposits.

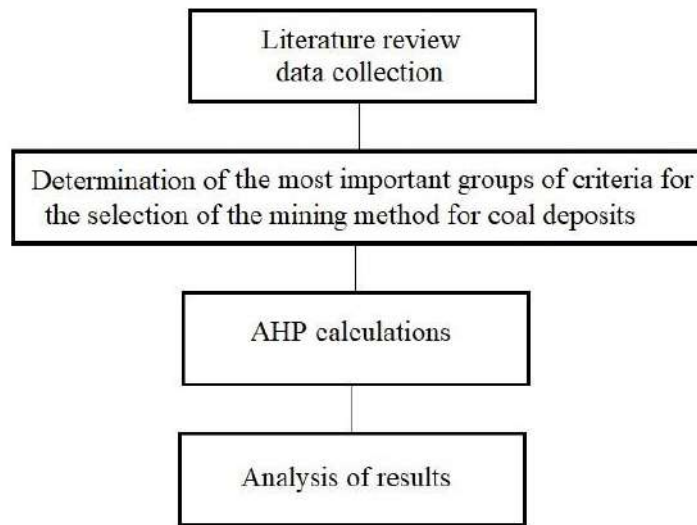
*Table 1.* Pair-wise comparison scale for AHP method (Saaty, 1980)

Verbal Judgement	Numerical Rating
Equally preferred	1
Moderately preferred	3
Strongly preferred	5
Very strongly preferred	7
Extremely preferred	9
2, 4, 6 and 8 are intermediate values	

### 3.2. The research method

The original research method was developed to rank the criteria and evaluate the degree of their influence on the selection of the mining method for coal deposits. The research method includes the following four steps: (1) literature review, data collection, (2) determination of the most important groups of criteria for coal deposit mining method selection, (3) AHP calculations, and (4) results and discussion (Figure 1.).

The study began with a literature review to define the most important groups of criteria for the selection of the mining method for coal deposits. The literature is extensive and extensive research was carried out to cover all criteria groups. Additionally, structured interviews were carried out with mining experts and industry managers to collect high-quality data and gain insights into practical decision-making processes. The final list of the most important groups of criteria was then determined. The next step was to rank the identified criteria groups using the AHP to determine their influence on the mining method selection process. Once the results of the ranking were obtained, the most important groups of criteria were identified and analysed to provide a useful basis for future mining method selection and to better understand the priorities in this process.



*Figure 1.* Schematic overview of the research method

## **4. RESULTS AND DISCUSSION**

### **4.1. Literature review, data collection**

As previously stated, the research commenced with a comprehensive literature review and interviews with mining experts and managers from Serbia and Iran. This phase was the most time-intensive and served as the foundation for subsequent research steps. Based on the collected data, a corresponding questionnaire was developed, structured in a manner that facilitated the identification and prioritization of key criteria derived from the responses received.

### **4.2. Determination of the most important groups of criteria for the selection of the mining method for coal deposits**

In this stage, the identified groups of criteria are categorized based on their inherent characteristics and their impact on mining method selection. This classification is derived from an extensive literature review and expert discussions involving mining professionals and industry managers to establish a consensus for each criteria group. Based on this approach, six primary criteria groups have been defined, namely:

- C1 – natural – geological conditions (depth of the coal seam, thickness of the coal seam, inclination of the seam, geological structure, overburden characteristics, hydrogeological conditions, hanging-wall and foot-wall conditions, coal quality).
- C2 – technical conditions (geotechnical conditions, operational factors, equipment availability and infrastructure).
- C3 – economic conditions (capital and operating costs, coal market price and demand, resource recovery and reserves, productivity and labor costs, infrastructure and transportation costs, government policies, taxes and royalties).
- C4 – technological (organisational) conditions (mine layout and development requirements, mechanization and equipment availability, workforce skill and

experience, ventilation and gas management, material handling and transportation, production planning and flexibility).

- C5 – safety conditions (ground stability and roof control, gas hazards, dust and air quality, water ingress and flooding risks, fire and explosion risks, equipment and operational safety, emergency response and escape routes).
- C6 – environmental protection (land disturbance and habitat destruction, water pollution and acid mine drainage, air pollution, soil degradation and erosion, waste generation and management, noise and vibration impacts, energy consumption and carbon footprint)

#### 4.3. AHP calculations

The AHP calculations were conducted using the group decision-making method, involving experts and managers from mining companies in Serbia and Iran. The aggregation of individual judgments (AIJ) method was employed to facilitate group decision-making. Figure 2. illustrates the hierarchical structure of the AHP problem. The criteria were deliberated and ranked until a consensus was achieved for each evaluation, utilizing the scale presented in Table 1. The comparison matrix (6×6) is provided in Table 2. The AHP calculations were performed using SuperDecisions software, and Figure 3 presents the results derived from the comparison matrix.

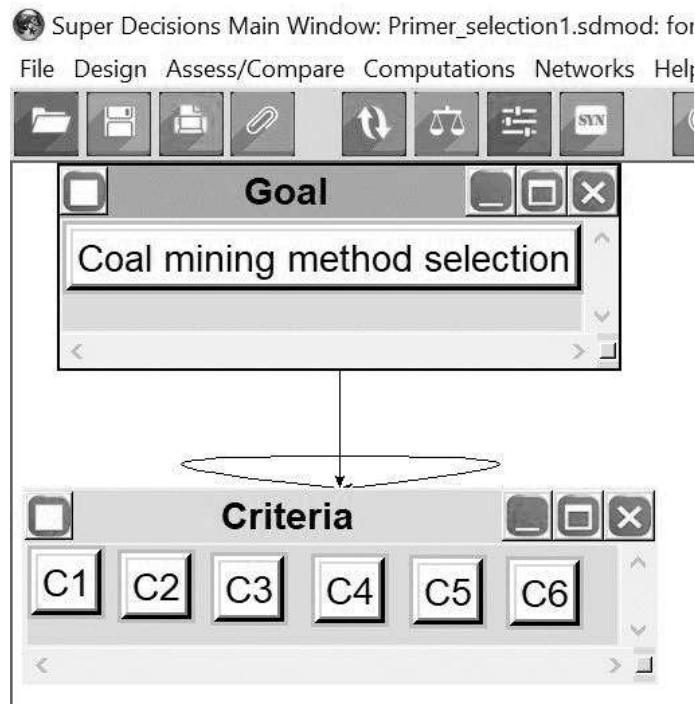


Figure 2. Hierarchical structure of the AHP problem

Table 2. Criteria comparison matrix

Criteria	C1	C2	C3	C4	C5	C6
C1	1	2	2	5	1	2
C2		1	2	3	1	2
C3			1	1	1	2
C4				1	1/2	2
C5					1	1
C6						1

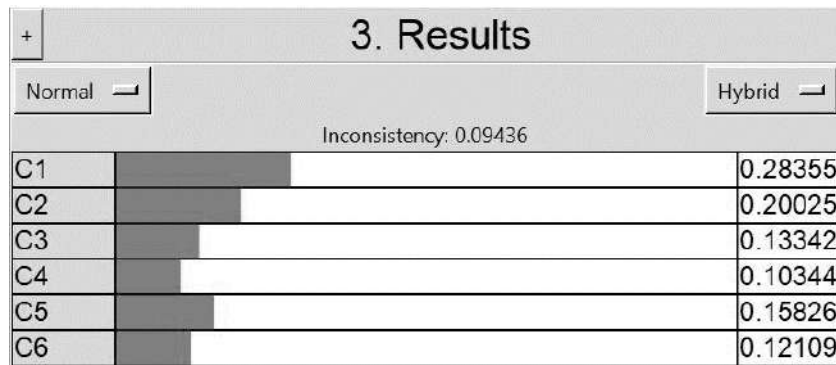


Figure 3. Results obtained by AHP calculations

#### 4.4. Results and discussion

The obtained results clearly indicate which group of criteria has the most significant influence on the selection process of mining methods for coal deposits. The results suggest that the criteria can be categorized into two distinct categories based on their impact on the selection process. The first category comprises criteria with weighting coefficients exceeding 0,2 (20%), including C1 – natural – geological conditions and C2 – technical conditions. Conversely, the second category consists of criteria with weighting coefficients below 0.2.

In the first category, the most influential group of criteria is C1 with a weighting coefficient of 0.28355. The natural – geological conditions — such as the depth and thickness of the seam, the inclination of the seam, the geological structure, the characteristics of the overburden, the hydrogeological conditions, the stability of the slope and footwall and the coal quality — are of decisive importance for the choice of the appropriate mining method. The second most important group of criteria is C2 with a weighting coefficient of 0.20025. The selection of a mining method is largely determined by the technical conditions, including geotechnical parameters, operational factors, availability of equipment and infrastructure. For example, operational factors such as production capacity, efficiency, mine layout and accessibility play a decisive role in the selection of the mining method.

The second major category of criteria is much less influential than the first. Within this category, safety conditions (C5) have the highest priority in determining the mining method. Underground coal mining is a major challenge due to numerous hazards such as the presence of hazardous gases (e.g. methane, carbon dioxide), coal dust, water and mud ingress, underground fires, spontaneous combustion of coal and the risk of coal, rock and roof collapses. All of these factors have a direct impact on the choice of mining method, as the safety risks must be effectively managed. The third group of criteria, C3 (economic conditions), ranks second within this category. Economic factors such as capital and operating costs, coal market prices, resource recovery and reserves, productivity, labor costs, government policies, taxation, and royalties must be carefully assessed to ensure the selection of a mining method that maximizes profitability while maintaining operational feasibility. Environmental protection (C6) is an increasingly critical factor in mining method selection. Potential environmental hazards must be carefully considered, with a primary objective of minimizing the ecological impact of mining activities. Preference should be given to mining methods that pose the least environmental risk. Lastly, technological and organizational conditions (C4) also play a significant role in mining method selection. These include mechanization levels, equipment availability, workforce skill, and operational experience, all of which directly influence the feasibility and efficiency of a given mining method.

## 5. CONCLUSION

The AHP method was employed to assess the most critical groups of criteria for selecting the appropriate mining method for coal deposits. Six criteria groups were analyzed: C1 (natural and geological conditions), C2 (technical conditions), C3 (economic conditions), C4 (technological conditions), C5 (safety conditions), and C6 (environmental protection).

Based on the ranking results, the criteria can be categorized into two distinct categories according to their influence on mining method selection. The first and most influential category encompasses C1 (natural and geological conditions) and C2 (technical conditions). The second category, which has a comparatively lower impact on the selection process, includes C5 (safety conditions), C3 (economic conditions), C6 (environmental protection), and C4 (technological conditions).

The ranking outcomes of these key criteria groups provide valuable guidance for mining experts and decision-makers in selecting the optimal mining method for coal deposits in their operations.

## ACKNOWLEDGMENT

The research presented in this paper was done with the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-137/2025-03/200131.

## REFERENCES

- Alpay, S. & Yavuz, M. (2009). Underground mining method selection by decision making tools. *Tunneling and Underground Space Technology*, 24, 173-184. <https://doi.org/10.1016/j.tust.2008.07.003>
- Azadeh, A., Osanloo, M. & Ataei, M. (2010). A new approach to mining method selection based on modifying the Nicholas technique. *Applied Soft Computing*, 10(4), 1040-1061. <https://doi.org/10.1016/j.asoc.2009.09.002>
- Bitarafan, M.vR. & Ataei, M. (2004). Mining method selection by multiple criteria decision making tools. *The Journal of The South African Institute of Mining and Metallurgy*, 493-498.
- Bogdanovic, D., Nikolic, D. & Ilic, I. (2012). Mining method selection by integrated AHP and PROMETHEE method. *Annals of the Brazilian Academy of Sciences*, 84(1), 219–233. DOI: 10.1590/s0001-37652012000100023
- Boshkov, S. H. & Wright, F.cD. (1973). Basic and parametric criteria in the selection, design and development of underground mining systems, SME Mining Engineering Handbook, In A.B. Cummins and I.A. Given, (eds.), SME-AIME., New York, Vol. 1, 12.2–12.13.
- Hartman, H. L. (1987). Introductory Mining Engineering. Wiley-Interscience. New York.
- Laubscher, D. H. (1981). Selection of mass underground mining methods, In: D. Stewart, ed. Design and operation of caving and sublevel stoping mines. (pp. 23-38). New York: SME-AIME, pp.23-38.
- Miller, T. L., Pakalnis, R. & Poulin, R. (1995). UBC mining method selection, mine planning and equipment selection. In (MPES), Singhal R. K. et al. (Eds). (pp. 163-168). Balkema, Rotterdam.
- Morrison, R. G. K. (1976). A Philosophy of Ground Control. (pp.125–159). Canada: McGill University, Montreal.

- Nicholas, D. E. (1981). Method selection—a numerical approach. design and operation of caving and sublevel stoping mines. United States of America: SME-AIME.
- Nicholas, D. E. (1992) Selection method. SME Mining Engineering Handbook (2nd ed.). Howard, L. Hartman, Society for Mining Engineering, Metallurgy and Exploration, Inc.
- Saaty, T.L. (1980). The Analytical Hierarchy Process. United States of America: McGraw-Hill.
- Saki, F., Dehghani, H., Shokri, B.J. & Bogdanovic, D. (2020). Determination of the most appropriate tools of multi-criteria decision analysis for underground mining method selection—a case study. *Arabian Journal of Geosciences*, 13, 1271. <https://doi.org/10.1007/s12517-020-06233-6>



## THE BUREAUCRATIC GRIP OF EUROPEAN UNIVERSITY ALLIANCES

Edita Lenkauskaitė<sup>1\*</sup>, Caio Cesar Souza<sup>2</sup>

<sup>1</sup> Klaipėda University, Lithuania

<sup>2</sup> Universidade Federal do ABC, Brasil

**Abstract:** European University Alliances (EUAs) are key instruments in the European Union's strategy for higher education integration. Funded primarily through Erasmus+ and Horizon2020. These alliances aim to enhance academic mobility, promote transnational collaboration, and foster curriculum innovation. However, despite their ambitious goals, EUAs face bureaucratic complexities that may hinder their long-term sustainability. This paper explores the governance structures of these alliances, analysing the role of bureaucratic mechanisms in shaping institutional dynamics. It also examines how digitalisation and curricular mobility present *a window of opportunity* for overcoming administrative barriers. By assessing the impact of EU policies, funding frameworks, and institutional practices, we argue that while EUAs offer a promising model for higher education cooperation, their long-term viability depends on streamlined governance and strategic policy support.

**Keywords:** European University Alliances, bureaucracy, academic mobility, governance, digitalization

### 1. INTRODUCTION

The governance of European University Alliances (EUI) is fragmented and lacks a standardised model, posing a significant challenge to their long-term sustainability and institutional integration. Next to the university's bureaucracy, new was added with the Alliance creation and participation in Erasmus+ and even more – Horizon2020 SwafS project for creation of joint research management within the Alliances. Despite financial support and strategic direction from the European Commission, bureaucratic rigidity and regulatory discrepancies among member states create barriers to effective cooperation. These challenges hinder the development of joint curricula, restrict the seamless mobility of students and staff, and complicate resource sharing among institutions.

Additionally, different governance frameworks might raise concerns about the long-term viability of the EUI initiative, as alliances struggle to transition from project-based collaborations to sustainable institutional networks. This paper examines how different governing structures, projects, outcomes, reports and similar might cause bureaucracy and what

---

\*Corresponding author: [edita.lenkauskaite@ku.lt](mailto:edita.lenkauskaite@ku.lt)

is “the window of opportunity”. The paper explores potential strategies to enhance institutional collaboration, ensure regulatory alignment, and foster deeper academic integration.

Over the past decades, the European Union (EU) has pursued an ambitious institutional agenda centred on regional integration, with mobility emerging as a fundamental pillar of supranational initiatives across various sectors, particularly in education. This focus spans all levels of education, from primary to higher education, the latter playing a crucial role in advancing European integration. To support this vision, several supranational public education policies and bureaucratic frameworks have been implemented through a series of structured programs over the decades. The Bologna Declaration, signed in 1999, was an example of a decisive milestone in the evolution of this entire policy agenda. It laid the groundwork for creating and consolidating the European Higher Education Area (EHEA), aiming to promote student mobility and integrate higher education systems across Europe. The implementation of the Erasmus Programme in 1987 had already been a significant step toward facilitating academic mobility among European countries. However, the Bologna Process and its subsequent reforms provided a more structured framework to ensure diploma recognition, the European Credit Transfer and Accumulation System (ECTS), and the development of a more cohesive and comparable higher education landscape.

The policies, programs, and bureaucracies mentioned enabled European Higher Education Institutions to form extensive networks, known as European Universities Alliances (EUA), which started as the European Universities Initiative (EUI) in 2019. The decision to support the creation of alliances was made at the 2017 Gothenburg Summit. However, the idea of strengthening cooperation among European universities had already gained traction before the official launch of the initiative in the Alpine winds. One of the most pivotal moments in this process was French President Emmanuel Macron’s speech at Sorbonne University in 2017. His address not only underscored the strategic importance of academic collaboration across borders but also positioned the EUIs as a central element of the European integration agenda. Macron’s vision extended beyond diploma recognition; he emphasised the need to forge a shared European identity among students and institutions, grounded in academic mobility and transnational cooperation. Macron’s broader vision of a European academic space that strengthens identity and mobility was the European Universities Initiative, which was conceived as a comprehensive internationalisation strategy led by the European Commission, aiming to integrate teaching, research, and civic engagement within transnational alliances (Rensimer & Brooks, 2024). More than just a financial investment, however, the initiative represents a shift in how European universities conceive mobility and academic cooperation. Rather than treating internationalisation as a set of isolated mobility experiences, the EUI promotes curricular integration and institutional interconnectedness, reinforcing the idea that mobility is not merely a movement of people but also of knowledge, pedagogical practices, and institutional policies (Rensimer & Brooks, 2024, p.2).

Since 2019, the EU has supported and financially promoted the EUI initiative, which by 2024 resulted in the formation and operation of 65 European universities involving more than 570 higher education institutions (*Observatory of EU Alliances*, n.d.). According to official data, there were 2,692 recognised higher education institutions in Europe in 2024, meaning that 20% of European higher education institutions are involved in the European University Alliances (Mazajnet, n.d.; *Universities in Europe*, n.d.). This initiative has not only strengthened institutional collaboration but also significantly enhanced academic mobility and curriculum integration across borders. By fostering interconnected networks of higher education institutions, it has provided an innovative and dynamic platform for scientific research, transnational learning experiences, and joint degree development. The initiative has



particularly attracted researchers in the social sciences, driven both by substantial financial support for alliance-building and by the structured funding mechanisms underlying the process.

The European Universities alliances were created by three key EU funding phases: 2019 (17 Alliances), 2020 (24 Alliances), and 2024 (14 Alliances). European Commission supported the creation of three major pillars: long-term joint strategy, European inter-university campuses, and Knowledge-creating teams with the Erasmus+ funding programme. Not stopping on that, the European Commission offered a more competitive call for establishing research management tools with Horizon2020 Science with and for Society financial instrument. These funding periods have allowed European higher education institutions to reflect on the advantages and challenges of forming Alliances and to apply for membership accordingly. This period has not only sustained but also increased interest in building Alliances. However, not all proposed Alliances have received EU approval, even after multiple applications. European universities within these Alliances are expected to develop and implement an integrated, long-term education strategy linked to research and innovation, to benefit society as a whole. To achieve their objectives, the EU envisions these Alliances operating under common governance structures and shared resource pools, including human resources, data, services, joint administration, and infrastructure.

Through this cooperation, the Alliances could address longstanding challenges, such as creating joint curricula more easily, enhancing high-quality inclusive education, research, and innovation, while aligning with the digital and ecological transitions of the current era. Deep institutional cooperation within the European University Alliances allows students, doctoral candidates, and staff to take advantage of opportunities for seamless mobility across so-called European university campuses. According to the European Union's vision, people can learn, teach, conduct research, work, and share services in any institution of an alliance partner, whether physically, *online*, or through hybrid formats. This seamless mobility is sought at all levels of study, with the ambitious goal of ensuring that at least 50% of the students in an alliance benefit from it.

*“Three “key elements” were developed to indicate what is expected from successful alliances by 2025. The first includes, firstly, a shared, integrated, and long-term joint strategy for education, with connections to research, innovation, and society at large; secondly, an “interuniversity” European higher education campus, where all students and staff can move seamlessly (physically or virtually) between any of the partner institutions that have incorporated mobility at all levels and offer new joint and flexible curricula; and finally, European knowledge creation teams made up of students, academics, and other relevant stakeholders for the alliances, aimed at addressing social challenges and other issues in a multidisciplinary way.” (GUNN, 2020, p.18)*

As part of the work process, Alliances must develop common, flexible learning programmes based on an interdisciplinary and cross-sectoral approach, integrating student-centred teaching and innovative pedagogy. The EU has committed to examining the creation of a *European Higher Education Degree*, based on jointly developed European criteria at national, regional, and institutional levels. This collaborative framework seeks to challenge bureaucratic elements and foster closer institutional cooperation, promoting innovative and inclusive education across participating institutions. While these ambitions are significant, the long-term sustainability of the Alliances remains an open question. The EU has primarily provided financial incentives such as Erasmus+ funding for establishing Alliances and additional support through the Horizon2020 program for scientific management, while leaving the question of long-term continuity to the independent governance of the institutions involved.

Also, the context of emerging Alliances does not have standardised requirements for a management model, so governing models differ in alliances. In addition, a small part of the alliances have legally authorised their activities. Others still operate as an informal network for project-oriented activities, which, according to scientists, has almost no institutional entrenchment and social impact (Kallinikos, 2003). Getting out of the framework of project activities and acting as a sustainable alliance requires financial and human resources. It is precisely that going beyond project activities and moving on to a permanent joint activity in which sustainable processes prevail is a sign of the sustainability of university alliances. However, this is not the only parameter that indicates the sustainability of European University Alliances.

## 2. METHODOLOGY

This study employs a qualitative approach based on document analysis, open data, and participatory observation to examine the bureaucratic structures and governance models of European University Alliances. The research methodology includes the analysis of institutional documents, official reports to the European Commission, guidelines from Erasmus+ and Horizon 2020 SwafS call. In addition, the research presents a case study of the EU-CONEXUS alliance from the observer position by working directly at the alliance level, the decision-making body. The observation of the EU-CONEXUS alliance extends to other Alliances, comparing their structures, experience and results with the SwafS project declared in various conferences, roundtables, workshops and official outlines of the project results. A comprehensive systematic literature review was made for the content analysis and conceptualisation of academic studies related to university governance, higher education internationalisation, institutional bureaucracy, and EU education policies. To frame this analysis, the study applies Weber's bureaucracy theory and Kingdon's (2003) "window of opportunity" framework, assessing how alliances can strategically adapt their governance models to enhance efficiency. Through this approach, the study seeks to identify key challenges and opportunities in the governance of European University Alliances, which will be further explored in the paper.

*Table 1. Research Methodology Overview (Source: Created by the authors, 2025)*

Methodological Approach	Description
<b>Qualitative Approach</b>	Combines document analysis, open data, and participatory observation.
<b>Institutional Document Analysis</b>	Examines reports to the European Commission, Horizon2020 project call guidelines, and SwafS project documents.
<b>Participatory Observation</b>	Involves direct engagement in EU-CONEXUS decision-making coordination bodies and direct management of SwafS projects.
<b>Comparative Analysis</b>	Assesses bureaucracy through the documentation of projects and mobility schemes, as well as governance structures that may influence the rise or fall of bureaucratic influence. Comparing alliances with the SwafS experience, assuming it might cause bureaucratic growth.
<b>Public Policy Framework</b>	Applies Weber's bureaucracy theory and Kingdon's "window of opportunity" framework to evaluate governance strategies for reducing bureaucracy.
<b>Policy and Governance Evaluation</b>	Analyses how alliances navigate bureaucratic complexities and leverage policies to sustain and integrate into the EUA market.

### *Theoretical Framework*

This analysis is based on Weber's bureaucracy theory and Kingdon's (2003) "window of opportunity" framework to assess how university alliances can leverage the political and institutional context to advance their objectives. The governance of these alliances is examined through the lens of decision-making structures, interinstitutional coordination mechanisms, and the challenges imposed by the diversity of national higher education systems.

*Table 2. Theoretical Framework Overview (Source: Created by the authors, 2025)*

Theoretical Approach	Key Concepts	Application to EUI Governance
<b>Weber's Bureaucracy Theory</b>	Hierarchical structures, formalised rules, efficiency vs. rigidity	Examines how bureaucratic governance influences decision-making and operational efficiency within EUI
<b>Kingdon's Window of Opportunity Framework</b>	Problem stream, policy stream, political stream	Identifies critical moments when policy changes can be implemented to improve alliance governance and integration

## **3. RESULTS AND DISCUSSION**

### **3.1. The Role of Horizon 2020 (SwafS) in the Development of Alliances**

European University Alliances, alongside their role in pooling studies under the Erasmus+ programme, were also invited to benefit from specialised Horizon2020 funding. This funding aimed to support the development and implementation of governance structures within these alliances, with a specific focus on managing scientific activities. An example of such an initiative is SwafS - Science with and for Society, launched as part of Horizon 2020, which funded 22 projects of the EUAs under the IBA-SwafS-SUPPORT-2-2020 call, complementing the Erasmus+ actions to strengthen institutional changes within the alliances, as presented in the Report on Good Practices from European University Alliances Projects (Pilot II), published in 2024.

One of the main focuses of SwafS within the Alliances was the development of a common research and innovation (R&I) agenda, strengthening transnational collaboration between higher education institutions. The alliances sought to map and share their research capacities, develop joint structures, and integrate open science into their academic practice. Its operationalisation within EUIs enabled institutions to develop robust regulatory frameworks, data governance mechanisms, and policies fostering responsible research and innovation. Some of the key areas, bureaucracies, and innovations that the EUIs can develop through SwafS may include:

- Strengthen governance structures to support responsible research and innovation, ensuring collaboration between institutions, policymakers, and industry;
- Enhance academic mobility through initiatives which facilitate researcher exchanges, international cooperation, and career development;
- Promote digital transformation in research and education, enabling open access, innovative publishing, and interdisciplinary collaboration;
- Support curriculum reform to better equip students with interdisciplinary skills and align educational programs with industry needs;

- Expand access to knowledge and training through MOOCs (Massive Open Online Courses) and other digital learning platforms;
- Encourage participation in Digital Projects, leveraging IT-based interaction to strengthen engagement between researchers, institutions, and society;
- Facilitate physical, virtual, and hybrid exchange models to offer flexible and inclusive international learning experiences;

To integrate these elements effectively, governance mechanisms must balance efficiency with flexibility. SwafS provides guidelines for structuring research collaboration, data management, and institutional policy alignment, offering a pathway to streamlined but effective administration. These frameworks present a unique opportunity for alliances to reduce unnecessary red tape while enhancing scientific integrity and cross-border cooperation. The SwafS project in alliances concluded in late 2023 and early 2024, resulting in an extensive collection of outputs, including best practices, guides, strategic frameworks, collections of various fields good practices, financial and administrative guidelines, feasibility studies, and policy recommendations, as presented in their reports. This initiative represents a significant step forward in developing robust scientific and administrative management tools for university alliances. However, the challenge now lies in determining the fate of these carefully crafted documents and procedures. Will they become indispensable tools for innovation and efficiency, or will they be buried under layers of bureaucracy? As Weber's theory of bureaucracy, revisited by Ferreira and Serpa (2019), suggests, rigid bureaucratic structures can sometimes hinder progress. The task ahead is to ensure that these governance frameworks serve as catalysts for meaningful collaboration rather than barriers to innovation in the European academic landscape.

### **3.2. Governance & Bureaucracy**

The Bureaucracy of the European Union ensures the implementation of standard policies and coordinates the policies of the (alliances) Member States. This often includes the interaction of national administrations with the European Union, as it will become a state apparatus (Mike, 2005). The integrated perspective shows that the European Union and the interested parties, e.g. European University Alliances, by acting the top-down and bottom-up processes, are calling for each other to change and strengthen each other's administrations, which in turn become more influential actors in the European Union. (Bach & Ruffing, 2017). The lack of administrative capacity and the interest in eliminating these shortcomings strongly impact the organisational structure and its adaptation to a superior apparatus. The advantage can likely be understood differently by countries, and alliances are likely to emerge in the alliances' totality, which consider themselves to be superior to the coordinating governing and administrative apparatus of the European Union and will choose the governance structure of the alliance independently of the logical development of the coordinating body, the European Commission. If we experience it, we will see alliances with different governance structures.

In M. Weber's model of bureaucracy, an ideal organisation has a clear hierarchical multi-level structure, usually with top-down management, where the higher layers of government oversee the lower layers of the hierarchical management structure. Our study of the publicly available governing structure schemes of the alliances leads us to conclude that those alliances that have formed a graphical representation of their alliance management structure belong to the hierarchical management category. This conclusion was brought to us because the top level of alliance governance is the European Commission (in case of project-oriented alliances) or the Collegial body (Governing board, Assembly, etc.). At the same time, these alliances establish a clear division of labour, where the tasks, responsibilities and roles are clearly defined

and assigned to specific positions within the alliance. Such management increases efficiency and productivity since it allows individuals to focus on their area of competence, but at the same time, requires a detailed description of the work or order of activity of each organ (collegial or sole) with an indication of the sphere of activity of the organ, competencies, responsibilities, deadlines for decision-making and many other nuances. This information is not publicly available on alliance websites. If it is provided, it is to a small extent. Hence, it is unclear whether or not there is a detailed documented regulation of each government/management body within the alliances.

Alliances' most common hierarchical governing structures start with a top management body consisting of university rectors (governing board) or a general meeting, like a General Assembly, to which all the alliance's managers are invited (*European Universities Initiative - Outcomes and Transformational Potential*, 2025). Followed by either a steering committee, a scientific/research council, and/or an academic council consisting of vice-rectors in the relevant field, respectively. Regardless of the hierarchical structure, the student council and the external advisory board often freely function (*European Universities Initiative - Outcomes and Transformational Potential*, 2025). However, more interesting governing structures are detected during open data analysis. Some of the alliances are put on the top-level government of the European Commission, showing their project-oriented and EC funding dependability. Minor Alliances showed flat or other types of management structures.

The European Universities Association's analysis of the governance structures of EU alliances refines the sustainability of some alliances by identifying the change from the perspective of project management to sustainable co-working as a network of organisations.

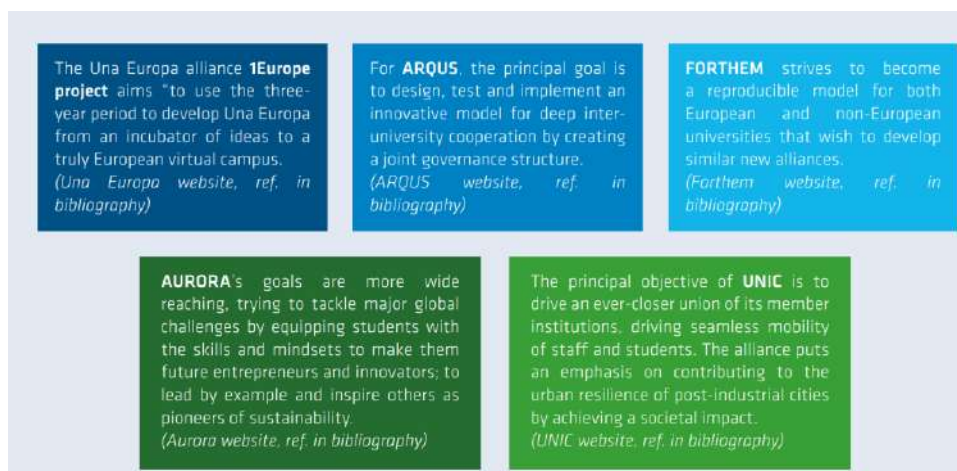


Figure 1. From project governance to sustainable collaborative governance (Esterman, 2021)

Projects and project management are often treated as a new, post-bureaucratic organisational form without separating the general perception of bureaucracy from the task being performed. The general approach to bureaucracy seems more harmful than a specific perception of bureaucracy, which can be both a nuisance and an auxiliary tool in the implementation of the project (Ologeanu-Taddei, 2020). The experience of project managers, the institutional situation and the proportion of administrative tasks in the project determine the extent to which bureaucracy is perceived as bureaucracy (Vento & Kuokkanen, 2020). While project management implies flexibility and innovation, it also includes bureaucracy, which usually affects less experienced project managers.

The EUI have incorporated the internationalization agenda of higher education within the European Union framework, where these dimensions can be visualized and understood through bureaucratic procedures and implementation processes, particularly in projects within the scope of Internationalization at Home (IaH). According to Gunn (2020), "(..) we can see how the EUI has the potential to be a driver of IaH, not only through curriculum reform and the promotion of foreign language learning but also by bringing international experiences to the local campus through virtual means." (2020, p.26). These processes reflect an institutional effort to develop international strategies, including administrative frameworks, policies, and programs that support student mobility and curriculum internationalization.

However, beyond the internal institutional dimension, bureaucratic structures and discussions extend into the political and governmental arena, where administrative rigidity becomes more pronounced, influencing the development realities of the alliances. The intersection between institutional flexibility and governmental rigidity shapes the bureaucratic landscape of these alliances, highlighting the complexities of multi-level governance in international education. This transition from institutional (at home) to governmental bureaucracy underscores the importance of governance instruments within the alliances, as well as project management tools and the elaboration of structured processes and documents. These governance instruments include steering committees, decision-making bodies, and quality assurance frameworks that regulate the alliances' activities, ensuring that projects align with the broader European education policy. The following example illustrates how these governance mechanisms, project management strategies, and document development procedures function within European higher education projects.

For example, in the European Universities Alliance EU-CONEXUS, the vast majority of documents are created during project activities or are influenced by certain activities related to project activities that need to be documented. If the document is created during project activities, then this is done in a specific work package, most often consisting of at least one person from all partner universities.

The work packages themselves always have a thematic focus, and even at the beginning of the development of the project, they have an assigned leading partner of the university who feels either that he is a leader in this field or seeks to make the most significant impact on the alliance in a particular area, or wants to hold in his hands an essential mission for him. In the work packages, representatives of universities are appointed according to the activities carried out in that package and the competencies necessary for it, so it can be said that the executive branch of universities trusts the appointed candidates and the products they create in a specific work package. The document drawn up in the work package is submitted for qualitative assessment. Depending on the project, the qualitative evaluation can be carried out by the project manager (if he has the appropriate competencies), the executive director of the alliance with a doctorate rank, or sent directly to the Research Council for a qualitative assessment. When all the corrections proposed during the qualitative assessment are made, the document is considered at a meeting of the Research Council, which is usually carried out using a remote meeting or during a written procedure. If the document is specifically related only to an academic issue, the consideration takes place in the Academic Council. Suppose the document is a political-level document after a qualitative assessment by the Research Council. In that case, it is always forwarded for approval to the Governing Board, which consists exclusively of the rectors of universities. The approved document goes back to the project manager for formal covering and submission to the European Commission Project Management Portal. After approval by the European Commission, the document is freely findable.

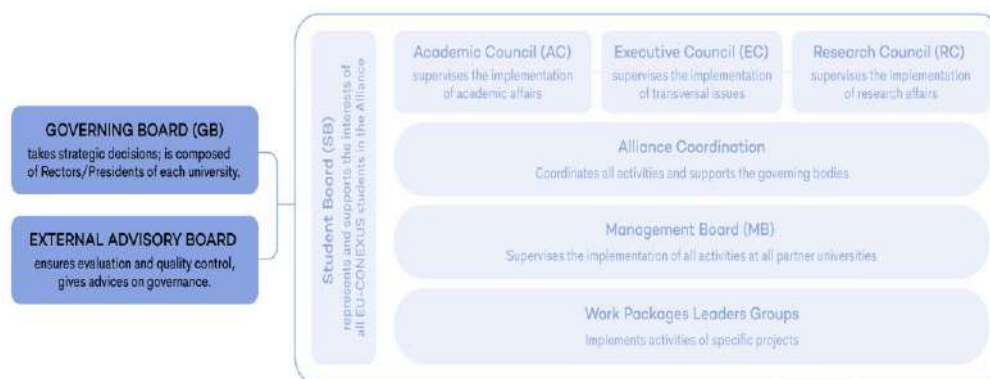


Figure 2. EU-CONEXUS alliance governance model (Source: EU-CONEXUS, 2022)

All of the Alliance's collegial governing bodies have established and approved rules of procedure, which, according to Weber, ensures consistency and predictability. These rules of procedure are drawn up within the framework of the SwafS project, as well as the optimisation of the management structure, which will leave a positive mark on the documentation processing in the long term. The period of qualitative verification of documents of one of the collegial management bodies is 2 weeks, and their meetings are held monthly, which allows you to quickly and effectively respond to new challenges.

The meetings of the governing bodies are recorded in writing, which, according to Weber, creates a large number of documents. Even if they were recorded in audio/video format, it would not change the game because virtual documents also need cloud space for saving, which is not unlimited and might cost a lot if there are a lot of saved recordings. European University Alliances, acting within the project framework, comply with the conditions dictated by the European Union, which means that the project activities have Data Management Plans (DMP). They define how documents and data are used, stored, and managed (including after the end of the project), helping to assess the sustainability of documentation and access to it. This aligns with FAIR principles (Findable, Accessible, Interoperable, Reusable).

Some documents, such as sets of good practices, reports, etc., do not intend to be constantly used by their nature, so they lie down in the registers as project documents. If there was no change of managerial personnel in alliances, and project managers remained in the activities of partnerships, the secondary use of documents would be much more frequent. Since this is not the case, since the managerial staff is changing, those newly involved in the activities of the Alliance do not know about the existence of already created documents and begin to do the same or similar work that has already been done. On the one hand, a different person has different perspectives, so there are no two identical documents on the same topic; on the other hand, the content of the previous document is likely to be outdated since, at present, in the abundance of such information, the written nomenclature is ageing lightning fast.

It is essential to mention that the collegial governing bodies of the Alliance are vice-rectors, rectors, and managers who work intensively in the activities of the university and often do not have time to carefully read and examine the documents of massively compiled project activities of which there are at least a few every month, and the deadline for their review is only 2 weeks. The approval of documents by a collegial body usually makes a formal gesture that demonstrates the unity of the Alliance, which has little to do with the genuine intention - to control the necessity and quality of the appearance of documents. However, the essential documents for the Alliance have received more attention and discussion. In the EU-CONEXUS Alliance, responsibility is shared, and control is mainly exercised by one person – the Alliance's executive director, who is employed by a leading university and is hired to act exclusively for

the sake of the Alliance. Such a system of document resource management is quite effective since it does not create obstacles to a quick response to changes. On the other hand, heuristic or approving decision-making tactics prevail, which can be either inefficient or harmful (Hunt et al., 2024). That is why it is not recommended to rely on one person's opinion and to engage more people in the decision-making procedure.

The Alliance continues to be dominated by project activities as the Alliance's primary source of funding, and project activities continue to be dominated by document preparation and validation in the developed management apparatus. Other projects will likely be less documented, or the documents will be more project-based than those focused on alliance formation activities and policies. We want to believe that the Alliance's management documents developed during the SwafS project will be sufficient and will not create the inertia to continue documenting everything, which would lead to red-tape and disrupt the Alliance's strategic manoeuvring, innovation and response to the needs of the academic and scientific communities. In 2024, the European Union promoted the creation of a community of practice for European University Alliances at the invitation of Erasmus+. This call aims to make the cross-cultural community of the alliances work more closely, exchange good practices, carry out coordinated dissemination activities in the broader higher education sector and thus become a full-fledged European university. This project will undoubtedly create even more sets of "good practices" to help improve intercultural governance. Still, it will depend on each Alliance individually and the European Commission on top of it on how they use these documents in their activities.

### **3.3. Bureaucracy, Window of Opportunity, and Mobility**

The window of opportunity concept, developed by Kingdon (2003), provides a useful lens to examine the bureaucratic evolution of European University Alliances. Kingdon argues that policies emerge and gain traction when three elements align: recognised problems, viable solutions, and political momentum. In the case of university alliances, the growing need for academic mobility and digitalisation has created an environment conducive to policy reforms that could enhance governance efficiency.

However, the implementation of full curricular mobility continues to face bureaucratic hurdles, particularly regarding credit recognition, diploma validation, and administrative coordination across different national regulatory frameworks. From a Weberian perspective, bureaucracy is essential for ensuring consistency and accountability in governance. Yet, when it becomes excessively rigid, it may obstruct rather than facilitate institutional cooperation. The alliances must, therefore, navigate the delicate balance between necessary bureaucratic structures and the flexibility required for innovation.

The creation of a European Higher Education Degree could represent a pivotal moment in reducing bureaucratic barriers, allowing students to move seamlessly across institutions without the administrative burden of individualised credit validation. Similarly, digitalisation offers another potential breakthrough, as virtual mobility programs and shared e-learning platforms could facilitate academic integration without the logistical complexities of physical relocation. This could also provide the emergence of a new model for curricular internationalisation within alliances, based on "curricular mobility" as a potential opportunity. Nonetheless, these transformations require policy alignment at both the European Union (EU) and national levels, ensuring that alliances can operate within a streamlined yet effective regulatory framework.



#### 4. CONCLUSION

European University Alliances represent a significant step forward in the EU's educational integration but still face bureaucratic challenges that may hinder their efficiency and sustainability.

EU funding, through Erasmus+ and Horizon 2020, has played a crucial role in structuring and consolidating these alliances; however, the transition to a self-sustaining model remains uncertain.

Governance structures within alliances vary significantly, ranging from hierarchical frameworks to more flexible models, which affects their ability to foster innovation and curriculum integration.

Digitalization and curricular mobility present a window of opportunity to minimise bureaucratic obstacles and enhance the impact of these alliances, yet they require further structuring and dedicated policy support.

The long-term sustainability of these alliances beyond EU funding cycles depends on the development of resilient governance mechanisms and the implementation of public policies that ensure their continuity.

#### REFERENCES

- Bach, T., & Ruffing, E. (2017). The transformative effects of transnational administrative coordination in the European multi-level system. In *Palgrave Macmillan UK eBooks* (pp. 747–763). [https://doi.org/10.1057/978-1-137-55269-3\\_39](https://doi.org/10.1057/978-1-137-55269-3_39)
- Estermann, T. (2021). *The governance models of the European University Alliances*. Www.eua.eu. <https://www.eua.eu/publications/briefings/evolving-models-of-university-governance.html>
- EU-Conexus. (2025, February 13). *Home - EU-CONEXUS*. EU-CONEXUS. <https://www.eu-conexus.eu/en/>
- EUROPEAN COMMISSION. Directorate-General for Research and Innovation, Iagher, R., Monachello, R., Warin, C., Delaney, N. et al., Science with and for society in Horizon 2020 – Achievements and recommendations for Horizon Europe, Delaney, N.(editor) and Tornasi, Z.(editor), Publications Office, 2020, <https://data.europa.eu/doi/10.2777/32018>
- EUROPEAN COMMISSION. European Research Executive Agency, O'Neill, G. and Acheson, H., Report on good practices from European University Alliances Projects (pilot II) – Projects funded under Horizon 2020 – IBA-SwafS-SUPPORT-2-2020 call, Publications Office of the European Union, 2024, <https://data.europa.eu/doi/10.2848/309549>
- EUROPEAN COMMISSION. European Universities Initiative Factsheet. Bruxelles: European Commission, 2021. Disponível em: <https://education.ec.europa.eu/document/european-universities-initiative-factsheet>. Acesso em: 30 nov. 2024.
- European Universities initiative - outcomes and transformational potential*. (2025, January 24). European Education Area. <https://education.ec.europa.eu/education-levels/higher-education/european-universities-initiative/outcomes-and-potentials>
- Ferreira, C. M., & Serpa, S. (2019). Rationalization and bureaucracy: ideal-type bureaucracy by max weber. *Humanities & Social Sciences Reviews*, 7(2), 187–195. <https://doi.org/10.18510/hssr.2019.7220>

- GUNN, A. The European Universities Initiative: A Study of Alliance Formation in Higher Education. In: MAASSEN, P.; OLSEN, J. (Eds.). *European Higher Education in a Changing World*. Cham: Springer, 2020. p. 17-30.
- Hunt, A. K., Wang, J., Alizadeh, A., & Pucelj, M. (2024). Advancing a theoretical framework for exploring heuristics and biases within HR decision-making contexts. *Personnel Review*, 53(7), 1823–1841. <https://doi.org/10.1108/pr-03-2023-0192>
- Kallinikos, J. (n.d.). *Networks as alternative Forms of organization: Some critical remarks*. AIS Electronic Library (AISeL). <https://aisel.aisnet.org/ecis2003/55/>
- KINGDON, John. *Agendas, alternatives, and public policies*. 3<sup>a</sup>. ed. New York: Harper Collins, [1984], 2003.
- MACRON, E. Discurso na Universidade Sorbonne sobre a European Universities Initiative. Paris: Presidência da República, 2017. Disponível em: <https://www.elysee.fr>. Acesso em: 30 nov. 2024.
- Mazajnet. (n.d.). *UNIRANKS 2024 - Europe University Rankings*. <https://www.uniranks.com/ranking?region=Europe&page=122>
- Mike, K. (2005). La tribu eurocratique. *Revue Française D Administration Publique*, n o 114(2), 281–292. <https://doi.org/10.3917/rfap.114.0281>
- Observatory of EU alliances*. (n.d.). <https://eua-observatory.sirislab.com/>
- Ologeanu-Taddei, R. (2020). Generative mechanisms of projects related to Enterprise Systems use in Bureaucracies: An embedded case study in a French hospital. *Systèmes D Information & Management*, Volume 24(3), 41–65. <https://doi.org/10.3917/sim.193.0041>
- RENSIMER, L.; BROOKS, R. The European Universities Initiative: further stratification in the pursuit of European cooperation? Compare: A Journal of Comparative and International Education, p. 1–19, 2024.
- Universities in Europe*. (n.d.). <https://www.4icu.org/Europe/>
- Vento, I., & Kuokkanen, K. (2020). Mapping the post-bureaucratic landscape: project managers' perception of bureaucracy in European Union Cohesion policy projects. *International Review of Administrative Sciences*, 88(2), 587–604. <https://doi.org/10.1177/0020852320969801>



## THE IMPACT OF FINTECH INNOVATION AND BANKING EFFICIENCY ON CUSTOMER LOYALTY: INVESTIGATING THE MEDIATING ROLE OF CUSTOMER TRUST

Sadiya Firdose R Z<sup>1\*</sup>, Laxmana Rao Goranta<sup>2</sup>

<sup>1</sup> School of Commerce and Management Studies, Dayananda Sagar University, Bangalore,  
India

<sup>2</sup> Dayananda Sagar University, Bangalore, India

**Abstract:** This research explores a model of customer loyalty determinants in the context of financial innovation and banking efficiency, with a focus on the mediating role of customer trust. It examines how fintech innovation influences customer satisfaction, bank efficiency, and trust in the Indian banking sector. The study aims to bridge the gap by analyzing the mediating effect of customer trust on the relationship between fintech innovation, banking efficiency, and customer loyalty. Using a quantitative approach, data were collected from 116 respondents through a structured questionnaire with a Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The data were analyzed using SPSS version 30 and employing the Structural Equation Modelling (SEM) to evaluate the hypotheses. Findings indicate that fintech innovation and banking efficiency positively and significantly influence customer loyalty. Moreover, customer trust mediates this relationship, reinforcing the importance of trust in driving customer loyalty. The study provides valuable insights for fintech companies and banking institutions aiming to enhance customer satisfaction and loyalty through trust-building and technological advancement.

**Keywords:** Fintech innovation, banking efficiency, customer loyalty, customer trust.

### 1. INTRODUCTION

The financial industry experiences a substantial transformation because fintech innovations reshape customer interactions with banks and financial institutions. These innovations improve service delivery and customer engagement, thus becoming essential for market competition. (Sethi, 2022). The advancement of technology through banking efficiency

---

\* Corresponding author: [sadiya.firdose-rs-mgt@dsu.edu.in](mailto:sadiya.firdose-rs-mgt@dsu.edu.in)

Sadiya R Z, ORCID: 0009-0000-8963-7929

Laxmana Rao Goranta, ORCID: 0000-0002-7911-7927

is a fundamental element that enhances customer satisfaction. The combination of reduced wait times with superior service quality stands as an essential factor that drives customer loyalty. (Rajan et al., 2022). Fintech innovations have rapidly evolved to reshape financial services which provide new possibilities to improve customer experiences and loyalty. The mechanisms behind how these innovations affect customer loyalty need further investigation, especially when analysing the mediating effect of customer trust. (Rajan et al., 2022; Bekker, 2024). The efficient banking operations development through streamlined processes leads to better service delivery, which creates loyal customers. The implementation and adoption of efficient banking practices lead to satisfied customers who may become more loyal as a result. (Karim et al., 2022; Bekker, 2024). The relationship between fintech innovations and customer trust is particularly important in the context of emerging markets, where traditional banking systems may lack the efficiency and accessibility that fintech solutions provide. Understanding this dynamic can help institutions tailor their offerings to meet customer needs (Vinutha & Hebbar, 2024).

The rise of fintech has fundamentally altered the landscape of financial services, enabling customers to access banking solutions through digital platforms, which enhances convenience and accessibility. This shift has made it essential for traditional banks to adapt to these changes to retain their customer base. (Kanimozhi & Dayana, 2022). As fintech companies continue to innovate, they disrupt traditional banking models by offering faster, more efficient services that cater to the evolving needs of consumers. This disruption compels established financial institutions to rethink their strategies to maintain competitiveness. (Kanimozhi & Dayana, 2022; Bajaj, 2022).

Banking efficiency, driven by technological advancements, plays an important role in improving customer satisfaction. Efficient processes reduce wait times and enhance service quality, which are essential factors that contribute to customer loyalty (Rajan et al., 2022). The efficiency of banking operations is crucial in today's fast-paced environment, where customers expect quick and seamless transactions. Improved operational efficiency not only enhances customer satisfaction but also plays a significant role in fostering long-term loyalty. (Kanimozhi & Dayana, 2022). The efficiency of banking operations, driven by fintech solutions, can lead to reduced transaction times and improved service quality. This operational efficiency is crucial for fostering customer satisfaction, which is a precursor to loyalty (Amnas et al., 2024)

Customer trust is a pivotal element in the fintech ecosystem, as it significantly impacts customers' willingness to adopt new technologies and remain loyal to financial institutions. Understanding how trust mediates the relationship between fintech innovations and customer loyalty is essential for developing effective strategies (Bekker, 2024; Shailaja & Devi, 2023). Existing research has primarily focused on the direct effects of fintech adoption on customer loyalty, often neglecting the indirect pathways through which customer trust operates. This gap highlights the need for more nuanced studies that investigate these relationships in depth (Rajan et al., 2022; Bekker, 2024). The interplay between fintech innovations, banking efficiency, and customer trust is particularly relevant in emerging markets, where the adoption of fintech solutions is rapidly increasing. Exploring this dynamic can provide valuable insights into how these factors collectively influence customer loyalty in diverse contexts. (Shailaja & Devi, 2023). By examining the mediating role of customer trust, this study aims to contribute to the existing literature by providing a comprehensive understanding of how fintech innovations and banking efficiency can be leveraged to enhance customer loyalty in the financial services sector. (Karim et al., 2022; Bekker, 2024). When customers perceive a high level of trust in a financial institution, they are more likely to engage with its services and remain loyal over time. This suggests that trust acts as a vital mediator in the relationship between fintech innovations and customer loyalty (Pea-Assounga et al., 2024; Uddin & Nasrin, 2023). By investigating how

customer trust mediates the effects of fintech innovation and banking efficiency on customer loyalty, this study aims to provide valuable insights for financial institutions seeking to enhance customer retention and satisfaction in an increasingly digital landscape.

## **2. LITERATURE REVIEW**

### **2.1. Fintech Innovations**

Fintech, defined as technology-enabled financial innovation, encompasses a wide range of services and applications that enhance the delivery of financial services, making them more accessible and efficient for consumers (Saputra et al., 2023). The Fintech innovations are reshaping the financial services landscape by leveraging technology to enhance efficiency, accessibility, and customer experience in banking and finance (Kim et al., 2024). The emergence of fintech has been significantly influenced by technological advancements and the global financial crisis, which have driven the need for innovative solutions in the financial sector (Firmansyah et al., 2022; Vijai, 2019). Various fintech innovations can be categorized into distinct groups based on their application in financial market activities, highlighting their potential impact on traditional financial services (Vijai, 2019). The integration of advanced technologies such as artificial intelligence, blockchain, and cloud computing is reshaping the fintech landscape, enabling new business models and enhancing operational efficiency (Firmansyah et al., 2022; Saputra et al., 2023).

Research indicates that fintech innovations not only improve service delivery but also foster customer engagement and satisfaction, which are critical for maintaining loyalty in a competitive market (Vijai, 2019). Despite the rapid growth of fintech, there remains a need for further research to explore the long-term effects of these innovations on consumer trust and the overall financial ecosystem (Singh et al., 2020).

### **2.2. Banking Efficiency**

The banking sector's efficiency is increasingly influenced by the integration of financial technology (fintech), which enhances operational processes and service delivery, leading to improved overall performance (Pea-Assounga et al., 2024). The integration of fintech innovations is crucial for enhancing banking efficiency, as these technologies streamline operations and improve service delivery, allowing banks to respond more effectively to customer needs (Kim et al., 2024; Sethi, 2022). Traditional banks are increasingly pressured to adopt efficient practices due to competition from agile fintech firms, which often provide faster and more cost-effective services (Rajan et al., 2022; Nguyen et al., 2024). Today customers can conduct financial transactions anywhere in the world without having to physically visit a bank branch (Judijanto et al., 2024). These innovative methods have increased the efficiency of banking operations to an unprecedented level. Customers should view innovation as the process by which a company introduces new ideas that improve the company performance (Chouhan et al., 2023). The rationale for innovative products and services depends on believing that innovative practices improve “customers’ experience”, “customers’ satisfaction”, and “customers’ loyalty” (Subramanian & Jayashree, 2022).

Research indicates that banks that embrace technological advancements can significantly reduce operational costs while simultaneously improving customer satisfaction, which is vital for maintaining a competitive edge in the market (Rajan et al., 2022; Redda, 2023). Collaborations between banks and fintech companies enhance efficiency by leveraging innovative capabilities, resulting in the development of new financial products tailored to consumer demands (Rajan et al., 2022; Sethi, 2022). The use of data analytics and modern IT

solutions in banking is essential for personalizing services, which not only boosts customer experience but also contributes to overall operational efficiency (Anand & Amutha, 2021). Continuous adaptation and innovation within banks are necessary to effectively navigate the evolving financial landscape and meet changing consumer expectations, as highlighted in various studies on banking efficiency (Kim et al., 2024).

### **2.3. Customer Trust**

Customer trust is a critical factor in the adoption of fintech services, as it significantly influences users' decisions to engage with these platforms. Factors such as ease of use, data security, and promotional strategies are essential in building this trust (Rajan et al., 2022). Customer trust plays a crucial role in mediating the relationship between service quality and customer loyalty. When customers trust a service provider, they are more likely to remain loyal, even in competitive environments (Uddin & Nasrin, 2023). Establishing customer trust should be a strategic priority for fintech firms, especially in a competitive market where new entrants can disrupt established players. Trust acts as a key differentiator in attracting and retaining customers (Firmansyah et al., 2022). Trust enhances customer satisfaction, which in turn can lead to increased loyalty. A satisfied customer who trusts the brand is more likely to engage in repeat purchases and recommend the service to others (Redda, 2023). In the context of financial services, trust is particularly important as it mitigates concerns regarding data security and privacy. Customers who trust their financial institutions are more likely to adopt digital banking services and remain loyal (Judijanto et al., 2024). Research indicates that customer trust in fintech not only affects the initial decision to use these services but also impacts long-term customer loyalty and satisfaction. This relationship underscores the importance of trust in the overall customer experience (Barbu et al., 2021). The mediation effect of trust can be observed in various sectors, including e-banking, where the quality of service and customer satisfaction are significantly influenced by the level of trust established between the customer and the institution (Uddin & Nasrin, 2023). Various factors, including perceived service quality and corporate social responsibility, influence customer trust. These elements collectively contribute to establishing a trustworthy brand in the fintech industry (Kim et al., 2024; Sethi, 2022). Overall, fostering customer trust is essential for businesses aiming to enhance customer loyalty, as it serves as a foundational element that influences satisfaction and long-term commitment (Uddin & Nasrin, 2023; Redda, 2023).

### **2.4. Customer Loyalty**

Customer loyalty is defined as a deep commitment to repurchase from the same provider in the future, which can be assessed through attitudinal and behavioural loyalty. Attitudinal loyalty reflects psychological tendencies, while behavioural loyalty indicates consistent repurchase behaviour (Dhanraj, 2019). The significance of customer loyalty lies in its direct correlation with a company's profitability and operational success. Loyal customers tend to exhibit a higher willingness to pay, provide positive word-of-mouth, and remain unaffected by competitive offers (Kim et al., 2024; Dhanraj, 2019). Key factors that influence customer loyalty include satisfaction, trust, service quality, and perceived value. These elements are particularly vital in competitive industries, such as banking, where customer retention is crucial (Kanimozhi & Dayana, 2022; Redda, 2023). Recent studies indicate a shift in customer loyalty mechanisms, particularly in the banking sector, where digital and electronic banking services are becoming increasingly relevant. This evolution necessitates ongoing research to understand the changing dynamics of customer loyalty (Amnas et al., 2024). The evolving

landscape of digital banking is reshaping customer loyalty dynamics, necessitating further exploration of how technological advancements influence customer relationships and loyalty (Bekker, 2024; Tiwari, 2023).

Based on the above literature review, the research problems can be formulated as follows:

- Does the fintech innovation enhance banking efficiency, and how do the fintech innovations influence customer loyalty?
- How does the customer trust mediate the relationship between fintech innovation and customer loyalty in the banking sector?
- Does improvement in banking efficiency through fintech innovations affect customer trust, and how does this trust impact customer loyalty?
- What methodologies can be employed to find the role of customer trust as a mediator in the relationship between fintech innovation, banking efficiency, and customer loyalty?
- How do the challenges like security and privacy issues impact customer trust in fintech services, and how this can affect customer loyalty?

### 3. RESEARCH HYPOTHESIS

#### 3.1. Direct Relationships

- H1: Fintech Innovation positively influences Customer Loyalty.
- H2: Banking Efficiency positively influences Customer Loyalty.
- H3: Fintech Innovation positively influences Customer Trust.
- H4: Banking Efficiency positively influences Customer Trust.

#### 3.2. Mediating Relationships

- H5: Customer Trust mediates the relationship between Fintech Innovation and Customer Loyalty.
- H6: Customer Trust mediates the relationship between Banking Efficiency and Customer Loyalty.

Mediating Model for Fintech Innovation, Banking Efficiency, and Customer Loyalty

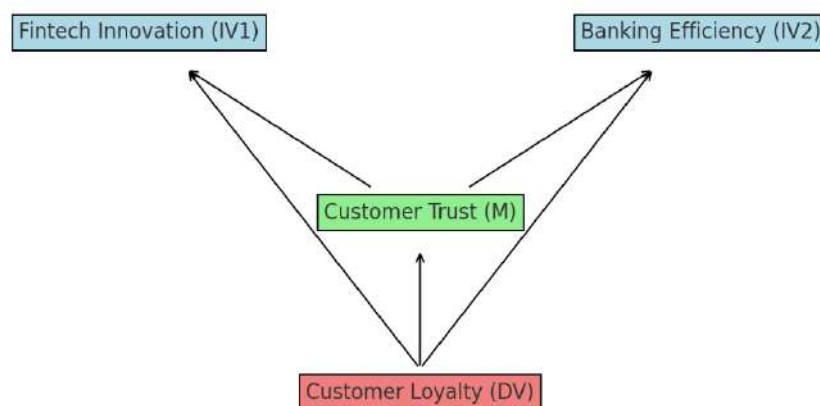


Figure 1. Conceptual Framework

## **4. DATA AND METHODOLOGY**

### **4.1. Research Approach**

This study aims to investigate the impact of fintech innovation and banking efficiency on customer loyalty, and also to assess the role of customer trust as a mediator between these variables. The study employs a quantitative research approach and empirical. To achieve the research objectives, the descriptive research design was employed.

### **4.2. Sampling design and data Collection**

The data has been collected from both primary and secondary sources, but the study is based on the primary data. The secondary data were collected from previous literature, articles, etc. The primary data was collected from 116 respondents, explaining the objective of the study, who are users of fintech services in their banking activities and are located in different cities in Karnataka, India. The sample was selected using a simple random sampling method, ensuring each individual has an equal chance of being selected. The data was collected through Google Forms, by providing a convenient and accessible method for respondents to provide their inputs. The ethical issues were addressed properly by giving assurance to the respondents about the confidentiality of their responses.

### **4.3. Variables and Measurement**

The semi-structured questionnaire was framed, which contains two sections. The first section includes demographic details like gender, age, occupation and education (Choudhary et al., 2023), and the second section contain questions related to research variables which were designed to measure two independent variables: Fintech Innovation (FI) and Banking Efficiency (BE) one mediating variable, Customer Trust (CT), and one dependent variable, Customer Loyalty (CL). The questionnaire contains both closed-ended and 5-point Likert Scale questions, with a scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The measures of scale were derived and adapted from previous studies.

For measuring the Fintech Innovation items were selected from the (Judijanto et al., 2024; Pea-Assounga et al., 2024). Banking Efficiency items were selected from (Choudhary et al., 2023) studies, Customer Trust items were selected from (Karim et al., 2022; Uddin & Nasrin, 2023) studies, and Customer loyalty items were selected from (Bekker, 2024; Judijanto et al., 2024). Some modifications have been done based on the research topic.

### **4.4. Statistical Tools/Techniques**

The data analysis was performed using SPSS version 30 and AMOS graphics version 26, following a systematic approach involving several key steps. Descriptive statistics were first calculated, including means, standard deviations, and frequencies, to describe the sample characteristics and the distribution of responses. Next, reliability analysis was conducted by computing Cronbach's alpha to assess the reliability of the measurement scales for fintech innovation, banking efficiency, customer trust, and customer loyalty. Exploratory factor analysis (EFA) was then performed to identify underlying factors and ensure the validity of the constructs measured by the questionnaire. Correlation analysis was undertaken by computing Pearson correlation coefficients to examine the relationships between the independent variables



(fintech innovation and Banking efficiency), mediating variables (customer trust), and the dependent variable (customer loyalty). Finally, the Structural Equation Modelling (SEM), a sequence of regression analysis, was employed to evaluate the estimates, the model's fit, and to find the relationship between exogenous and endogenous variables.

## 5. RESULTS AND DISCUSSION

### 5.1. Respondents' demographic statistics

*Table 1.* Demographic factors (N=116)

Demographic Factors	Items	Frequency	Valid Percentage (%)	Cumulative Percentage (%)
Gender	Male	70	60.3	60.3
	Female	46	39.7	100.0
Age	Below 25 years	29	25.0	25.0
	25 years to 40 years	42	36.2	61.2
	40 years to 55 years	26	22.4	83.6
	Above 55 years	19	16.4	100.0
Occupation	Businessman	39	33.6	33.6
	Working Professionals	50	43.1	76.7
	Others	27	23.3	100.0
Education	Graduation	43	37.1	37.1
	Post Graduation	56	48.3	85.3
	Others	17	14.7	100.0

**Factor Analysis:** The primary factor analysis was employed to ascertain the customer trust and customer loyalty towards fintech innovation and banking efficiency. The Kaiser-Meyer-Olkin (KMO) determines whether the sample size is adequate for further study or not, and whether the data are suitable for factor analysis. The threshold for evaluating KMO is above 0.90- Marvelous, 0.80 to 0.90- Meritorious, 0.70 to 0.80- Average, 0.60 to 0.70- Mediocre, 0.50 to 0.60- Terrible, below 0.50- Unacceptable (Kaiser, 1974). In the current analysis, the KMO value is 0.912, which indicates 'Marvelous', and Bartlett's Test of Sphericity tests whether the correlation matrix is an identity matrix. The significant p-value (<0.001) indicates that the data provided is suitable for conducting factor analysis.

**Factor Extraction:** Eighteen questions are factor analysed using Principal Component Analysis (PCA) with Varimax rotation. These questions were extracted into four factors explaining a total variance of 71.111 %, with eigenvalues above 1.

*Table 2.* Factor loading of variables

Factors	Items	Factor loading
Fintech Innovation (FI)	Fintech innovations have made Financial Management more convenient	0.659
	Innovative Fintech Solutions have increased the satisfaction and strengthened the customer loyalty	0.721
	Fintech Innovations increased the trust in managing finances through digital platforms	0.714
	The operations performed in FinTech service are quite simple and save a lot of time	0.743
Banking Efficiency (BE)	Customers are more satisfied with the banks, as they provide more efficient and faster services	0.629
	Banks can understand and solve each individual customer's requirements	0.627
	Banks value the time of customers by providing quick processing transactions	0.626

	The improved efficiency of banking services makes me more likely to recommend my bank to others.	0.687
Customer Trust (CT)	Customers feel confident when using FinTech services	0.668
	Trust in fintech innovations influences customers to continue using them in the future	0.769
	Innovative fintech services paired with banking efficiency build a strong foundation of customer trust.	0.779
	Customers believe that fintech innovations, along with banking efficiency, create a secure environment that strengthens the trust in their bank	0.643
	The customers have trust in the bank mainly due to its ability to deliver both innovative fintech solutions and efficient banking services	0.757
Customer Loyalty (CL)	Customers remain loyal to the platform as it provides secure and reliable services	0.785
	The selection of FinTech is a wise decision as its services inspire customer loyalty	0.768
	The bank's efficiency and innovative fintech services foster customer loyalty to the institution	0.666
	Customer trust in the efficiency of the bank's services plays a key role in Customer loyalty to the bank.	0.730
	Bank use of both fintech solutions and efficient services significantly contributes to customers' decision to stay loyal	0.772

Table 3. Cronbach's Alpha, Mean, Standard Deviation (S.D), and Pearson Correlation of the variables

	FI	BE	CT	CL
Cronbach's Alpha	0.828	0.889	0.801	0.809
Mean	3.8642	3.7629	3.7845	3.8414
S. D	0.82712	0.81883	0.76994	0.84710
FI	1	0.511**	0.695**	0.699**
BE	0.511**	1	0.555**	0.508**
CT	0.695**	0.555**	1	0.793**
CL	0.699**	0.508**	0.793**	1

Note: \*\* indicates Correlation is significant at the 0.01 level (2-tailed)

The Table 3 provides an overview of reliability (Cronbach's Alpha), central tendency (Mean), and variability (S.D) of the variables, as well as inter-correlation between variables.

The Cronbach's Alpha commonly accepted threshold is 0.7; the values suggest good internal consistency for all variables, which confirms the reliability of the data.

The Mean values indicate respondents have a positive perception of the factors.

The correlation indicates that customer trust and customer loyalty are highly correlated, whereas fintech innovation and banking efficiency are positively correlated.

Based on the above findings, it can be suggested that improving fintech innovation and banking efficiency is likely to positively influence customer trust and loyalty.

## 5.2. Hypotheses Testing Using Structural Equation Model

The maximum likelihood estimation method was used to assess the significant relevance of the structural model. The threshold criteria for acceptance of the hypothesis are based on a path having a p value less than 0.05 at a 5% level of significance.

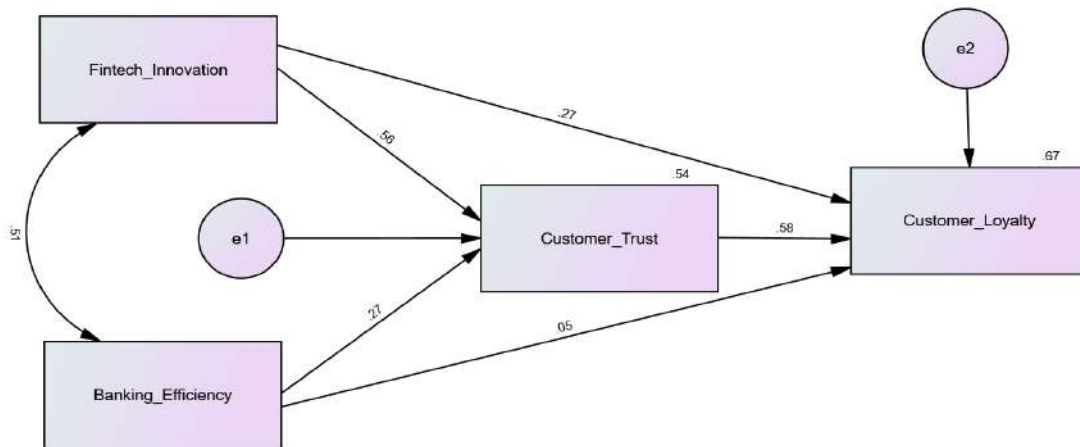


Figure 2. Path analysis

- Direct Relationship:

Table 4. Path coefficients of the structural model

Hypotheses	Variables	S.E.	C.R	P	Path Coefficient	Result
H1	FI →→ CL	0.076	3.837	***	0.286	Accepted
H2	BE →→ CL	0.068	0.737	0.451	0.048	Rejected
H3	FI →→ CT	0.069	7.541	***	0.557	Accepted
H4	BE →→ CT	0.069	3.670	***	0.271	Accepted

Note: SE; Standard error, CR; Critical ratio, Path coefficient: Standardized regression weights; and p: the probability of significance. \*\*\* indicates  $p < 0.000$

- Mediating Relationship:

Table 5. Path coefficients of the structural model

Hypotheses	Variables	S.E.	C.R	P	Path Coefficient	Result
H5	FI →→ CT →→ CL	0.070	4.671	***	0.518	Accepted
H6	BE →→ CT →→ CL	0.048	3.354	***	0.161	Accepted

By referring the above Table 4, Table 5, and Figure 2, it can be concluded that the standardized regression weights ( $\beta$ ) for fintech innovations on customer loyalty are 0.286 ( $p < 0.05$ ), inferring a positive effect on customer loyalty. So, H1 is proved and accepted, whereas standardized regression weights( $\beta$ ) for banking efficiency to customer loyalty are 0.048 ( $p > 0.05$ ), which is not significant and suggesting that Banking Efficiency does not directly influence Customer Loyalty in this model. The standardized regression weights ( $\beta$ ) for fintech innovation and banking efficiency positively influence customer trust, and H3 and H4 are proven and accepted.

In a mediating relationship, both fintech innovation and banking efficiency positively influence customer loyalty through customer trust. Therefore, both are statistically significant, and H5 and H6 are accepted by suggesting that customer trust plays a vital role in explaining the fintech innovation and banking efficiency on customer loyalty.

Table 6. Overall Model Fit

Indices	Threshold	Model Values
Chi square ( $\chi^2$ )	pval>0.05	0.462
Normed chi square( $\chi^2/DF$ )	$1 < \chi^2 / df < 3$	0.541
Goodness of Fit Index (GFI)	>0.95	0.998
Adjusted GFI (AGFI)	>0.80	0.977
Comparative fit index (CFI)	>0.98	1.000
Root Mean Square Error of Approximation (RMSEA)	<0.05 good fit <0.08 acceptable fit	0.000-0.021
Tucker-Lewis Index (TLI)	>0.98	1.011

The above Table 6 indicates the overall model fit considering certain indices. These indices suggest that the model fits the data exceptionally well.

- Chi-square ( $\chi^2$ ): No significant difference between model and data.
- Normed Chi-square ( $\chi^2/DF$ ): Excellent fit, well within the acceptable range.
- Goodness of Fit Index (GFI): Almost perfect fit.
- Adjusted GFI (AGFI): Very good fit.
- Comparative Fit Index (CFI): Perfect fit.
- RMSEA: Very low error, indicating an excellent fit.
- Tucker-Lewis Index (TLI): Excellent fit, well above the threshold.

Overall, the model demonstrates excellent fit across all indices, suggesting it is a very well-specified model with strong explanatory power for the data.

## 6. CONCLUSION

This study aimed to evaluate the mediating role of customer trust between fintech innovation, banking efficiency, and customer loyalty in India. The study shows that fintech innovation and banking efficiency have a positive and significant influence on customer trust. The study also found that fintech innovation has positively influenced customer loyalty, whereas banking efficiency does not directly influence customer loyalty. It also revealed that customer trust has both direct and indirect impacts on fintech innovation and banking efficiency, which improves customer loyalty.

The study reveals customers are more likely to remain loyal to banks that offer advanced fintech solutions and efficient services, as these factors improve their overall banking experience and convenience.

Trust emerged as a pivotal mediator between fintech innovation, banking efficiency, and customer loyalty. Customers who trust a bank's technology and its efficient service delivery are more likely to demonstrate loyalty, making trust a critical factor for banks looking to retain customers in the digital era.

The study shows that customer loyalty is not merely a result of transactional benefits but is deeply influenced by intangible factors such as trust in the bank's technological capabilities and operational efficiency. Loyal customers, who are more satisfied with their banking experience, tend to engage in repeat transactions, recommend the bank to others, and maintain long-term relationships with the institution.

Finally, fintech innovations and banking efficiency contribute significantly to customer loyalty, but customer trust plays a crucial role in reinforcing these effects. Banks that prioritize trust-building alongside technological advancements and efficient operations will likely see stronger customer loyalty and greater long-term success in a competitive financial landscape.

## REFERENCES:

- Amnas, M. B., Selvam, M., & Parayitam, S. .. (2024). FinTech and Financial Inclusion: Exploring the Mediating Role of Digital Financial Literacy and the Moderating Influence of Perceived Regulatory Support. *Jornal of Risk and Financial Management.*, 17(108), 1-20. <https://doi.org/0.3390/jrfm17030108>
- Amnas, M. B., Selvam, M., & Parayitam, S. .. (2024). FinTech and Financial Inclusion: Exploring the Mediating Role of Digital Financial Literacy and the Moderating Influence of Perceived Regulatory Support. *Jornal of Risk and Financial Management.*, 17(108), 1-20. <https://doi.org/0.3390/jrfm17030108>
- Anand, M., & Amutha, S. (2021). Customer satisfaction towards recent trend in banking and financial services in Chengalpattu Dist. *Journal of Education: Rabindranbharati University*, 23(9), 138-146.
- Bajaj, R. (2022). Research on the Impact of Fintech on Customer Satisfaction in Gurgaon's Banking Sector. *Journal of Survey in Fisheries Sciences*, 08(3), 451-456.
- Barbu, C., Florea, D., Dabija, D.-C., & Barbu, M. (2021). Customer Experience in Fintech. *Journal of Theoretical and Applied Electronic Commerce Research*, 16, 1415-1433. <https://doi.org/10.3390/jtaer16050080>
- Bekker, F. (2024). The impact of FinTech services on customer satisfaction and customer loyalty in the banking industry in The Netherlands. *University of Twente Student Theses*.
- Choudhary, U., Dang, K., & Kaur, S. (2023). A research study on the impact of fintech on customer satisfaction in banking sector. *Journal of the Oriental Institute*, 72, 61-65. <https://www.researchgate.net/publication/37395210>
- Chouhan, V., Ali, S., Sharma, R. B., & Sharma, A. (2023). The effect of financial technology (Fin-tech) on the conventional banking industry in India. *International Journal of Innovative Research and Scientific Studies*, 6(3), 538-544.
- Dhanraj, N. (2019). The Impact Of Fintech On Banking - Indian Economy. *Think India Journal*, 22(14), 2546-2552.
- Firmansyah, E., Masri, M., Anshari, M., & Besar, M. (2022). Factors Affecting Fintech Adoption: A Systematic Literature Review. *MDPI- fintech*, 2(1), 21-33. <https://doi.org/10.3390/fintech2010002>
- Judijanto, L., Ariyanti, R., & Suryani, S. (2024). Analysis of the Impact of Mobile Banking Technology, Fintech, and Digital Transaction Security on Customer Loyalty at BUMN Banks in Indonesia. *West Science Social and Humanities Studies*, 2(8), 1299-1309.
- Kaiser, H. F. (1974). An index of Factorial Simplicity. *Psychometrika*, 39, 31-36. <https://doi.org/10.1007/BF02291575>
- Kanimozhi, V., & Dayana, R. (2022). The Key Drives of Fintech in India; Study on Customer Adoption and Attitude. *Journal of Research in Business and Management*, 66-73.
- Karim, R., Sobhani, F., Rabiul, M., Lepee, N., Kabir, M., & Chowdhury, M. (2022). Linking Fintech Payment Services and Customer Loyalty Intention in the Hospitality Industry: The Mediating Role of Customer Experience and Attitude. *Sustainability*, 14(16481). <https://doi.org/10.3390/su142416481>

- Kim, L., Jindabot, T., & Sook, F. Y. (2024). Understanding customer loyalty in banking industry: A systematic review and meta analysis. *Heliyon*, 10. <https://doi.org/10.1016/j.heliyon.2024.e36619>
- Nguyen, H. M., Thi, H. T., & Ngo, T. T. (2024). The impact of service innovation on customer satisfaction and customer loyalty: a case in Vietnamese retail banks. *Future Business Journal*, 10(61), 1-15. <https://doi.org/10.1186/s43093-024-00354-0>
- Pea-Assounga, J., Yao, H., Bahizire, G. M., B. P., & Ngapey, J. N. (2024, Feb). Effect of financial innovation and stakeholders' satisfaction on investment decisions: Does internet security matter? *Heliyon*, 1-19. <https://doi.org/10.1016/j.heliyon.2024.e27242>
- Rajan, N., George, A., Saravanan, S., Kavitha, J., & Gopalakrishnan, C. S. (2022). An Analysis on Customer Perception towards Fintech Adoption. *Journal of Logistics, Informatics and Service Science*, 9(3), 146-158. <https://doi.org/10.33168/LISS.2022.0311>
- Redda, E. H. (2023). E-banking quality and customer loyalty: The mediating role of customer satisfaction. *Banks and Bank Systems*, 18(2), 177-188. [https://doi.org/10.21511/bbs.18\(2\).2023.15](https://doi.org/10.21511/bbs.18(2).2023.15)
- Saputra, M., Santosa, P. I., & Permanasari, A. E. (2023). Consumer Behaviour and Acceptance in Fintech Adoption: A Systematic Literature Review. *Acta Informatica Pragensia*, 12(2), 468–489. <https://doi.org/10.18267/j.aip.222>
- Sethi, C. (2022). A study on Consumer Behaviour towards Fintech in the Banking Sector. *International Journal of Social Science and Economic Research*, 7(7), 1905-1953. <https://doi.org/10.46609/IJSSER.2022.v07i07.013>
- Shailaja, P., & Devi, R. (2023). Impact of Fintech on Customer Satisfaction– A Study of Selected Banks in Hydrabad. *International Journal of Research in Management Sciences (IJRMS)*, 11(2), 1-9. <https://iaeme.com/Home/issue/IJRMS?Volume=11&Issue=1>
- Singh, S., Sahni, M. M., & Kovid, R. K. (2020). What drives FinTech adoption? A multi-method evaluation using an adapted technology acceptance model. *Emerald- Management Decision*, 58(8), 1675-1697. <https://doi.org/10.1108/MD-09-2019-1318>
- Subramanian, S. L., & Jayashree, C. (2022). A Study on Fintech Services Revolutionizing Traditional Banking System in an Inclusive Growth Perspective. *Journal of Management and Entrepreneurship*, 16(3(III)), 61-66. <https://www.researchgate.net/publication/366621549>
- Tiwari, P. (2023). Effect of Innovation Practices of Banks on Customer Loyalty: an SEM-ANN approach. *Benchmarking: An International Journal*, 30(10), 4536-4568. <https://doi.org/10.1108/BIJ-06-2022-0392>
- Uddin, M. K., & Nasrin, S. (2023). The Mediating Effect of Customer Satisfaction on Fintech Literacy and Sustainable Intention of Using Mobile Financial Services. *Open Journal of Business and Management*, 2488-2504. <https://doi.org/10.4236/ojbm.2023.115138>
- Vijai, C. (2019). Fintech in India- Opportunities and Challenges. *SAARJ Journal on Banking & Insurance Research*, 8(1), 42-54. <https://doi.org/10.5958/2319-1422.2019.00002.X>

Vinutha, H., & Hebbar, C. (2024). A Systematic Review on Customers' Usage Intention towards Fintech in the Banking Sector. *IRJEMS International Research Journal of Economics and Management Studies*, 3(7), 160-169. <https://doi.org/10.56472/25835238/IRJEMS-V3I7P117>





## LANGUAGE LEARNING MOTIVATION AS A REFLECTION OF PERSONAL POTENTIAL: THE ROLE OF EU ATTITUDES, ACTIVE CITIZENSHIP, EMPLOYABILITY, AND INFORMEDNESS

Tamara Verežan<sup>1\*</sup>, Zrinka Fišer<sup>2</sup>, Nataša Papić-Blagojević<sup>1</sup>, Ivana Jošanov-Vrgović<sup>3</sup>

<sup>1</sup> Novi Sad School of Business, Novi Sad, Republic of Serbia

<sup>2</sup> University of Slavonski Brod, Department of Social Sciences and Humanities EDUDpt,  
Slavonski Brod, Croatia

<sup>3</sup> University Business Academy in Novi Sad, Faculty of Organizational Studies 'Eduka',  
Belgrade, Republic of Serbia

**Abstract:** This paper looks at personal potential through the prism of language learning motivation which is a multifaceted concept socially embedded and impacted by environment, politics, and cultural preferences and attitudes. From the perspective of the European Union (EU), the study explores the association between English learning motivation and four EU-related factors: attitude toward the EU, active citizenship, employability, and informedness. During November 2024 and January 2025, 231 students from the University of Slavonski Brod in Croatia, and the Novi Sad School of Business and the Faculty of Organizational Studies 'Eduka' in Belgrade in Serbia took part in the study. The findings reveal statistically significant positive correlations between motivation for learning English and four key factors. Active citizenship in the EU showed a stronger positive correlation with English learning motivation than employability. Additionally, the research confirmed the hypothesis that the level of informedness about the EU and opinion on the EU are associated with motivation to learn English.

**Keywords:** English learning, instrumentality-promotion motivation, personal potential, EU attitude, EU informedness, active citizenship, employability.

---

\* Corresponding author: [tverezan@gmail.com](mailto:tverezan@gmail.com)

Tamara Verežan, ORCID: 0009-0002-2769-6979

Zrinka Fišer, ORCID: 0000-0001-5425-6659

Nataša Papić-Blagojević, ORCID: 0000-0002-1110-3414

Ivana Jošanov-Vrgović, ORCID: 0000-0003-3010-3206



## 1. INTRODUCTION

In today's globalized world, managing personal potential is increasingly tied to language proficiency and civic engagement. English has become the *de facto* lingua franca in the EU, serving as an essential means for communication, trade, education, and political engagement. While the EU promotes multilingualism, proficiency in English language is often perceived as a gateway to labor markets, mobility, and democratic processes—especially in non-English-speaking member states like Croatia and candidate countries like Serbia.

In these contexts, motivation to learn English is frequently driven by economic and political aspirations, which can be categorized as extrinsic motivational factors and as such contribute to instrumentality promotion motivation (Dörnyei, 2009, 2019). However, attitudes toward the EU in both countries reflect distinct historical, political, and socio-economic realities. Serbian views on EU accession remain divided, with some seeing it as a path to progress and others raising concerns about sovereignty. In Croatia, a decade of EU membership has brought both opportunities, such as increased mobility, and challenges, including youth emigration and regional disparities. Despite these developments, youth political participation remains low.

This paper examines the relationship between motivation to learn English, knowledge about and attitude toward the EU, and employability and active citizenship in the EU among young people in Serbia and Croatia. It investigates whether motivation to study English is linked to perceptions of the EU and to EU-related opportunities in terms of job opportunities and active citizenship.

By exploring these intersections, the study aims to contribute to a better understanding of how language learning, EU perceptions, and civic engagement collectively shape the personal and professional trajectories of young people in the western Balkans, and how their personal potential, i.e., English learning motivation in this case, could be better managed.

## 2. LITERATURE REVIEW

The management of personal potential is a critical construct in the fields of human resource development, leadership, and organizational behaviour, covered in a few different theories. Seligman and Csikszentmihalyi (2000) emphasize the significance of personal potential within the framework of positive psychology, highlighting its role in human flourishing and well-being. Boyatzis (2008) links it to emotional intelligence and performance enhancement. Self-determination theory (Ryan & Deci, 2000) and the concept of psychological capital (Luthans et al. 2006) complement this perspective, providing an essential theoretical basis for understanding personal potential management. This paper looks at personal potential through the prism of language learning motivation and as such falls into the management of personal potential domain but adopts a broader view as motivation is socially embedded and impacted by environment, politics and cultural preferences and attitudes.

Motivation has long been recognized as a key determinant of L2 achievement (Dörnyei, 2001). In this paper, it is assumed that the EU labour market, interest in active citizenship in the context of the EU, knowledge about the EU and attitudes towards the EU could be perceived as extrinsic factors, i.e., instrumentality motives with promotion focus. Authors who explore instrumentality promotion (Fišer, 2023, 2024a, 2024b; Dörnyei, 2005; Kormos & Csizér, 2008) do not link it explicitly to the EU, but Serbian and Croatian position in the EU and perceptions of their citizens allow for such an assumption. For example, Gvozdanović et al. (2019) found that 80% of respondents believe that employment opportunities in the EU represent a positive aspect of Croatia's accession to the EU.

Additionally, “language motivation today has an inescapably political dimension” (Ushioda, 2006, p.149) and the interplay between motivation and attitudes toward foreign cultures is well-studied in the literature. Dörnyei et al. (2006) and Lamb (2004) demonstrated that positive attitudes toward foreign cultures enhanced L2 motivation, fostering a sense of openness and interest in international communities, while Yashima (2002, 2009) explored the concept of International posture (IP), which is closely related to instrumentality, and found that the motivation to learn English may be primarily related to learners' idea of an international community where they are willing to become active members.

Active citizenship is another relevant construct in understanding the link between personal potential and L2 learning. This is a broad concept defined as “participation in civil society, community and/or political life, characterized by mutual respect and non-violence and in accordance with human rights and democracy” (Hoskins, 2006). The present study focuses specifically on the political dimension as an indicator of active citizenship (Mascherini et al., 2006).

We hypothesize that knowledge about the EU, the attitude towards the EU, and willingness to participate in EU political and economic life can impact motivation to learn English. There is a plethora of data on young people in Europe and active citizenship. Damiani et al. (2025) explored students' knowledge, attitudes, behaviours, and perceptions related to civic and citizenship education, with emphasis on European identity and contemporary issues. Jovičić Vuković & Papić-Blagojević (2018) and Jovičić Vuković et al. (2022) found attitudes towards the EU correlate with knowledge about the EU. They also concluded that Serbian youth do not have a clear position or decisive opinion on the EU, which the authors relate to the lack of formal education on the EU and the lack of information. Earlier studies found Croatian youth were ambivalent about their position and participation in politics in general: while they tended to avoid political discourse, the majority express interest in having greater opportunities to voice their opinions, and they believe they are not adequately represented within the political sphere but do not want to assume political office or roles (Gvozdanović et al., 2019). Pisarović et al. (2021) found that Croatian high-school students, although generally knowledgeable o EU are not well informed on certain areas (e.g., official languages) which impacts their attitudes on EU. However, this seems to be changing as more recent studies found that Croatian citizens achieved above-average results in the knowledge of civic rules, opportunities, democracy, institutions etc. (Schultz et al., 2025). Also, Croatian students showed above-average positive attitudes towards the EU and all its features (education, mobility, sustainability, immigration, law, education, politics and institutions) compared to students from other EU countries (Damiani et al., 2025).

### **3. DATA AND METHODOLOGY**

The study was conducted from November 2024 to January 2025 on a sample of 231 students. Students from Croatia's University of Slavonski Brod (N=69), the Novi Sad School of Business (N=90), and the Faculty of Organizational Studies Eduka in Belgrade (N=72) participated in the study. Female students account for 77.49% of the observed sample, while male students constitute 21.65%. There were only 0.87% of students who did not wish to answer.

The participants are aged 19 to 33 and are enrolled in bachelor's and master's programs. The majority of respondents are first-year bachelor students (70.13%), followed by third-year bachelor students (20.78%). First-year master's students comprise 6.49%, and the number of second and fourth-year students is around 1%.

Apart from demographic questions, students answered questions related to their motivation to learn English (IPro Scale), and four additional questions. The IPro Scale which was used to measure motivation to learn English is an instrument adapted from the L2 Motivational Self System (L2MSS) questionnaire (Dörnyei, 1990, 1994, 2019; Dörnyei et al., 2006, 2016; Taguchi et al., 2009), which is widely used to investigate motivational dimensions in language learning. The present research used the version by Fišer & Pongračić (2025) who re-evaluated the scale to better align with post-pandemic contexts and retained nine items from the original scale (Annex). The retained items reflect a self-oriented perspective, emphasizing behaviours aimed at maximizing the benefits of L2/FL learning. All items were measured using a 5-point Likert scale, ranging from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*). Next, students answered the questions regarding better employment opportunities in the EU (*The positive side of joining the EU is: better employment opportunities*), an active role in EU citizenship (*I believe that I will need English for active EU citizenship*), informedness about the EU (*How well-informed do you consider yourself about the EU?*), and opinions on the EU (*What is your general opinion about the EU?*). Afterwards, the correlations between selected motivational statements, on one side, and better employment opportunities and an active role in EU citizenship, informedness and opinion on the EU on the other side, were examined. The statistical analysis included regression analysis, ANOVA and Kruskal-Wallis tests done in SPSS.

#### 4. RESULTS AND DISCUSSION

The connection between motivation for learning English, measured through nine motivational factors, was examined through the individual dependence of these factors on variables defined by better employment opportunities and active EU citizenship (Table 1).

Table 1. Correlation Matrix – IPro scale items

Variables	Better employability	Active citizenship in the EU
P25. I have to study English; otherwise, I think I cannot be successful in my future career.	$r=0.116$ $p=0.079$	$r=0.325$ $p=0.000$
P32. The things I want to do in the future require me to use English.	$r=0.142$ $p=0.031$	$r=0.318$ $p=0.000$
P44. Studying English can be important to me because I think it will someday be useful in getting a good job.	$r=0.234$ $p=0.000$	$r=0.365$ $p=0.000$
P47. Studying English is important to me because with English I can work globally	$r=0.233$ $p=0.000$	$r=0.340$ $p=0.000$
P49. Studying English is important because with a high level of English proficiency I will be able to make a lot of money.	$r=0.111$ $p=0.092$	$r=0.318$ $p=0.000$
P51. Studying English can be important for me because I think I'll need it for further studies on my major.	$r=0.168$ $p=0.011$	$r=0.299$ $p=0.000$
P9. Studying English can be important to me because I think I'll need it for further studies.	$r=0.193$ $p=0.003$	$r=0.323$ $p=0.000$
P4. Studying English is important to me because English proficiency is necessary for promotion in the future.	$r=0.194$ $p=0.003$	$r=0.329$ $p=0.000$
P34. Studying English is important to me because it offers a new challenge in my life	$r=0.123$ $p=0.062$	$r=0.258$ $p=0.000$

Regarding the link between the *Better employability* factor and IPro scale items, the findings suggest that there is a weak positive correlation between motivation for learning English and potentially better chances for employment in the EU. Furthermore, there is no statistically significant relationship with the variables P25. *I have to learn English - career failure*, P49. *Learning English - higher earnings* and P34. *Learning English – challenge*. P44. *Studying English can will someday be useful in getting a good job* and P47 *with English I can work globally* showed the strongest, albeit moderate, correlation.

There is a statistically significant moderate positive (Lušňáková et al., 2019; De Vaus, 2002) correlation between all the items on the IPro scale and the desire to take part in the EU citizenship. Again, getting a good job and working globally (items P44 and P47) showed the strongest correlation ( $r=.365$ ,  $r=.340$ , respectively).

Furthermore, the impact of *Better employability* and *Active citizenship in the EU* on the average values of motivational factors (Table 2) was examined. It is noticeable that there is a statistically significant positive correlation, which is weak regarding the effect of the *Better employability* factor, and moderate to essential regarding the effect of the *Active citizenship in the EU* factor. This further confirms that students are more motivated to learn English in order to participate more intensively in youth initiatives and activities in the EU.

Table 2. Correlation Matrix – Average values of motivation variables

Variables	Better employability	Active citizenship in the EU
Motivation variables - average	$r=0.227$ $p=0.001$	$r=0.450$ $p=0.000$

To further verify the overall significance of the chosen model, ANOVA parameters for the impact of the *Better employability* factor on the average values of the observed motivational factors were calculated (Table 3). The model is statistically significant,  $F(1, 229) = 12.414$ ,  $p = .001$ , indicating that the predictor variable contributes meaningfully to explaining variance in *Ipro average*. However, the amount of variance explained is relatively low (5.1%). This suggests that the belief in better employment opportunities as a positive aspect of EU membership has a **small but statistically significant** predictive power on *Ipro average*. Other factors likely contribute more substantially to *Ipro average*. In this way, the low values of the correlation coefficient in observing individual influences were confirmed (Table 1). However, the low  $p$ -value (*Significance F* =  $0.001 < p = 0.05$ ) indicates that the model fits the selected data.

Table 3. ANOVA parameters for variables *Better employability* and IPro Average

	<i>Df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	4.976	4.976	12.414	0.01
Residual	229	91.789	0.401		
Total	230	96.765			

Table 4. shows the ANOVA results for *Active citizenship* as independent and *IPro average* as dependent variable. The regression model is statistically significant,  $F(1, 229) = 58.176$ ,  $p < .001$ . This indicates that the predictor variable, *I believe that knowledge of the English language will be necessary for active participation (active citizenship) in the EU*, significantly predicts the dependent variable *IPro average*. The regression explains a substantial portion of the variance (about 20.3%).

Table 4. ANOVA parameters for variables *Active citizenship in the EU* and *IPro average*

	<i>Df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	19.603	19.603	58.176	.000
Residual	229	77.163	0.337		
Total	230	96.765			

The ANOVA results strongly support the hypothesis that active citizenship in the EU is significantly associated with motivation to learn English as measured by the IPro scale. Active citizenship might be more associated with English learning motivation than employability because students perceive that employability entails qualifications and personal qualities other than English. Additionally, getting a job in EU countries does not imply only English but other languages (e.g., German, as many people from Croatia and Serbia emigrate to Germany or Austria). On the other hand, active participation in the EU is probably perceived as linked predominantly to English as *lingua franca*. However, qualitative research is needed to support these assumptions and provide more insight into reasons behind this relationship.

As for the attitude towards the EU (Table 5), the majority expressed a neutral opinion (113), followed by a positive opinion (39), while only 22 respondents expressed a negative opinion on the EU. A smaller number of respondents chose options with no opinion (47) and *prefer not to say* (10). A Kruskal-Wallis test showed a statistically significant difference in IPro scores between groups ( $\chi^2=23.31$ ,  $df=4$ ,  $p=0.00<0.05$ ), suggesting a possible link between pro-EU attitudes and motivation to learn English. Respondents with positive opinions about the EU have the highest IPro scale scores (*Mean Rank* 146.56), while those with negative or no opinion show lower scores (87.02 and 87.01, respectively). Neutral respondents and those who preferred not to disclose their opinions fall in between.

Table 5. Kruskal-Wallis test for variables *IPro average* and *General opinion on EU*

	General opinion on EU	N	Mean Rank
Ipro Scale Average	No opinion	47	87,01
	Prefer not to say	10	120,70
	Negative	22	87,02
	Neutral	113	122,73
	Positive	39	<b>146,56</b>
	Total	231	

The self-assessed level of informedness about the EU was compared to the IPro scale scores using the Kruskal-Wallis test (Table 6). The level of informedness was measured on the Likert scale. The test revealed a statistically significant difference in IPro scale scores between groups with different levels of informedness ( $\chi^2=18.87$ ,  $df=4$ ,  $p=0.01<0.05$ ). Participants who rated themselves as more informed about the EU tended to have higher IPro scale scores.

Table 6. Kruskal-Wallis test for variables *IPro average* and *Informedness about the EU*

	How informed are you about the EU	N	Mean Rank
IPro Scale average	1	17	72,03
	2	53	95,26
	3	111	124,29
	4	40	135,81
	5	10	129,35
	total	231	

The lowest *Mean Rank* was among those who reported the lowest informedness level (72.03), while the highest *Mean Rank* was among participants who rated their informedness as 4 out of 5 (135.81). The group with the highest self-assessed informedness (5 out of 5) had a slightly lower *Mean Rank* (129.35), possibly due to the small sample size (N = 10). These findings suggest that higher perceived informedness about the EU is associated with higher motivation to learn English.

## 5. CONCLUSION

The present study explored the relationship between motivation for learning English, measured by the IPro Scale and four factors: better employability opportunities and active citizenship in the EU, level of informedness about the EU, and attitude towards the EU. The results indicate there is a positive correlation between these four factors and motivation to learn English. These results align with previous research presented in Section 2. of this paper.

Better employability demonstrated a weak yet statistically significant correlation with average Ipro values. It seems that career opportunities have only a modest role in driving language learning. On the other hand, active EU citizenship exhibited a moderate positive correlation suggesting that the desire to engage actively in EU participation could be a stronger motivator for learning English. Furthermore, opinion on the EU and self-assessed informedness about the EU emerged as significant variables linked to higher levels of motivation. More positive perception and greater informedness correlate with higher motivation scores.

Nevertheless, the presented results should be taken tentatively as there are some limitations. First, the study relied on self-reported data, which may result in social desirability bias and inaccuracies in self-assessment (Fowler, 2013). Second, the study does not reveal other hidden factors which may impact all the variables. A qualitative method is needed to provide further insights and complement the present research. Third, the sample size of certain subgroups, such as participants with highly positive opinions of the EU or those with the highest self-assessed informedness, was relatively small, thus limiting the generalizability of the findings. Additionally, the disproportion in the sample prevented comparing participants from Croatia and participants from Serbia. Further research could explore these aspects as well.

To conclude, the findings highlight the multifaceted nature of language learning motivation as a personal potential in the context of EU integration. The stronger association between active citizenship and motivation might be revealing the perception of the role of English in EU political and economic sphere. The observed relationship between informedness about the EU and the opinions on the EU and language learning motivation underscore the importance of promoting awareness of EU initiatives among young people in Serbia and Croatia.

## REFERENCES

- Boyatzis, R. E. (2008). Leadership development from a complexity perspective. *Consulting Psychology Journal: Practice and Research*, 60(4), 298–313. <https://doi.org/10.1037/1065-9293.60.4.298>
- Damiani, V., Losito, B., Agrusti, G., & Schultz, W. (2025). Young citizens' views and engagement in a changing Europe. Springer Cham. <https://doi.org/10.1007/978-3-031-68631-3>
- De Vaus, D. (2002). *Analyzing Social Science Data: 50 Key Problems in Data Analysis*. The United Kingdom: Sage, London.
- Dörnyei, Z. (1990). Conceptualizing motivation in foreign-language learning. *Language Learning*, 40(1), 45-78. <https://doi.org/10.1111/j.1467-1770.1990.tb00954.x>
- Dörnyei, Z. (1994). Motivation and motivating in the foreign language classroom. *The Modern Language Journal*, 78(3), 273-284. <https://doi.org/10.1111/j.1540-4781.1994.tb02042.x>
- Dörnyei, Z. (2001). *Motivational Strategies in the Language Classroom*. Cambridge: Cambridge University Press. <http://dx.doi.org/10.1017/CBO9780511667343>
- Dörnyei, Z. (2005). *The Psychology of the Language Learner: Individual Differences in Second Language Acquisition*. Mahwah, NJ: Lawrence Erlbaum. <https://doi.org/10.4324/9781410613349>
- Dörnyei, Z. (2009). The L2 Motivational Self System. In Z. Dörnyei, & E. Ushioda (Eds.), *Motivation, Language Identity and the L2 Self* (pp. 9-42). Bristol/Buffalo/Toronto: Multilingual Matters. <https://doi.org/10.21832/9781847691293-003>
- Dörnyei, Z. (2019). Towards a better understanding of the L2 Learning Experience, the cinderella of the L2 Motivational Self System. *Studies in Second Language Learning and Teaching*, 9(1), 19-30. <http://dx.doi.org/10.14746/ssllt.2019.9.1.2>
- Dörnyei, Z., Csizér, K., & Németh, N. (2006). *Motivation, Language Attitudes and Globalisation: A Hungarian Perspective*. Clevedon: Multilingual Matters. <https://doi.org/10.21832/9781853598876>
- Dörnyei, Z., Alastair, H., & Muir, C. (2016). *Motivational Currents in Language Learning: Frameworks for Focused Interventions*. New York: Routledge. <https://doi.org/10.4324/9781315772714>
- Fišer, Z. (2023). The effect of online learning setting on motivation, intended effort, emotional engagement, and language learning strategies among non-English majors in Croatia – A pilot study. In I. Karabegovic, A. Kovacevic, & S. Mandzuka (Eds.), *New Technologies, Development and Application VI. NT 2023. Lecture Notes in Networks and Systems*, vol 687 (pp. 542-549). Springer, Cham. [https://doi.org/10.1007/978-3-031-31066-9\\_60](https://doi.org/10.1007/978-3-031-31066-9_60)
- Fišer, Z. (2024a). How is the use of ICT shaping our intended effort for learning? In I. Karabegović, I. Kovačević & A. Mandžuka (Eds.). *New Technologies, Development and Application VII. NT 2024. Lecture Notes in Networks and Systems*, vol. 1070 (pp. 279-288) Springer, Cham. [https://doi.org/10.1007/978-3-031-66271-3\\_30](https://doi.org/10.1007/978-3-031-66271-3_30)
- Fišer, Z. (2024b). Has our motivation to use English language globally changed during COVID-19? In M. H. Bilgin & H. Danis (Eds.). *45th EBES Conference Proceedings, Eurasian Studies in Business and Economics* (IN PRESS). Springer Nature Switzerland
- Fišer, Z., & Pongračić, L. (2025). Re-Evaluating the L2mss Scale in the Context of Croatian Non-English Major Students. *Iranian Journal of Language Teaching and Research*. <https://doi.org/10.30466/ijltr.2025.55206.2687>
- Fowler, F. J. (2013). *Survey research methods* (5th ed.). Sage publications.

- Gvozdanović, A., Ilišin, V., Adamović, M., Potočnik, D., Baketa, N., & Kovačić, M. (2019). *Youth Study Croatia 2018/2019*. Friedrich-Ebert-Stiftung e.V. Referat Mittel- und Osteuropa Hiroshimastr. Berlin.
- Hoskins, B. (2006). A framework for the creation of indicators on active citizenship and education and training for active citizenship. Ispra, Joint Research Centre
- Jovičić Vuković, A., & Papić-Blagojević, N. (2018). Preduzetnički potencijali studenata turizma i ugostiteljstva. *Škola biznisa*, (1), 54-72.
- Jovičić Vuković, A., Papić-Blagojević, N., Damjanović, J., Jošanov-Vrgović, I., Stankov, B., & Tomašević, D.. (2022). *How well do we know each other? Secondary-school Students' Attitudes Towards the European Union – Research Results*. Novi Sad School of Business. <http://inees.vps.ns.ac.rs/wp-content/uploads/2022/07/How-well-do-we-know-each-other-eng.pdf>
- Kormos, J., & Csizér, K. (2008). Age-related differences in the motivation of learning English as a foreign language: Attitudes, selves, and motivated learning behavior. *Language Learning*, 58(2), 327–355. <https://doi.org/10.1111/j.1467-9922.2008.00443.x>
- Lamb, M. (2004). Integrative motivation in a globalizing world. *System*, 32(1), 3-19. <https://doi.org/10.1016/j.system.2003.04.002>
- Lušňáková, Z, Lenčesová, S., & Šajbidorová, M. (2019). Growing role of CSR activities in the area of human resources management and its evaluation using quantitative methods. *Mathematics in Education, Research and Application*, 2019(5), 1, 16-29. <https://doi.org/10.15414/meraa.2019.05.01.16-29>
- Luthans, F., Avey, J. B., Avolio, B. J., Norman, S. M., & Combs, G. M. (2006). Psychological capital development: Toward a micro-intervention. *Journal of Organizational Behavior*, 27(3), 387–393. <https://doi.org/10.1002/job.373>
- Mascherini, M., Jesinghaus, J., & Hoskins, B. (2006). *Measuring active citizenship in Europe*. Joint Research Centre: Institute for the Protection and Security of the Citizen, PublicationsOffice. <https://op.europa.eu/en/publication-detail/-/publication/04fed606-d912-44d6-8c06-5c20c62dff7a>
- Pisarović, A., Tišma, S., Dujmović, K. A., & Škrtić, M. M. (2021). The Event of Croatia's EU Accession and Membership from the Croatian High School Students' Perspective. *Journal of Risk and Financial Management*, 14(1), 2. <https://dx.doi.org/10.3390/jrfm14010002>
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), 68–78. <https://doi.org/10.1037/0003-066X.55.1.68>
- Schultz, W., Ainley, J., Fraillon, J., Losito, B., Agrusti, G., Damiani, V., & Friedman, T. (2025). education for citizenship in times of global challenge. Springer Cham. <https://doi.org/10.1007/978-3-031-65603-3>
- Seligman, M. E. P., & Csikszentmihalyi, M. (2000). Positive psychology: An introduction. *American Psychologist*, 55(1), 5–14. <https://doi.org/10.1037/0003-066X.55.1.5>
- Taguchi, T., Magid, M., & Papi, M. (2009). The L2 motivational self-system among Japanese, Chinese and Iranian learners of English: A comparative study. In Z. Dörnyei & E. Ushioda (Eds.) *Motivation, Language Identity and the L2 self* (pp. 66-97), Bristol: Multilingual Matters. <https://doi.org/10.21832/9781847691293-005>
- Ushioda, E. (2006). Language motivation in a reconfigured Europe: Access, identity, autonomy. *Journal of Multilingual and Multicultural Development*, 27(2), 148–161. <https://doi.org/10.1080/01434630608668545>
- Yashima, T. (2002). Willingness to Communicate in a Second Language: The Japanese EFL Context. *The Modern Language Journal*, 86(1), 54–66.



Yashima, T. (2009). International Posture and the Ideal L2 Self in the Japanese EFL Context. In Z. Dornyei, & E. Ushioda (Eds.), *Motivation, Language Identity and the L2 Self* (pp. 144–163). Bristol: Multilingual Matters.<https://doi.org/10.21832/9781847691293-008>



## SUSTAINABILITY PROBLEM SOLVING IN THE MINING INDUSTRY: RISK ASSESSMENT APPROACH

**Snežana Sando\***

*Ministry of Agriculture, Forestry and Water Management, Directorate for Agrarian Payments,  
Serbia*

**Abstract:** This paper applies risk assessment methods for determining the risks in the mining industry based on social, environmental and economic aspects of sustainability. The objectives of this work are to examine specific indicators for the mining industry related to a given state of sustainability and to identify the risks and their quantification. The risk identification is the first step in the process of risk assessment. Hierarchical Holographic Modelling (HHM) is the initial phase of mathematical theory for creating new models in terms to indicate and illustrate new types of risks and their further treatment. Hierarchical Holographic Modelling is applied to identify sources of risks for the mining industry by considering sustainability indicators. The method Risk Filtering, Ranking and Management (RFRM) is used in this study as a technique for filtering, ranking and creating new ideas for risk management. The holistic approach in this study enables a systematic and comprehensive review of risk sources and probable emerging risks. The results of this work show determined potential sources of risks and quantified the scenarios of risks as based information for risk management. The use of graphical representation, quantified and qualified data provides the basis for further research.

**Keywords:** risk assessment, sustainability, hierarchical holographic modeling, decision making.

### 1. INTRODUCTION

The role of the mining sector in the global economy and the world's gross domestic products (GDP) has grown rapidly over the last decade, and a low growth rate will be insufficient to foster sustained economic development (World Bank, 2025). Many countries consider that the mining industry has become a focal point in the overall economic picture (Jahanmiri et al., 2021).

On the one hand the mining industry has a significant role in the world's GDP, but on the other hand, it poses challenges from a sustainability point of view. The enormous growth in

---

\* Corresponding author: [ssando75@gmail.com](mailto:ssando75@gmail.com)

Snežana Sando, ORCID: 0000-0002-1234-1924

the value of mining materials, along with the recognition of risks and the consideration of sustainability principles are reasons for increased research in this sector.

The methods Hierarchical Holographic Modelling (HHM) and Risk Filtering, Ranking and Management (RFRM) are used in this study as analytical and more usable frameworks for risk modelling, assessment and management. These methods were created by Yacov Haimes, Stan Kaplan and James Lambert (2002).

HHM is a holistic philosophy/methodology aimed at capturing and representing the inherent diverse risks of systems and their attributes - multiple aspects, perspectives, and hierarchies (Haimes, 2008). The holographic approach means seeing the system from various aspects and analysing the system from different perspectives. The hierarchical means approach involves analysing the different layers of the system.

This paper presents examples of the risks in the mining sector associated achieving a state of sustainability in social, environmental and economic aspects. The main objectives of this work are to determine specific indicators for the mining sector used in different areas of sustainability, as well as to identify and quantify risks.

## **2. LITERATURE REVIEW**

Risk-based decision making and risk-based approach in decision making are terms frequently used to indicate that some systematic process dealing with uncertainties is being used to formulate policy options and assess their various distributional impacts and ramifications (Haimes, 2008). Rausand (2013) stressed that risk-based decision making is “a process that uses quantification of risks, costs, and benefits to evaluate and compare decision options competing for limited resources”.

Kaplan (1997) defined risk as the complete set of triplets risk scenario, likelihood of scenario and resulting consequences. Also, it is possible to assess the set of scenarios which should be complete. “The risk assessment process is a set of logical, systemic, and well-defined activities that provide the decision maker with a sound identification, measurement, quantification, and evaluation of the risk associated with certain natural phenomena or man-made activities” (Haimes, 2008). The same author defined Total Risk Management (TRM) as a systematic, statistically based, holistic process that uses quantitative risk assessment and management. The positive outcomes in the theory of the risk management process are considered, but in practice mitigating losses is more in focus (Evans et al., 2007).

Sustainability indicators show the impact and importance of economic, environmental, and social performance in the decision-making process. The assessments and decisions of stakeholders are influenced by organizations' economic, environmental, and social aspects (Global Reporting Initiative, 2015). “The purpose of sustainability indicators for industry is to help measure a company's economic, environmental and social performance and to provide information on how it contributes to sustainable development” (Azapagic, 2004; Azapagic & Perdan, 2000).

“The social dimension of sustainability concerns the impacts the organization has on the social systems within which it operates” (Global Reporting Initiative, 2015). Environmental indicators are important, because they reflect the impact of care on the living and not - living world, including land, air, water and ecosystems. The economic dimension of sustainability is concerned with the impact of economic conditions on the participants in the system. The economic aspect is important because it follows the flow of capital between the different stakeholders, as well as the impacts on society as a whole and on the natural environment.

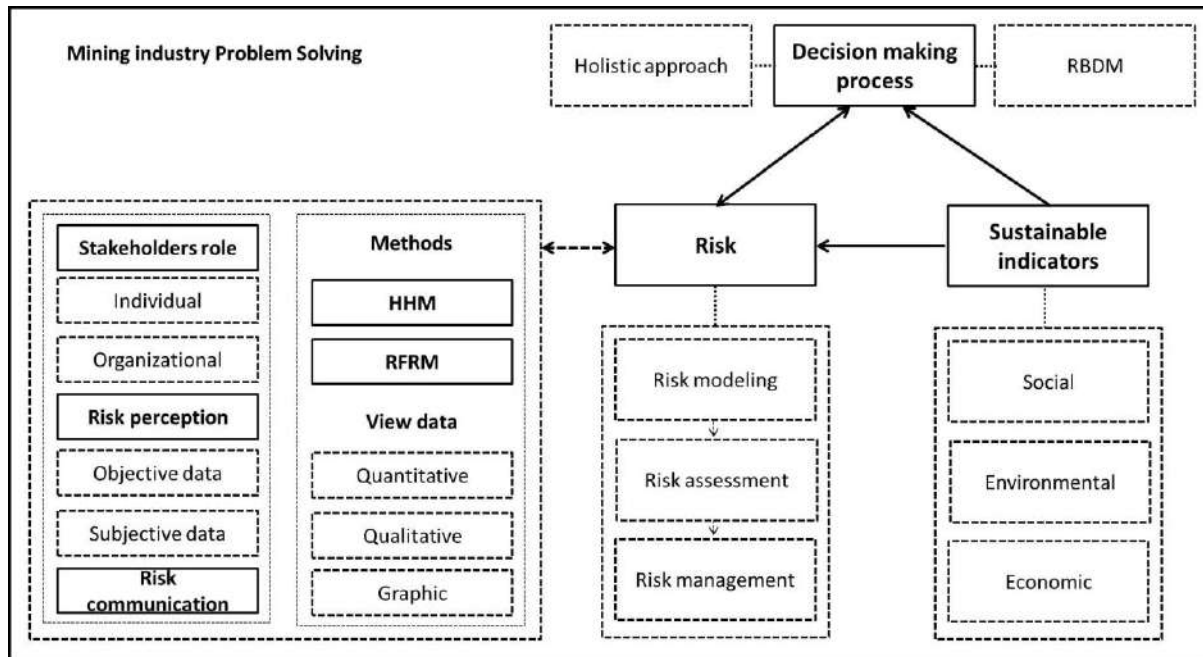


Figure 1. Holistic approach Risk-based decision making (RBDM) in the mining industry based on sustainable indicators (RBDM – Risk Based Decision Making, HHM – Hierarchical Holographic Modelling, RFRM – Risk Filtering, Ranking and Management)

The holistic approach (Figure 1) in this study examines overall sources where risks may appear and develops risk scenarios. The systems approach may be defined as a logical and disciplined process of problem solving (Kerzner, 2013). According to Haimes (1992), one of the operational principles of a holistic approach to sustainable development is the consideration of multiple decision makers and constituencies. The most difficult part related to this principle is comprehensiveness and practicability / operability (Haimes, 1992). Evans, Brereton and Joy (2007) studied about the connection between risk management and sustainability in the mining sector. The authors pointed out that risk assessment represents a potentially useful methodology to involve operations with the wider range of issues involved.

Hierarchical Holographic Modelling (HHM) is applied in this research to identify and view sources of risks. Some of the authors used HHM as an approach in risk identification to show which companies “need to adopt various risk management principles to visualize a full picture of the organizational risk level” (Ting et al., 2009). HHM and RBDM are considered by the authors to be desirable methodologies for making predictions on maritime traffic risks (Zhang et al., 2022). Giannakis and Papadopoulos (2016) revealed in their research that risk treatment strategies are proposed for sustainability-related risks. The authors Pan, Ihlenfeld and Voulvoulis (2010) used the HHM method for identifying chemical risks from mining operations. They stressed that a risk-based methodology for identification, filtering and ranking risks can be used as initial information for risk management. “It also provides a practical decision making tool for mine acquisition and helps to communicate risk to all members of mining operation teams” (Pan et al., 2010).

The final result of using Risk Filtering, Ranking and Management (RFRM) is the creation of new ideas for risk management based on qualitative, quantitative and graphic views and data.

### 3. DATA AND METHODOLOGY

In this paper are combined methods of risk assessment and sustainability indicators as key factors for identifying sources of risk. The explanation of these methods follows.

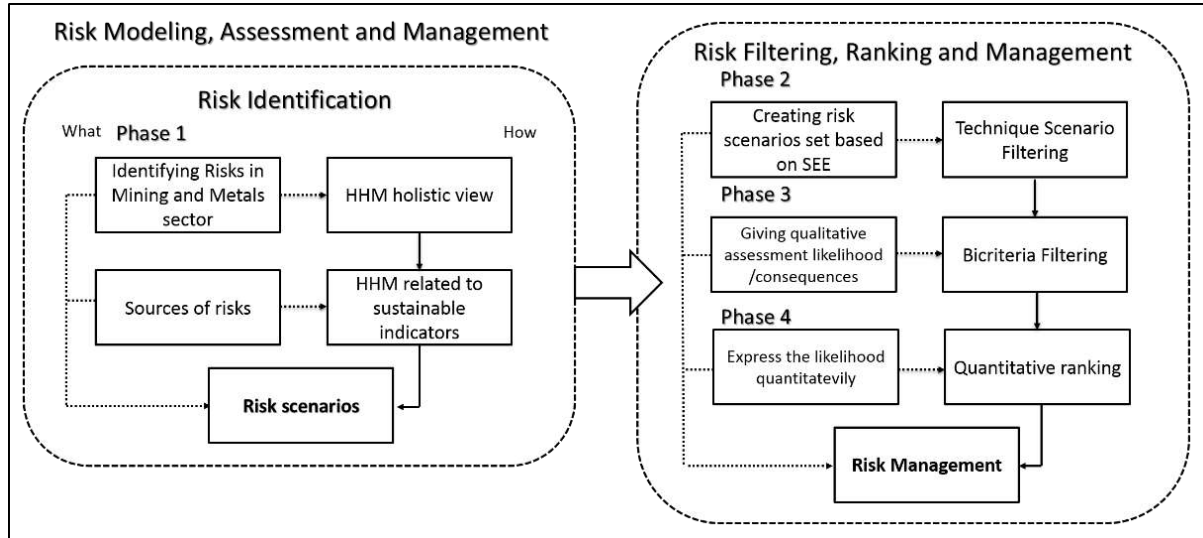


Figure 2. The phases of risk identification and quantification according to Haimes approach (Haimes, 2008)

**Phase 1. Risk identification.** Risk identification is the first step in the process of risk assessment. In the Figure 2 a framework for Risk Modeling, Assessment and Management used in this research according to the Haimes approach (Haimes, 2008) is shown. The first phase is Risk identification which includes two HHM figures (Figure 3 and Figure 4). The first HHM figure presents a holistic view of potential places of risk and the second one presents a selected certain number of areas where possible emerging risks exist. The HHM Diagram presents the main topics / categories and subtopics / subcategories as each represents an area of potential risk scenarios. Results from this phase determine potential places for risk scenarios.

**Phase 2. Scenario filtering.** The next step involves creating a set of risk scenarios from the HHM model, based on the given state of sustainability. This phase is the first phase of Risk Filtering, Ranking and Management (RFRM) as a technique for filtering, ranking and generating new ideas for risk management. The RFRM technique combines qualitative and quantitative data for ranking risk scenarios. In this phase it is necessary to create a set of scenarios based on research questions and objectives and filter the subtopics using the scenario filtering technique. Identification of scenarios is based on expert thinking, managers from different levels or investor interest.

*Table 1. Qualitative Measures of Likelihood*

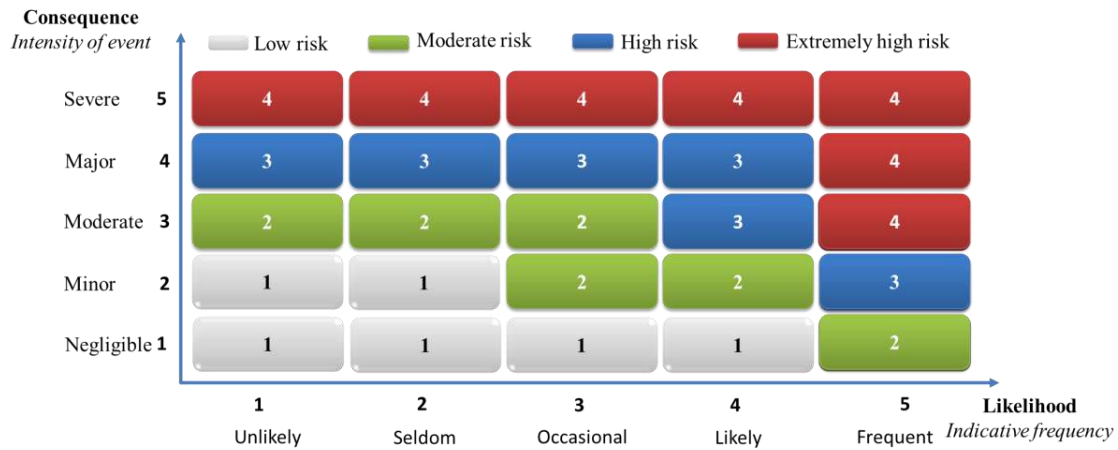
Level	Description	Frequency
5	Frequent	Expected risk scenario
4	Likely	Risk scenario more likely than not emerge
3	Occasional	Risk scenario may or may not emerge
2	Seldom	Risk scenario less likely than not to emerge
1	Unlikely	Risk scenario not expected to emerge

**Phase 3. Bicriteria filtering.** In phase three, it is necessary to give qualitative assessment of the likelihood and consequences of filtered subtopics using bicriteria filtering. Each scenario is evaluated in relation to the criteria of severity of impact and frequency of likelihood. Reducing the number of risk scenarios is done based on the preferences of decision makers. The levels for qualitative measures of likelihood are shown in Table 1. The levels of qualitative measures of consequence are shown in Table 2. In the same tables, quantitative levels of frequency and intensity of risks are also presented. This data is the basis for the next phase and for creating the risk matrix.

*Table 2. Qualitative Measures of Impact*

The level of intensity	Score	Description
Severe	5	Unacceptable risk, 100 % loss of jobs, resources of materials is at the non-appropriate level, profit loss.
Major	4	Unacceptable risk. Major loss of jobs, major lack of resources of materials, major profit loss.
Moderate	3	Moderate loss of jobs. Moderate lack of resources. Moderate profit loss.
Minor	2	Tolerable risk / Minor loss of jobs. Minor lack of resources. Minor profit loss.
Negligible	1	Risk acceptable under review. / No loss of jobs. No treatment for lack of resources. No profit loss.

**Phase 4. Quantitative ranking.** The quantitative ranking is used here as a technique for giving qualitative characteristics and expressing the likelihood of risk scenarios quantitatively. The categories for qualitative measures of likelihood are: Frequent, Likely, Occasional, Seldom and Unlikely, with quantitative values of 5, 4, 3, 2, and 1, respectively. The categories for qualitative measures of impact are: Severe, Major, Moderate, Minor and Negligible, with quantitative values of 5, 4, 3, 2, and 1, respectively. Explanation of colors and numbers: 1, Grey - Low risk, 2, Green - Moderate risk, 3, Blue - High risk, 4, Red - Extremely high risk (Graphic 1).



Graphic 1. Risk Matrix - Likelihood vs. Consequence

Using the HHM method it is possible to decompose the system, build clear a understandable view, and depict connections between categories and potential sources of risks. In the research of complex systems such as industry, this method enables systematic and comprehensive review of sources of risks and emerging appearing risks.

The RFRM method provides decision makers with filtering, ranking and quantification of risk scenarios. The combination of qualitative and quantitative aspects is important as a way of taking holistic approach. The crucial significance lies in preferences of decision-makers. Decision-makers provide a subjective assessment in the process of creating and selecting risk scenarios using available techniques and analyses. All steps of the RFRM as a result, provide important suggestions and basis for calculations in risk management.

The importance of indicators has several aspects. Indicators are a tool for the implementation and further development of the decision matrix. It is very important that there are available data measured indicators. The use of sustainability indicators provides the opportunity to use quantified data in the next phase and further research.

Before starting the risk identification process it is necessary to determine who the participants or stakeholders are and their role in the decision-making process. The importance of each stakeholder has significant implications for the further flow of the risk analyses. The condition for including indicators in the analysis is that they are closely related to some of the participants in the decision-making process in the mining industry. By recognizing the indicators it is possible to measure the behaviour of the system, and also based on the measured indicators and the determined rules between them, it is possible to determine measures for the future state of system. In this case, recognized risks are given the highest probabilities of risk scenarios.

These methods are suitable for risk analyses and view the situations from different and multidisciplinary aspects. The use of a combined graphic view and quantified and qualified data emphasizes the importance of a holistic approach which is applied in this research. Finally, the results from risk modeling and assessment are important information for risk management decision makers.

#### 4. RESULTS AND DISCUSSION

Applicability of the described Risk Assessment methods is presented through the following example in mining. The source of primary data was literature (Global Reporting

Initiative, 2015; United Nations, 2007; Popovic et al., 2014; Azapagic, 2004). and on finally stage expert opinion samples. There were several iterations explained below.

**Phase 1. Risk identification.** Figure 3 shows a Hierarchical Holographic Modeling example framework for risk identification which is decomposed from multiple perspectives, by considering sustainability indicators determined in the papers (Global Reporting Initiative, 2015; United Nations, 2007; Popovic et al., 2014; Azapagic, 2004).

Firstly, there were 9 categories and a total of 42 subtopics, extended to 74. The defined categories are Social, Operational / Functional, Phases, Environmental, Geographical / Location, Institutional / Organizational, Economic, Infrastructure and Temporal. Related to the given type of sustainability specific indicators within the social category include employment, health and safety, education, equally, employee welfare, innovation and competitiveness, human rights, community funding and support, corruption and fair business and operations (Popovic et al., 2014). The defined specific indicators within environmental indicators are pollution, use of natural resources, climate change, nuisance, eco-tourism and biodiversity (Global Reporting Initiative, 2015; United Nations, 2007). Within the economic part of sustainability, specific indicators include economic performance, trade, material consumption and energy use (Global Reporting Initiative, 2015; Azapagic, 2004). Based on the aim of the research associated with the three types of sustainable development, the focus of the next phase of research is 8 subtopics, determined as potential areas of sources of risk (Figure 4). Figures 5, 6 and 7 show the social, environmental and economic main categories and their subcategories, respectively.

**Description of subcategories:**

- Employment - Employment benefits and characteristics include staff turnover, dismissal of employees, working hours, full-time and part-time employees and years of service (Popovic et al., 2014),
- Education – includes training, education and personal skills as well as training and educational level (Popovic et al., 2014),
- Innovation and competitiveness – Innovations, new products, and scientific publications (Popovic et al., 2014),
- Pollution – Solid waste (Global Reporting Initiative, 2015; United Nations, 2007),
- Use of natural resources - Primary resources extracted and reserved of resources (Azapagic, 2004),
- Economic performance – Investment, per capita GDP and value added (Global Reporting Initiative, 2015; Azapagic, 2004),

**Phase 2. Scenario filtering.** Techniques for creating scenarios are applied in this phase. From Phase 1, the following potential fields of risk are filtered:

- Employment - loss of jobs, number of dismissals of employees,
- Education - lack of qualified people,
- Innovation - lack of new technological processes,
- Solid waste - low level of recycling materials,
- Primary resources extracted - high level of extracted raw materials,
- Reserves of resources - lack of raw materials,
- Investment - lack of investment,
- Value added - risk of low profit,
- Price volatility - risk of price changes.



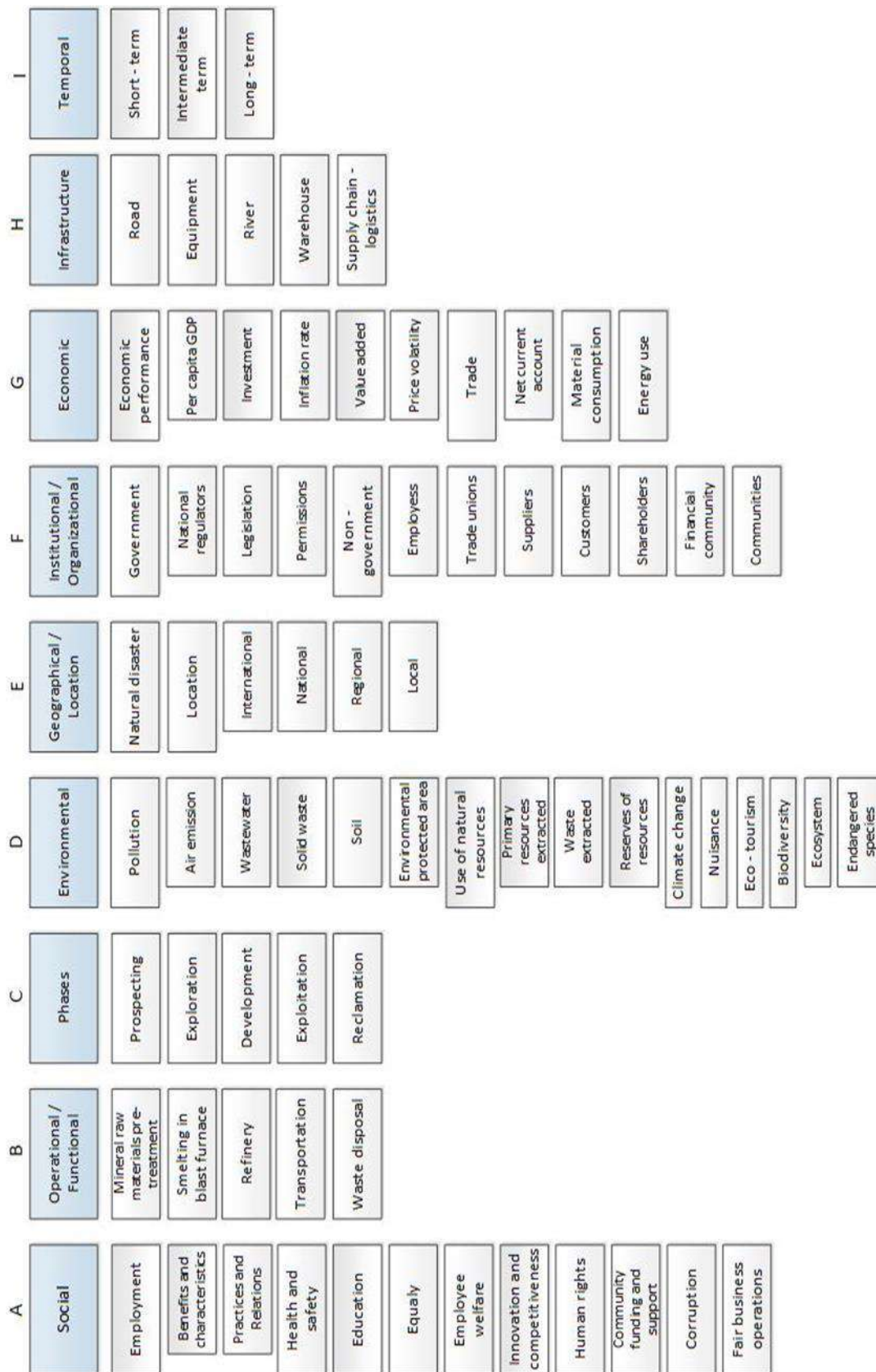


Figure 3. HHM example framework for risk identification based on sustainability indicators: social (Popovic et al., 2014), environmental and economic (Global Reporting Initiative, 2015; United Nations, 2007; Azapagic, 2004).

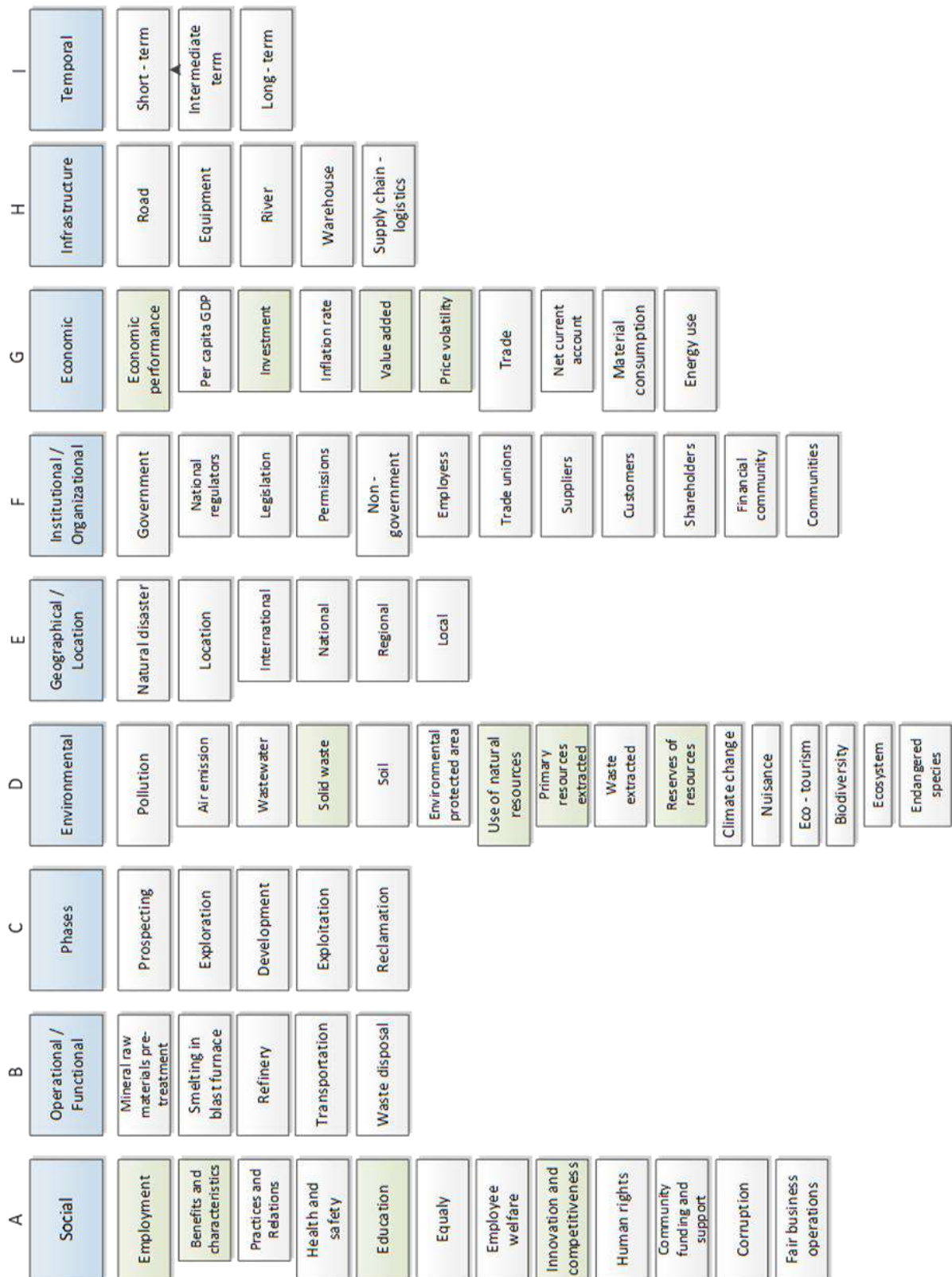


Figure 4. HHM - determined 8 potential areas of sources of risks based on sustainability indicators: social (Popovic et al., 2014), environmental and economic (Global Reporting Initiative, 2015; United Nations, 2007; Azapagic, 2004).

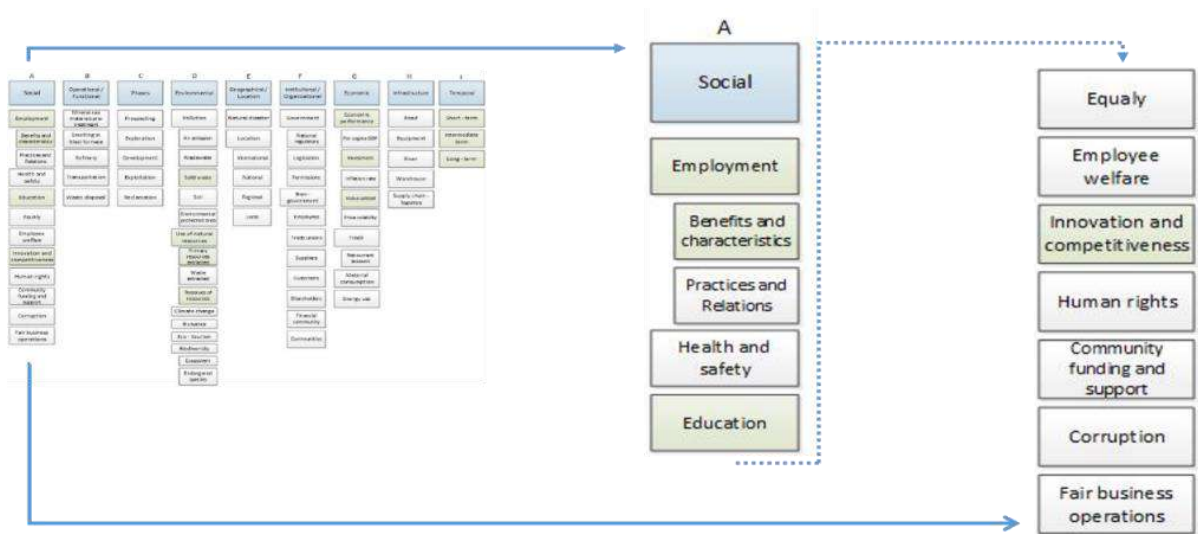


Figure 5. HHM example framework for risk identification in the social category

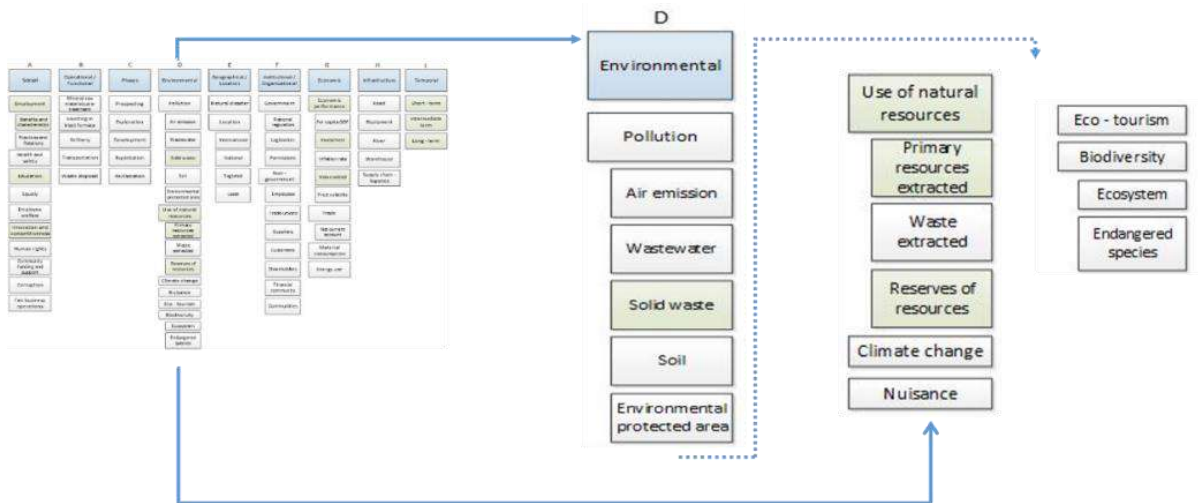


Figure 6. HHM example framework for risk identification in the environmental category

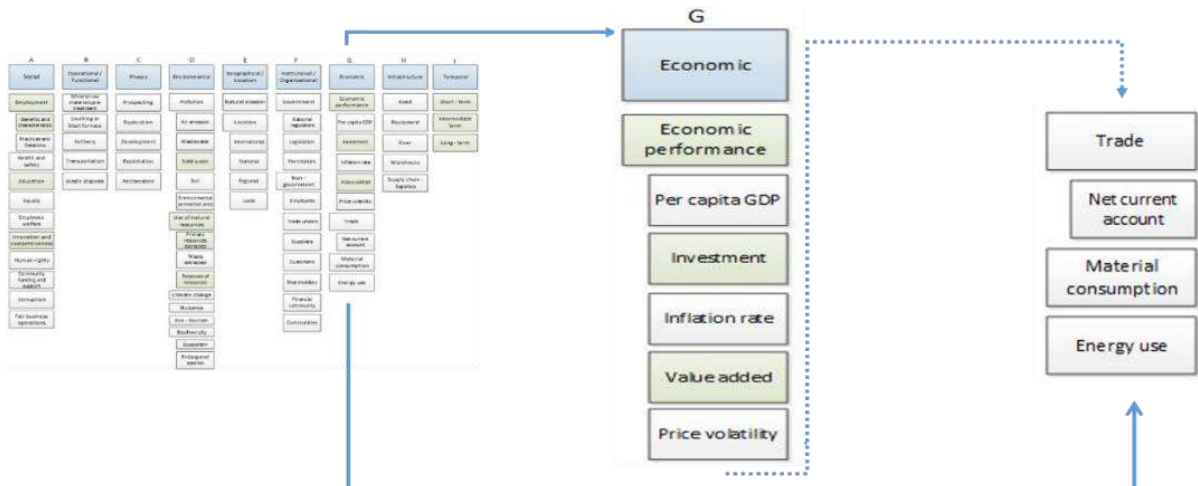


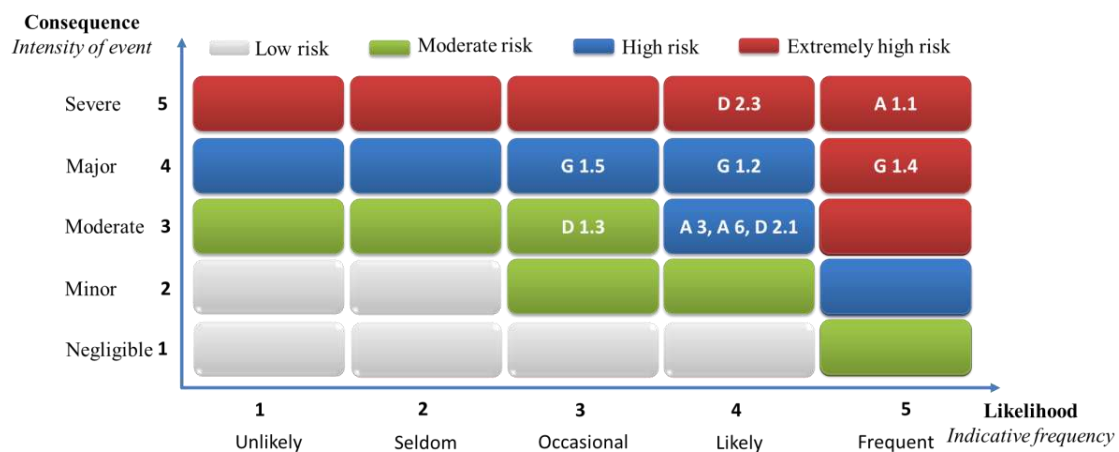
Figure 7. HHM example framework for risk identification in the economic category

**Phase 3. Bicriteria filtering.** In this phase, Bicriteria filtering is used as the second step in Risk Filtering, Ranking, and Management (RFRM) explained in the methodology approach. Preferences of decision makers and an intuitive approach are the basis for reducing the number of scenarios. Finally, Table 4 shows risk scenarios of probable risks using qualitative measures of likelihood. The labels A1.1, A3, A6, D1.3, D2.1, D2.3, G1.2, G1.4, G1.5 are derived from HHM diagrams (Figures 5, 6, 7).

Table 4. Risk Scenarios of Probable Risks

Topic	Subtopic	Risk scenario	Likelihood	Consequence
A 1.1 Social	Employment	loss of jobs	5	5
A 3 Social	Education	lack of qualified people	4	3
A 6 Social	Innovation	lack of new technological processes	4	3
D 1.3 Environmental	Solid waste	low level of recycling materials	3	3
D 2.1 Environmental	Primary resources extracted	high level of extracted raw materials	4	3
D 2.3 Environmental	Reserves of resources	lack of raw materials	4	5
G 1.2 Economic	Investment	lack of investment	4	4
G 1.4 Economic	Value added	risk of low profit	5	4
G 1.5 Economic	Price volatility	risk of price changes	3	4

**Phase 4. Quantitative ranking.** In this phase, a given quantitative value is assigned to the likelihood of risk scenarios. In Graphic 2, examples of measures of likelihood are shown. The most probable risk scenarios based on the given state of sustainability are loss of jobs, lack of raw materials and the risk of low profit.



Graphic 2. Risk Matrix Example - Likelihood vs Consequence

## 5. CONCLUSION

Using the HHM model for risk identification in the mining industry considering sustainability indicators in Figure 2, 9 categories and a total of 42 subtopics, extended to 74, are shown. In the next stage of this phase, 8 subtopics are determined as potential sources of risks. The following phases of risk filtering, ranking and management show identified risk scenarios in the social aspect of sustainability employment, education and innovation. The identified risks here are loss of jobs, the number of dismissals of employees, lack of qualified people and lack of new technological processes. In the environmental aspect of sustainability the main topics identified include solid waste, primary resources extracted and reserves of resources. The following risk scenarios are identified: low levels of recycling materials, high levels of extracted raw materials and lack of raw materials. Finally, the economic aspect of sustainability includes topics such as investment, value added and price volatility. Risk scenarios identified include lack of investment, risk of low profit and risk of price changes.

In this example a combination of graphic, quantitative and qualitative analyses is presented. The analyses show the most probable risks lack of raw materials, loss of jobs and risk of low profit.

Involving sustainability indicators in order to determine the potential sources of risks in the mining industry is an emerging approach in research related to this field. The huge importance of natural resources and their enormous impact on the world's GDP provide motivation to examine the state of this area in this way. This paper presents an example of the risks in the mining industry based on the given three types of sustainability.

The findings of this research provide valuable insights for the next phase of risk management and serve as a basis for developing a decision matrix as a crucial tool for decision makers. Utilizing and examining the methodology in this research is just the first step in the decision making process related to risk management, which is the most important process in discovering and managing new situations that could arise. Additionally, in the second phase, the research focuses on several sources of risk, not all of them. In further research it is possible to develop a combined method of risk management and provide solutions to the questions of what is an acceptable level of risk and how to achieve balance among the three types of sustainability related to the condition of minimum risks in all aspects.

## ACKNOWLEDGMENT

I would like to express my sincere gratitude to Professor Dr. Andrzej Kraslawski from Lappeenranta University of Technology in Finland.

## REFERENCES

- Azapagic, A. (2004). Developing a framework for sustainable development indicators for the mining and minerals industry. *Journal of cleaner production*, 12(6), 639-662. doi: 10.1016/S0959-6526(03)00075-1.
- Azapagic, A. & Perdan, S. (2000) 'Indicators of Sustainable Development : Guidelines and Methodologies', *Process Safety and Environmental Protection*, 78(4), pp. 243–261. doi: 10.1205/095758200530763.
- Evans, R., Brereton, D., & Joy, J. (2007). Risk assessment as a tool to explore sustainable development issues: lessons from the Australian coal industry. *International Journal of Risk Assessment and Management*, 7(5), 607-619.

- Giannakis, M., & Papadopoulos, T. (2016). Supply chain sustainability: A risk management approach. *International journal of production economics*, 171, 455-470.
- Global Reporting Initiative (2015) G4 Sustainability Reporting Guidelines, Global Reporting Initiative. Available at: <https://www.globalreporting.org/standards/g4/Pages/default.aspx>.
- Haimes, Y. (1992) 'Sustainable development: a holistic approach to natural resource management', *IEEE Transactions on Systems, Man, and Cybernetics*, 22(3), pp. 413–417. doi: 10.1109/21.155942.
- Haimes, Y. Y. (2008) 'Risk Modeling, Assessment, and Management', *Risk Modeling, Assessment, and Management*, Third Edition, pp. 1–1012. doi: 10.1002/9780470422489.
- Haimes, Y. Y., Kaplan, S., & Lambert, J. H. (2002). Risk filtering, ranking, and management framework using hierarchical holographic modeling. *Risk Analysis*, 22(2), 383-397.
- Jahanmiri, S., Asadzadeh, M., Alipour, A., Nowak, S., & Sherizadeh, T. (2021). Predicting the contribution of mining sector to the gross domestic product (GDP) index utilizing heuristic approaches. *Applied Artificial Intelligence*, 35(15), 1990-2012.
- Kaplan, S. (1997). The words of risk analysis. *Risk analysis*, 17(4), 407-417.
- Kerzner, H. H. R. (2013) *Project management: a systems approach to planning, scheduling, and controlling*, New York. doi: 10.1016/0377-2217(82)90164-3.
- Pan, J., Oates, C. J., Ihlenfeld, C., Plant, J. A., & Voulvoulis, N. (2010). Screening and prioritisation of chemical risks from metal mining operations, identifying exposure media of concern. *Environmental monitoring and assessment*, 163, 555-571. doi: 10.1007/s10661-009-0858-0.
- Popovic, T., Kraslawski, A., Heiduschke, R., & Repke, J. U. (2014). Indicators of social sustainability for wastewater treatment processes. In *Computer Aided Chemical Engineering* (Vol. 34, pp. 723-728). Elsevier. doi: 10.1016/B978-0-444-63433-7.50105-X.
- Rausand, M. (2013). *Risk assessment: theory, methods, and applications* (Vol. 115). John Wiley & Sons.
- Ting, J. S. L., Kwok, S. K. & Tsang, A. H. C. (2009) 'Hybrid Risk Management Methodology: A Case Study', *International Journal of Engineering Business Management*, 1, p. 3. doi: 10.5772/6783.
- United Nations (2007). *Indicators of Sustainable Development : Guidelines and Methodologies*, New York, (October), pp. 1–90. doi: 10.1016/j.cirpj.2010.03.002.
- World Bank. (2025). *Global Economic Prospects*, January 2025. © World Bank. <http://hdl.handle.net/10986/42452> License: CC BY 3.0 IGO.
- Zhang, W., Zhang, Y., & Qiao, W. (2022). Risk scenario evaluation for intelligent ships by mapping hierarchical holographic modelling into risk filtering, ranking and management. *Sustainability*, 14(4), 2103.





## STRATEGIC STRUCTURING OF HUMAN RESOURCE MANAGEMENT THROUGH THE INTEGRATION OF INNOVATIONS

Miloš Dimitrijević\*, Miloš Nikolić

*“MB” University, Faculty of Business and Law, Serbia*

**Abstract:** In an increasingly dynamic business environment, human resource management is becoming more complex, necessitating the integration of innovative approaches in strategy formulation. This paper examines the impact of digitalization, artificial intelligence, data analytics, and flexible work models on human resource management. Digital tools enhance the efficiency of recruitment, training, and performance evaluation processes, while HR analytics provides data-driven insights for strategic decision-making. Innovation fosters greater security and transparency in HR strategy development. Moreover, flexible work models and the cultivation of a digital organizational culture contribute to higher employee engagement, while the adoption of ESG criteria reinforces corporate sustainability. Organizations that successfully integrate innovative HR strategies gain a competitive advantage and ensure long-term sustainability. This study underscores the necessity of adapting human resource management through contemporary technological and organizational frameworks, fostering more resilient and productive work environments.

**Keywords:** Innovation, strategy, management, sustainability, human resources.

### 1. INTRODUCTION

In the contemporary business landscape, the human resources function has transcended its traditional operational role to emerge as a pivotal strategic actor in the creation of sustainable competitive advantage and long-term organizational viability. Rapid technological advancements, accelerated digitalization, pervasive automation, and the evolving value orientations of the workforce have fundamentally transformed the HR function—from a reactive administrative support mechanism to a proactive strategic partner. Within this dynamic context, innovation in human resource management has become imperative for navigating labor market uncertainties, securing top talent, and cultivating organizational agility.

The transformation of the HR domain spans multiple dimensions, including the integration of artificial intelligence in recruitment and selection processes, the deployment of predictive analytics for talent development and retention, and the establishment of digital

---

\* Corresponding author: [midi1983@gmail.com](mailto:midi1983@gmail.com)

Miloš Dimitrijević, ORCID: 0009-0006-3168-1509  
Miloš Nikolić, ORCID: 0000-0003-0690-8047

organizational cultures predicated on inclusivity, adaptability, and lifelong learning. These paradigm shifts necessitate a comprehensive reconfiguration of traditional HR processes, along with the adoption of novel leadership frameworks, communication models, and performance management systems that are attuned to the exigencies of the digital era.

The COVID-19 pandemic has further catalyzed these transformations, compelling organizations to adopt flexible work arrangements, embrace remote workforce structures, and enhance digital competencies across all organizational levels, including among HR professionals themselves. In this evolving environment, an organization's capacity to innovate in the management of human capital has become a critical determinant of its resilience and potential for sustainable growth. Thus, innovative HR practices are no longer a strategic advantage but a prerequisite for organizational continuity and advancement.

This paper seeks to identify and critically examine cutting-edge approaches to strategic human resource management, with a particular focus on exemplary global and domestic practices that demonstrate the effective application of contemporary technologies and methodologies in the governance of human capital. Through a comparative case study methodology, the study aims to elucidate best practices that may serve as replicable models for organizations aspiring toward digital transformation and the refinement of their HR strategies.

Accordingly, the role of HR is undergoing a profound redefinition—from a custodian of operational processes to an architect of organizational culture and strategic direction. Innovations in human resource management now represent a vital instrument for realizing strategic objectives, cultivating enduring competitive advantage, and shaping resilient, future-oriented organizations.

## **2. LITERATURE REVIEW AND HYPOTHESES**

Strategic Human Resource Management (SHRM) has undergone a profound transformation over the past decade, evolving from a traditional administrative function into a critical strategic partner in organizational development. Ulrich (2020) emphasizes that the modern HR function is oriented toward creating value for all stakeholders—including employees, management, and the broader community. In today's context, the integration of innovation and digital technologies into SHRM is essential for achieving competitiveness, adapting to change, and retaining talent.

The digital transformation of the HR function enables a more personalized and efficient approach to managing human capital. Bondarouk and Brewster (2016) argue that digital tools, such as talent management software and internal communication platforms, enhance decision-making and employee engagement. Marler and Boudreau (2017) highlight the importance of HR analytics, which allow organizations to gain predictive insights into employee behavior and optimize recruitment, development, and retention processes.

Deloitte's (2023) Global Human Capital Trends report identifies three key areas of innovation: the application of artificial intelligence, the development of employee experience strategies, and the implementation of agile organizational structures. These trends signify a shift from static to dynamic approaches to workforce management, with an emphasis on flexibility and continuous learning.

In the domestic context, Vesić and Milić (2022) analyze the application of digital platforms in HRM in Serbia, noting that the COVID-19 pandemic accelerated the digitalization process but also revealed significant deficiencies in organizational capacities for rapid adaptation. Their research indicates that agile methodologies and digital competencies have become critical success factors in the transformation of HR practices.



Nikolić and Radosavljević (2024) underscore the importance of data-driven decision-making in HR analytics. Their study reveals that organizations employing advanced tools for employee data analysis achieve higher levels of engagement and lower turnover rates. Petrović and Stanković (2024) focus on agile leadership, concluding that leaders who promote autonomy, collaboration, and transparent communication contribute significantly to employee innovation and satisfaction, particularly in the IT sector.

Wright and McMahan (2019) advocate for the redefinition of the concept of "human capital" and its role within organizational strategy. They support an approach that reintroduces the "human" dimension into SHRM, emphasizing inclusivity, empathy, and the holistic development of employee potential. Similarly, Northouse (2021), through the lens of contemporary leadership theories, underscores the relevance of emotional intelligence and ethical conduct in shaping a sustainable HR strategy.

The literature, both domestic and international, affirms that innovation in HRM is not merely a technical or procedural advancement but rather a profound paradigm shift in how organizations perceive their workforce and develop organizational culture. Within this framework, the literature review serves as a foundation for understanding the challenges and opportunities that innovative approaches bring to contemporary human resource management.

Based on the analysis of existing theoretical frameworks and the objectives of this study, the following hypotheses are proposed:

H1: A strategic approach to human resource design contributes to the enhancement of an enterprise's innovation capacity.

H2: Innovative HR practices positively influence organizational efficiency and competitiveness.

H3: The integration of innovation into human resource management increases employee motivation and job satisfaction.

These hypotheses serve as the basis for further analysis of the impact of strategic human resource approaches—driven by innovation—on overall organizational performance.

### **3. DATA AND METHODOLOGY**

This study employs a qualitative and comparative analytical methodology, grounded in secondary data drawn from scholarly journals, case studies, industry reports, and official company documentation. A multiple case study approach was adopted to facilitate comparison between global and domestic examples of HR innovation. The selected cases were chosen based on their relevance, novelty of practices, and availability of public documentation from the period 2020 to 2024.

In addition to secondary sources, a descriptive method was applied to portray key innovations in HR practices. Content analysis of available reports and publications enabled the identification of patterns in the application of digital tools and leadership strategies.

Furthermore, a meta-analysis was conducted on the findings presented in papers from the international conference IMCSM 2024, with the aim of identifying contemporary trends in HR innovation and digitalization.

The comparative analysis encompassed corporate practices across diverse geographical and industrial contexts, thereby enabling an understanding of the influence of cultural and institutional factors on HR strategies.

Qualitative data were categorized into the following thematic areas: digital transformation of HR, the role of leadership, HR analytics, and inclusivity. This thematic categorization facilitated the synthesis of findings and the formulation of targeted recommendations.

To enhance the validity of the findings, examples from domestic practice were also analyzed—for instance, the role of Nordeus in fostering an agile HR culture, and the use of AI in candidate selection by Telekom Srbija. Finally, a benchmarking method was employed to identify best practices in HR innovation, focusing on companies ranked among the most desirable employers.

Additionally, content analysis of media and corporate reports was utilized to track the development of HR innovations in real time, providing valuable insight into rapidly evolving trends. SWOT analyses were also conducted for selected organizations to identify internal strengths and weaknesses, as well as external opportunities and threats influencing HR strategy.

#### **4. RESULTS AND DISCUSSION**

In the contemporary business environment, innovations in human resource management have become a critical differentiating factor between high-performing and average organizations. Research findings, as well as practical case examples, reveal that the implementation of innovative approaches within HRM (Human Resource Management) directly influences employee engagement, organizational efficiency, and long-term sustainability. This chapter presents the most prominent examples of innovative HRM practices globally and in Serbia, with the objective of identifying the key elements that contribute to effective human capital management.

The analysis includes cases of global leaders such as Google, Unilever, and Salesforce, whose strategic approaches to HR innovation are actively shaping the future of work. Simultaneously, domestic companies such as Nordeus, Delta Holding, and OTP Bank Serbia demonstrate progress in adopting contemporary HR tools and principles, despite the limitations of the local market context. In addition to a descriptive overview, the results are also presented through visual illustrations, enabling a clear and swift comparison of dominant trends.

The subsequent discussion offers a critical perspective on the level of development of innovative HR strategies, emphasizing opportunities for further enhancement through practice-oriented recommendations based on empirical evidence and international best practices.

##### **4.1. Innovative HRM Cases Worldwide**

Google (USA) – Renowned for its “20% time” initiative, which allows employees to dedicate 20% of their working hours to self-selected projects, this approach has led to groundbreaking innovations such as Gmail and AdSense. In addition, Google leverages advanced HR analytics through projects like Oxygen and Aristotle, which identify key drivers of successful leadership and team effectiveness. These data-driven strategies enhance managerial practices, increase employee engagement, and facilitate informed decision-making (Google HR, 2023).

Unilever (UK/NL) – This company integrates artificial intelligence into the recruitment process via the HireVue platform, which analyzes facial expressions, voice tone, and body language in video interviews. This approach fosters greater objectivity, efficiency, and diversity in candidate selection. Unilever is also a pioneer in inclusive practices and sustainable business, aligning its HR strategies with ESG principles and broader corporate goals (Unilever HR Report, 2022).

Salesforce (USA) – Salesforce promotes an “Ohana” culture, symbolizing family and community, by fostering employee care, inclusion, and well-being. The company utilizes internal digital platforms to monitor employee satisfaction, facilitate education, and support

knowledge sharing. Initiatives such as the Trailhead platform enable continuous learning and development, directly impacting talent retention and organizational agility (Salesforce, 2023).

#### 4.2. Innovative HRM Cases in Serbia

**Nordeus (Belgrade)** – As a leading company in the video game industry, Nordeus applies agile team models that facilitate a high level of autonomy in work processes and enable swift adaptation to change. The internal development initiative “Nordeus Academy” offers tailored training programs in technology, management, and communication. In addition to internal HR practices, the company actively invests in the broader community through STEM outreach initiatives, thereby extending the influence of its human resource strategies beyond organizational boundaries (Nordeus, 2023).

**Delta Holding** – Delta leverages e-learning platforms to support employee training and development, providing seamless access to knowledge regardless of time and location. Special emphasis is placed on inclusive programs targeting young talents, women in leadership, and individuals with disabilities. Through the use of digital leadership development tools, the company monitors employee progress and ensures targeted talent development aligned with its strategic organizational needs (Delta HR Report, 2023).

**OTP Bank Serbia** – The bank has implemented advanced digital tools for performance and career management, including 360° feedback mechanisms, goal-setting systems, and individualized development plans. These tools promote transparent communication between management and employees, foster career advancement, and enhance overall organizational effectiveness. Furthermore, OTP supports flexible working models, including hybrid work arrangements, which significantly contribute to employee satisfaction and productivity (OTP Serbia, 2022).

#### 4.3. Visual Illustrations

To provide a clearer representation of the differences and similarities between global and domestic approaches to innovative human resource management, the following chart and table illustrate key aspects of digital tools and strategic practices in HRM.

*Table 1. Comparison of Digital HR Tools Between Global and Domestic Companies*

Digital Tool / Technology	<b>Global Companies</b> (Google, Unilever, Salesforce)	<b>Domestic Companies</b> (Nordeus, Delta, OTP)
AI-Based Recruitment Systems	✓✓✓	✓✓
HR Analytics	✓✓✓	✓✓
360° Feedback Systems	✓✓✓	✓✓
Digital Learning Platforms	✓✓✓	✓✓✓
Employee Engagement Measurement Tools	✓✓✓	✓
Diversity and Inclusion Initiatives	✓✓✓	✓
Flexible Work Models	✓✓✓	✓✓

Legend: ✓ – Present to a limited extent; ✓✓ – Moderately developed; ✓✓✓ – Highly developed and integrated

**Table 2. Key Differences in Innovative HR Strategies Between Global and Domestic Practices**

Aspect	Global Practices	Practices in Serbia
Technological Integration	High level of automation, use of artificial intelligence and cloud-based solutions	Gradual implementation of digital tools, with limited automation
Innovation Culture	Strategically driven and institutionally embedded innovation across the organization	Innovation initiatives developed primarily at the departmental or team level
Employee Learning and Development	Continuous, digital, and personalized learning through advanced platforms	Focus on e-learning and internal academies, with limited personalization
Inclusion and Diversity	Strongly integrated targeted policies and structured support programs	Limited resources and initiatives, often lacking a strategic framework
Flexible Work Models	Standardized hybrid and remote work models embedded in organizational culture	Flexibility introduced primarily as a response to the COVID-19 pandemic
HR Analytics	Advanced use of predictive and real-time analytics to support data-driven decisions	Basic statistical analysis and periodic reporting
ESG and HR Strategy Integration	Structured alignment of HR initiatives with sustainability and ESG objectives	Initial steps towards aligning HR strategies with ESG principles

These visual representations enable a swift analysis of the maturity level of HR innovations and help identify areas with improvement potential in the domestic context. The table emphasizes qualitative differences in strategic approaches. Specifically, while global companies strive for full integration of innovation across all dimensions of human resource management—including ESG objectives and organizational culture—domestic companies are in a transitional phase. Although there is considerable potential for advancement, structural barriers to full digitalization and innovation remain present.

#### **4.4. Conclusion from the Comparative Analysis**

The comparative analysis of innovative HRM practices in global and domestic contexts reveals clear disparities in terms of maturity level, technological sophistication, and strategic orientation. Global corporations such as Google, Unilever, and Salesforce demonstrate a high degree of integration of advanced technologies, systematic support for innovation, and a strong emphasis on inclusiveness. These elements enable them to position the HRM function as a key driver of competitive advantage. Their cases highlight the importance of institutionalizing innovation, data-driven decision-making, and the explicit alignment of HR strategies with organizational performance and sustainability objectives.

In contrast, although domestic companies exhibit signs of progress, they continue to face challenges related to limited resources, underdeveloped innovation cultures, and insufficient systemic support. Practices implemented by companies such as Nordeus, Delta Holding, and OTP Banka Serbia reflect both potential and capacity for advancement, yet they often remain fragmented and rely heavily on the initiative of individuals or select members of management, rather than being embedded within comprehensive organizational strategies.

The following chart further illustrates the disparity in the application of artificial intelligence in HR processes between global and Serbian companies:

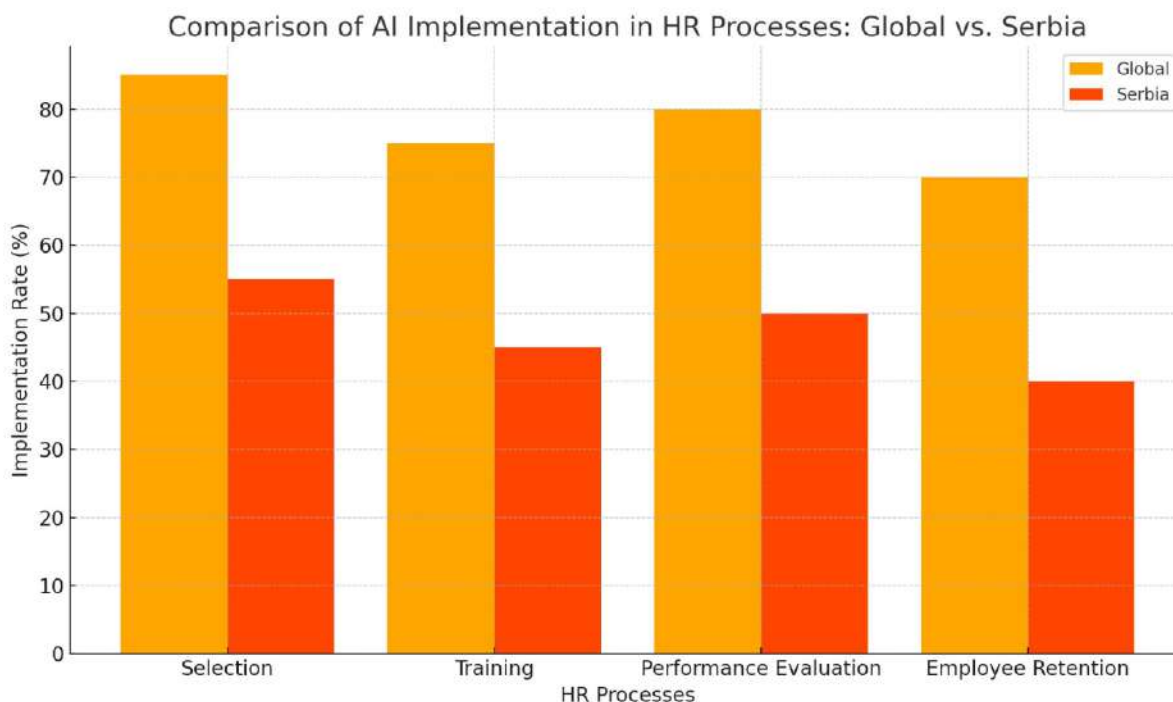


Chart 1. Comparison of AI Implementation in HR Processes – Global vs. Serbia

This chart clearly illustrates that areas such as candidate selection, employee training, performance evaluation, and talent retention are significantly more digitized within global companies compared to their Serbian counterparts. These insights highlight the pressing need for a systematic approach to enhancing HR strategies in Serbia, with a particular emphasis on AI technologies, advanced analytics, and the continuous development of HR professionals' competencies.

The key differences between global and local approaches are reflected in the degree of digital transformation, the depth of HR analytics implementation, and the institutionalization of inclusive and flexible work models. While global leaders are increasingly integrating ESG objectives into their HRM policies, domestic companies are only beginning this process.

Nevertheless, the analysis indicates a growing awareness in Serbia of the need for innovation in human resource management. This is evident in emerging practices such as digital learning platforms, feedback systems, and agile work models. Benchmarking and participation in international initiatives can serve as catalysts for further development.

The common denominator of successful HRM innovations is strategic orientation, readiness for change, and sustained investment in both people and technology. In conclusion, the successful adaptation of innovative HRM practices requires a balanced approach between global trends and local context, underpinned by a clearly defined vision and strong support from top management.

#### 4.5. Recommendations for Practice

Modern organizations aiming to remain competitive and resilient in the face of market changes must strategically integrate innovative practices into their human resource management systems. Based on the case analyses from both global and Serbian contexts, as well as a review of recent literature, the following recommendations emerge as key for advancing HRM practices:

- **Investment in HR Analytics** – The use of tools for analyzing large data sets enables informed, evidence-based decision-making grounded in employee behavior and performance. By implementing analytical models, organizations can identify turnover trends, engagement drivers, and recruitment optimization strategies (Nikolić & Radosavljević, 2024).
- **Application of Artificial Intelligence in Talent Selection and Development** – AI facilitates the automation of early-stage selection processes, analysis of candidates' non-verbal communication, and prediction of employee success. Its implementation should be guided by clearly defined ethical standards to prevent bias and ensure transparency (Unilever HR Report, 2022).
- **Fostering a Culture of Innovation** – Organizations should cultivate environments in which employees have the autonomy to experiment and propose new ideas. Programs such as Google's "20% time" serve as best practice examples that foster innovation and increase employee motivation (Google HR, 2023).
- **Digital Platforms for Continuous Learning** – Innovations in employee training, such as Learning Management Systems (LMS), support personalized learning and skill development. The integration of micro-learning, gamification, and adaptive courses enhances both engagement and learning outcomes (Delta HR Report, 2023).
- **Inclusion and Diversity Strategies** – Recruitment tools should support diversity through structured interviews and blind selection processes. A culture of belonging should be nurtured through empowerment initiatives for underrepresented groups and ongoing measurement of inclusion perception (Salesforce, 2023).
- **Flexible Work Models** – The introduction of remote work, hybrid arrangements, and flexible hours contributes to increased employee satisfaction and better work-life balance. Organizations must develop digital infrastructures that enable productivity and teamwork across virtual environments (OTP Serbia, 2022).
- **Leadership Development through Digital Tools** – Platforms for 360-degree feedback, e-coaching, and digital leadership assessment enable more effective identification of development needs and succession planning (Northouse, 2021).
- **Benchmarking and Knowledge Sharing** – Participation in international conferences, partnerships, and HR networks empowers organizations to adopt best practices and continuously improve their strategies through global insights and local adaptation (Deloitte, 2023).
- **Alignment with ESG Goals** – HR innovations must align with sustainability and corporate social responsibility objectives. This includes promoting green workplace policies, community engagement, and ethical employee relations (Petrović & Stanković, 2024).
- **Continuous Measurement of HR Strategy Outcomes** – It is essential to define KPIs for the HR function and employ metrics such as the Employee Net Promoter Score (eNPS), employee engagement rates, and training program ROI to assess the effectiveness of strategies and facilitate their optimization (Vesić & Milić, 2022).

By integrating these recommendations into HR strategies, organizations can not only follow global trends but also take a proactive approach in shaping their own future. Investment in data and digital tools is critical for swift and accurate decision-making, while ethical implementation of AI in talent management promotes fairness and inclusion.

The culture of innovation in HRM must not be sporadic or confined to isolated departments; rather, it must become a fundamental organizational value. Promoting continuous

learning, flexible working conditions, and an inclusive climate contributes to the creation of agile and resilient teams capable of responding to complex market challenges.

Furthermore, alignment with ESG goals elevates the HR function as a strategic partner in achieving sustainable development. Benchmarking and participation in international initiatives enable learning from successful global examples. Finally, the continuous evaluation of HR strategy impacts on organizational performance fosters the development of a responsible and effective HR function, establishing it as a pillar of competitive advantage.

## 5. CONCLUSION

The analysis of innovative HRM practices in both global and Serbian contexts highlights the growing significance of technology, analytics, and a culture of innovation in the development of human resources. The comparative study reveals that global companies lead in the adoption of advanced technologies and personalized approaches, whereas domestic organizations are gradually implementing similar models, adapted to local conditions.

Cases such as Google and Unilever demonstrate the impact of applying sophisticated digital and analytical tools, while domestic examples like Nordeus and OTP Bank Serbia point to a positive shift in the digital transformation of the HR function. Nevertheless, challenges such as limited resources, resistance to change, and restrictive legal frameworks continue to pose barriers.

In conclusion, the success of HR innovations hinges on organizations' willingness to embrace change, invest in new technologies, and strengthen leadership capabilities. Innovation in HRM serves as a bridge toward the creation of more flexible, inclusive, and sustainable work environments capable of responding to the demands of modern business.

Looking ahead, it is anticipated that the digital transformation of HR functions will intensify, with a stronger focus on employee experience, automation of routine tasks, and the development of artificial intelligence. Organizations that adopt a proactive approach to innovation and ensure continuous education for HR professionals will be better positioned to retain talent and achieve competitive advantage in the marketplace.

Based on the cases analyzed, it can be concluded that both global and local contexts present unique challenges and opportunities, yet they share a common goal—creating environments that foster development, learning, innovation, and resilience. The key advantage will lie in the flexibility of HR strategies, their adaptability to technological shifts, and their orientation toward human potential as a primary source of innovation.

## REFERENCES

- Bondarouk, T., & Brewster, C. (2021). Conceptualizing the future of HRM and technology research. *The International Journal of Human Resource Management*, 32(2), 1–28. <https://doi.org/10.1080/09585192.2020.1839775>
- Deloitte. (2023). *Global Human Capital Trends 2023: New Fundamentals for a Boundaryless World*. Deloitte Insights. <https://www2.deloitte.com/insights/us/en/focus/human-capital-trends/2023.html>
- Delta Holding. (2023). *Sustainability and Human Resources Report 2022–2023*. (in Serbian). <https://www.deltaholding.rs/upload/documents/izvestaji/izvestaj-2023.pdf>
- Google HR. (2023). *Project Oxygen: Building Better Managers*. (internal documentation summary). <https://rework.withgoogle.com/guides/managers-project-oxygen/steps/introduction/>

- HireVue. (2022). *AI-Driven Hiring Practices: A Case Study with Unilever*. <https://www.hirevue.com/resources/case-study/unilever>
- Marler, J. H., & Boudreau, J. W. (2017). An evidence-based review of HR Analytics. *The International Journal of Human Resource Management*, 28(1), 3–26. <https://doi.org/10.1080/09585192.2016.1244699>
- Nikolić, J., & Radosavljević, M. (2024). Digital HR transformation in the public sector of Serbia. In *IMCSM 2024 Conference Proceedings*, Book 2, pp. 85–95. (in Serbian). <https://doi.org/10.5281/zenodo.10654321>
- Nordeus. (2023). *Nordeus People Report: Empowering Through Learning and Agility*. (in Serbian). <https://nordeus.com/people-report-2023.pdf>
- Northouse, P. G. (2021). *Leadership: Theory and Practice* (9th ed.). SAGE Publications. <https://doi.org/10.4135/9781071834472>
- OTP Serbia. (2022). *HR Innovations in the Banking Sector: Employee Performance Report*. (in Serbian). <https://www.otpbanka.rs/hr-izvestaj-2022.pdf>
- Petrović, M., & Stanković, V. (2024). Agile leadership in Serbia's IT sector. In *IMCSM 2024 Conference Proceedings*, Book 1, pp. 72–81. (in Serbian). <https://doi.org/10.5281/zenodo.10654012>
- Salesforce. (2023). *Ohana Culture and Inclusion Report*. <https://www.salesforce.com/company/careers/ohana-culture/>
- Unilever. (2022). *Human Resources Annual Report 2022*. <https://www.unilever.com/investors/annual-report-2022/>
- Ulrich, D. (2020). *HR for the Future: Technology, Purpose, and People*. Society for Human Resource Management (SHRM). <https://www.shrm.org/hr-today/news/hr-magazine/winter2020/pages/default.aspx>
- Vesić, A., & Milić, B. (2022). Agile approaches in human resource management: Experiences from Serbia. *Economic Horizons*, 24(1), 55–67. <https://doi.org/10.5937/ekonhor2201055V>
- Wright, P. M., & McMahan, G. C. (2019). The evolution of strategic HRM through two founding articles. *Human Resource Management*, 58(1), 105–117. <https://doi.org/10.1002/hrm.21918>
- Živanović, M., & Đorđević, T. (2024). Application of AI in HR practices in telecommunications. In *IMCSM 2024 Conference Proceedings*, Book 1, pp. 125–134. (in Serbian). <https://doi.org/10.5281/zenodo.10654389>





## INTEGRATED PLANNING OF LOGISTICS PROCESSES IN THE FIELD OF WAREHOUSING WITH SIMULATION SUPPORT

Miriam Pekarcikova\*, Peter Trebuna, Jana Kronova, Marek Kliment

*Technical University, Faculty of Mechanical Engineering, Slovakia*

**Abstract:** An innovative approach to solving wholesale logistics problems in industrial practice can yield significant results, reflected in the high flexibility and efficiency of business processes and systems. The article focuses on analysing parameters and designing a warehouse management solution for the food industry. It deals with the more efficient management of logistics flows with an orientation to supply, storage, modelling, simulation and virtualization, as digitalization correlates with its use in optimizing business processes and systems. The topic is oriented towards the use of digital software in searching and finding alternative and optimal storage solutions in the food sector. A new approach to solving common business problems moves businesses to a high level of achieving goals. The enormous variety of foods available in retail stores has a great impact on the processes of food manufacturers. The number of different processes related to production means that food businesses are increasingly complex, and raw material and packaging warehouses must be well-managed to maintain control over the amount and location of stocks. A great impact on production processes, respectively. Its complexity is influenced by the diversity of requirements and seasonality within the calendar year.

**Keywords:** logistics, simulation, strategy, warehousing, inventory.

### 1. INTRODUCTION

If a company in the food industry wants to achieve good results, costs must be controlled and minimized, and performance must be high and consistent. A company that does not achieve good results in any area of its activity will soon get into trouble with its customers, like companies in other business sectors. The specifics of the food industry are that a high level of performance must be maintained daily with relatively low profit margins. A food company

---

\* Corresponding author: [miriam.pekarcikova@tuke.sk](mailto:miriam.pekarcikova@tuke.sk)

Miriam Pekarcikova, ORCID: 0000-0002-6898-3774

Peter Trebuna, ORCID: 0000-0003-3666-5066

Jana Kronova, ORCID: 0009-0004-7102-5755

Marek Kliment, ORCID: 0000-0002-3486-6107

cannot afford to have a spare production line and maintain high safety stocks due to the limited consumption period. The production process must be at a high level on the part of all processes, input materials and other activities related to the transformation process and must be flexible to customer requirements.

Economies of scale in the food industry mean that the more a company produces, the cheaper each item will be. The price of input materials and packaging materials for the manufacturer is reduced by the increased volume of inputs. Therefore, the volume also increases the costs of energy, depreciation, distribution, etc., which also has an impact on reducing production costs. This is a generally theoretical approach to the question posed in this way. Enterprises that operate in the food industry have large processes, i.e. in the short term, some generally valid rules do not apply, but in the medium and long term, it will be necessary to deal with some rules if the enterprises are to remain competitive.

## **2. LITERATURE REVIEW**

Integrated planning and management of logistics systems and networks based on digital models, methods and tools, which are built on a common flexible information and communication platform, is the future or even a reality if a company wants to achieve a high level of competitiveness. Increasing demands on the complexity and diversity of production mean achieving high agility in planning, management of logistics processes and visibility along the entire value chain. This fact can be applied primarily in the context of the food industry. In this case, however, there are specifics that need to be considered more demandingly due to the nature of production.

### **2.1. Supply cycle optimization with an emphasis on limited shelf life**

The first models focused on inventory management were created decades ago in the form of Harris's EOQ model (Economic Order Quantity, "How Many Parts to Make at Once", 1913, the first inventory model). They were helpful for the correct setting of the order size and the timing of its implementation. Years after the introduction of this model, other theoretical variants and extensions of this model began to emerge, trying to find answers to the following questions:

- What should the order size be?
- When should the order be placed?

The MRP system is still a widely used material requirements planning technique. A major disadvantage of MRP is the lack of sufficient visibility of orders sufficiently in advance in the context of proper production and purchasing planning. The input data processed in MRP is based on forecasts. Subsequent adjustments are made close to the point of order visibility. The impact on reducing flexibility in responding to customer demands results from the fact that items that enter the product at the end of the production cycle are often ordered at the beginning of the planning period. The length of the planning horizon, the so-called cumulative planning horizon, which includes the procurement and production period, in turn affects the accuracy of order planning in quantity and time. This subsequently requires modifications that may mean exceeding the customer's tolerance time, when he can accept this excess (Katana MPR, 2025; MRPeasy, 2025).

The agility of the MRP system can be increased by optimizing the disconnection points of the logistics chain, i.e. by creating intermediate warehouses, so-called sur tanks within the supply network. This issue is addressed in detail by researchers (Ptak & Smith, 2016) who are the authors of the publication Demand Driven MRP (2016). This is a model of a demand-driven

MRP system, which is built on a strategic calculation of disconnection points with a determined level of inventory at these points, where defined signal levels (red, yellow, green) signal the need to procure inventory at a specific time, size and location, thus eliminating the so-called bullwhip effect.

DDMRP is an innovative method of planning and managing the supply chain. In 2010, pilot applications were implemented, which are currently gaining momentum with a wide scope in the food industry. They are introduced in companies such as Michelin, Coasa, Nestlé, Moog, Shell, etc. By creating specific disconnection points by introducing DDMRP, it is possible to eliminate 4 main causes that cause demand variability:

- volatility, i.e. instability,
- uncertainty,
- complexity, or complexity,
- ambiguity.

## **2.2. The impact of seasonality on demand variability**

Seasonality or seasonal effects the three following conditions met:

1. Demand growth occurs within the same time frame for each seasonal cycle.
2. Seasonal fluctuations are measurably larger than random fluctuations in demand.
3. A cause can be found that explains the demand fluctuations.

The best way to forecast and account for seasonality is to compare the structure of demand over several years. When choosing a forecasting technique, it is important to find the appropriate one that provides the greatest accuracy in matching the structure of demand. The following criteria play a role in the selection:

- adaptability to performance requirements,
- possibility of forecast errors,
- necessary tools for processing the analysis,
- costs of data collection and preparation for the analysis,
- detectability of parameters that describe the performance of the system to be predicted,
- purpose of the forecast and the importance of a single item,
- forecast time frame,
- transparency for the user.

## **2.3. Principles of picking of perishable stocks**

The basic question regarding the policy of picking of perishable stocks is what is the best picking method that should be used. The choice of one or the other depends on various factors, e.g. type of warehouse, stored products, logistics processes, etc. There are several options for perishable stocks. From practical experience, it can be stated that the following are of greatest importance from the point of view of the most efficient organization and control of inputs and outputs of stored items:

- FIFO/First-In-First-Out - the first product that enters the warehouse will be used first to satisfy demand,
- LIFO/Last-In-First-Out - the last product that enters the warehouse will be used first to satisfy demand
- FEFO/ First expired, first out, or LSFO/Least-Shelf Life-First-Out - the product with the shortest shelf life or usability will be used first to satisfy demand

The automation of warehouse activities allows businesses and companies to develop more effective management methods that help eliminate possible errors that arise.

#### **2.4. Logistic chain disconnection point in the food industry**

The logistic chain disconnection point is a point or level of the value chain of a company to which the entry of a customer or production order is limited. Usually, it is a so-called intermediate warehouse for which the company's supply strategy is defined in terms of MTO, MTS, ETO, ATO, etc. The flexibility of the company depends on the position where the disconnection point is located, i.e. how quickly and in what ways it can satisfy the customer's needs or personalize the product. The efficiency of all processes that are implemented from the disconnection point to the customer depends on the correct planning and scheduling of production and logistics activities in production and distribution (Saniuk et al., 2022; Nyhuis & Wiendahl, 2009). The processes before the disconnection point depend on the quality of supplier-customer relations, since this point can be located directly at the supplier. On the one hand, the company reduces the costs associated with, for example, with purchasing, storage and maintaining stocks, but on the other hand it depends on the supplier's delivery times. As mentioned above, it is necessary that this period does not exceed the customer's tolerance time. A suitable tool in this sense is the aforementioned DDMRP, built on pillars that are proven in practice and commonly implemented and used in every business system.

For the above reasons, it is necessary to emphasize the importance of the disconnection point of the logistics chain, specifically its location in the logistics or. value chain of the company. It is therefore a strategic decision that should ensure flexibility in the long term to reflect on demand while taking into account the complexity and specific nature of the products, the form and organization of production and the logistics network, which includes:

- identification of influencing factors, problems and activities,
- definition of methods and tools for achieving the optimal solution,
- presentation of qualitative evaluation rules and parameters,
- arrangement in a goal-oriented logical flow.

Attention should also be paid to the specificity of demand, as the food industry covers a wide range of products. The diversity of products should also be seen in the great variety of packaging, labels and markings, which, among other things, include information on the date of minimum durability. In this regard, the author (Van Donk, 2001) draw attention to the specificity that many products have a so-called technical minimum shelf life, which is reasonably long. Deliveries to retail outlets are not accepted with the same dates of minimum durability, which results in products that are technically still fresh, but commercially outdated and in fact perishable extremely quickly.

#### **2.5. Storage in the food industry**

A warehouse performs one of the most important functions in connection with the points of disconnection of the logistics chain. It usually does not add value to the stored items (except for technological stock), but on the contrary, it increases the costs associated with the activities associated with it, with the maintenance of warehouse spaces, the implementation of an information system that ensures the management of warehouse processes, service, etc (Marasova et al., 2020). The main requirement for effective storage is:

- maximum use of the warehouse volume through the compact design of warehouse systems that ensure permanent access to warehouse items,

- introduction of semi-automated and automated warehouse solutions aimed at reducing manual operations, especially in refrigerated and frozen warehouses,
- resistance of warehouse equipment and equipment used for picking to cold.

The trend in the food industry is a constant increase in demand for fresh and frozen food. This is reflected in the increased energy consumption of warehouses. Constantly rising energy prices are pushing logistics to find more efficient ways to implement storage processes. Average energy costs in cold storage facilities are around 25% of operating costs. An important task of logistics in the food industry is to ensure the cooling of food along the entire supply chain.

### 3. DATA AND METHODOLOGY

Companies that want to be competitive in the future must develop strategies that focus not only on reflecting on past mistakes and recognizing their own weaknesses but also on clearly defining business goals and visions. A key element in shaping such strategies is the use of tools such as modelling and simulation, which allow testing different scenarios, predicting the consequences of decisions, and optimizing processes before their actual implementation. Such an approach provides deeper insight into complex system relationships and supports effective strategic decision-making. Special attention is required for products with a limited shelf life, such as food, which place high demands on planning accuracy, distribution speed, and minimizing downtime. For these commodities, it is essential to create strategies that take into account not only production and storage capacities but also time-critical logistical aspects such as refrigeration, delivery times, and limited consumption windows. The use of simulation software is particularly important in the following phases (see Fig.1).

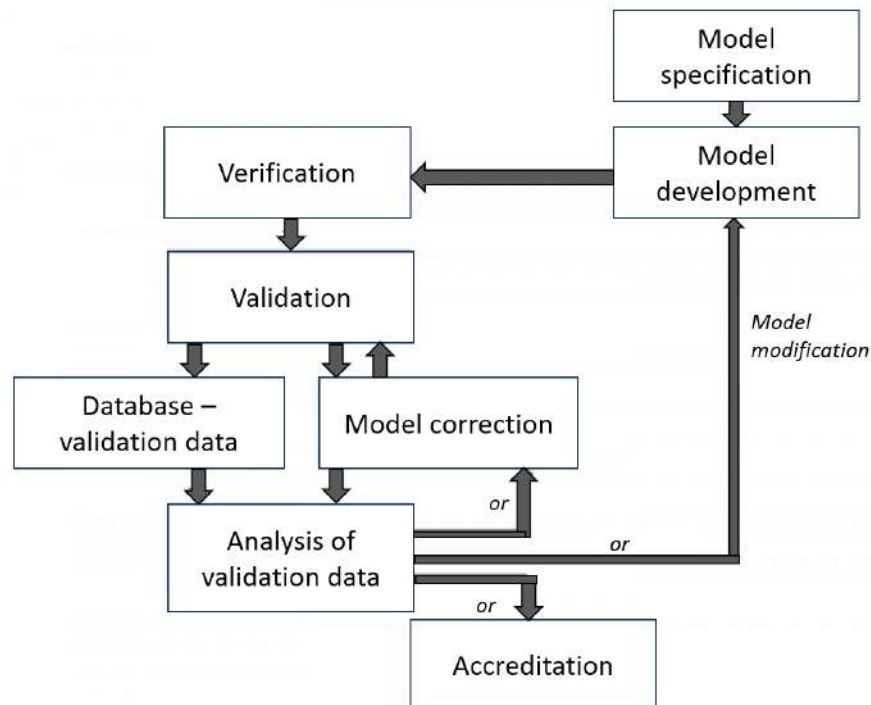


Figure 1. Methodological procedure for applying simulation tools

Simulation tools in this case allow to verify the behaviour of the supply chain under different scenarios of demand, distribution failures or seasonal fluctuations, thus significantly

reducing the risk of waste and at the same time increasing the reliability of supply. Companies from the food sector are increasingly turning to distribution simulations, discrete modelling or systems analysis, which allow to test different distribution strategies, plan transport routes, optimize warehouse stocks and assess the sensitivity of the system to unexpected changes.

Discrete simulations (DES) are particularly suitable for the analysis of operational processes, such as order sorting, unloading planning, utilization of warehouse equipment or loading queues in distribution centres. Conversely, systems analysis allows the examination the broader relationships between demand, production capacities, warehouse stocks and cash flow over a longer time horizon. These approaches are often complemented by agent-oriented modelling, which allows simulating the behaviour of individual entities (e.g. business partners, customers, or warehouse workers) and their interactions within the entire supply chain (Grznar et al., 2020; Straka et al., 2020; Fedorko et al., 2021).

## **4. RESULTS AND DISCUSSION**

### **4.1. Digital tools for the modelling and simulation of processes**

The TX Plant Simulation software was chosen for the case study solution because it is object-oriented and allows you to simulate discrete processes and systems with a focus on logistics, etc. The created simulation model can be defined in a specific time horizon, which allows you to replay the future state on a minute-by-minute basis, which would take hours or days in real time. It is advantageous to test alternative solutions based on a criterion function, which allows you to monitor, evaluate and increase the efficiency of the use of machines, equipment, workers, transport equipment, warehouse capacity, etc. Since visualization is an indisputable part of digital trends, this software allows you to work in a high-quality 3D space, use 3D models from the library, or import them in an allowed format (JT format) and use them in the virtualization of simulation models. The TX Plant Simulation software supports connection with virtual reality (Bangsow, 2010; Bangsow, 2012; Bangsow 2015). This functionality was used in solving a case study in the context of visualization and virtual inspection of a proposed warehouse project in a virtual reality environment. It is an effective tool for managerial decision-making, as it allows for the prediction and qualification of possible outcomes from different scenarios, which helps managers gain valuable knowledge and understand the effects of their potential decisions on the performance of the value chain in terms of time and costs.

The strength of a well-processed simulation model is its ability to reflect the system performance in detail and provide relevant information for decision-making. Since the simulation model represents a simplified model of the real system, it cannot be trusted blindly. This leads to the need for so-called virtual trust. Important in this sense is the connection of the process data of the real system to the simulation model, which leads to the creation of a digital twin. To achieve a realistic simulation model, the accuracy of the process data must be as high as possible. The process data defines the simulation model, and if this data is invalid, the model becomes invalid as well. This fact must therefore be considered. Based on the possibilities of precise modelling and statistical analysis, an accuracy of at least 99% of the throughput values is usually achieved with TX Plant Simulation models in real projects, depending on the level of detail (Bangsow, 2010). This fact has been verified on the created model. Another option, which is important from a managerial point of view, is the visualization of the complete model in a virtual reality environment through TX Plant Simulation via the 3D module.

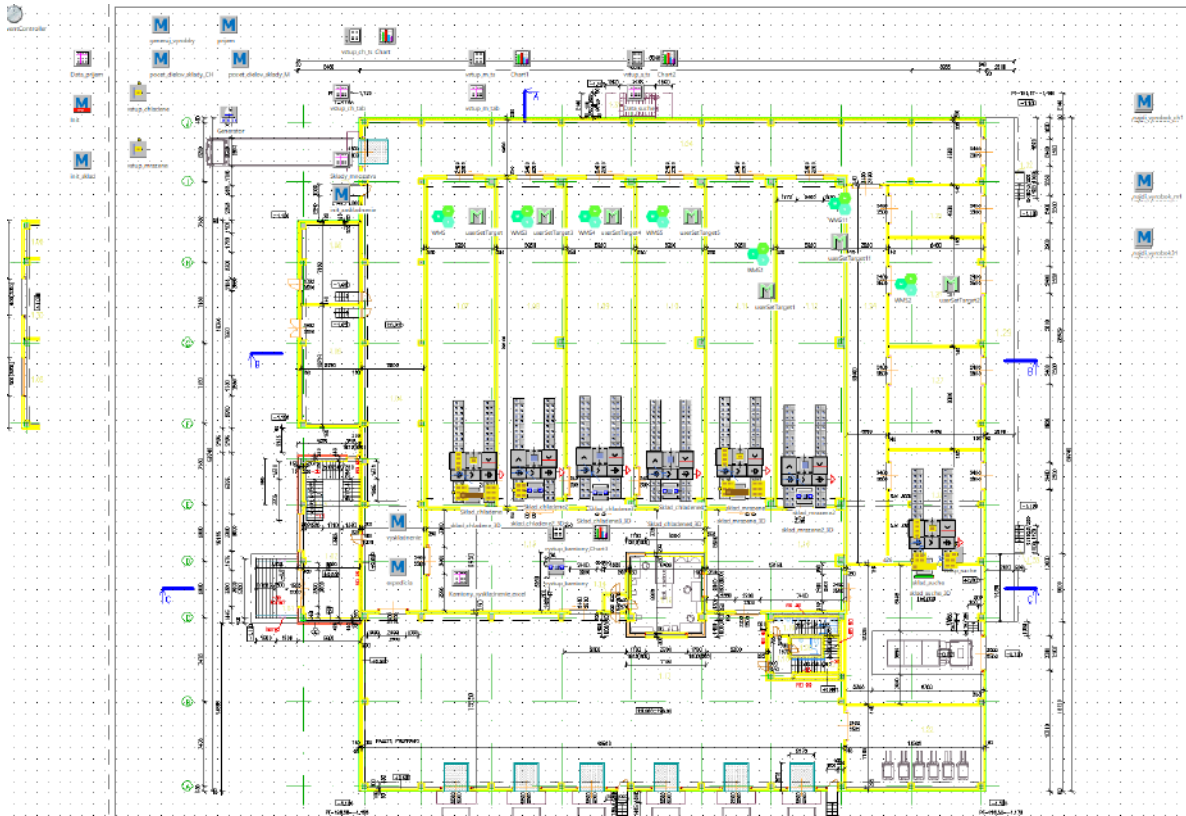


Figure 2. Process model of the Calmar warehouse in the Tx Plant Simulation simulation - layout solution

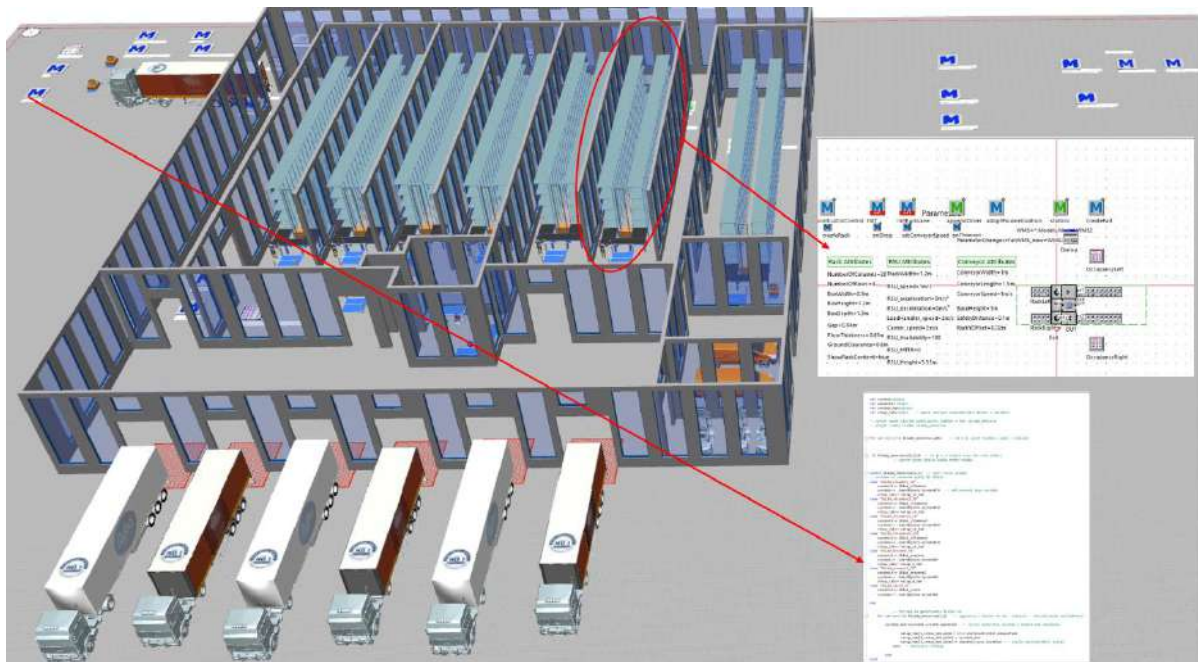


Figure 3. Simulation model of the Calmar warehouse in 3D with a demonstration of the simulation methodology



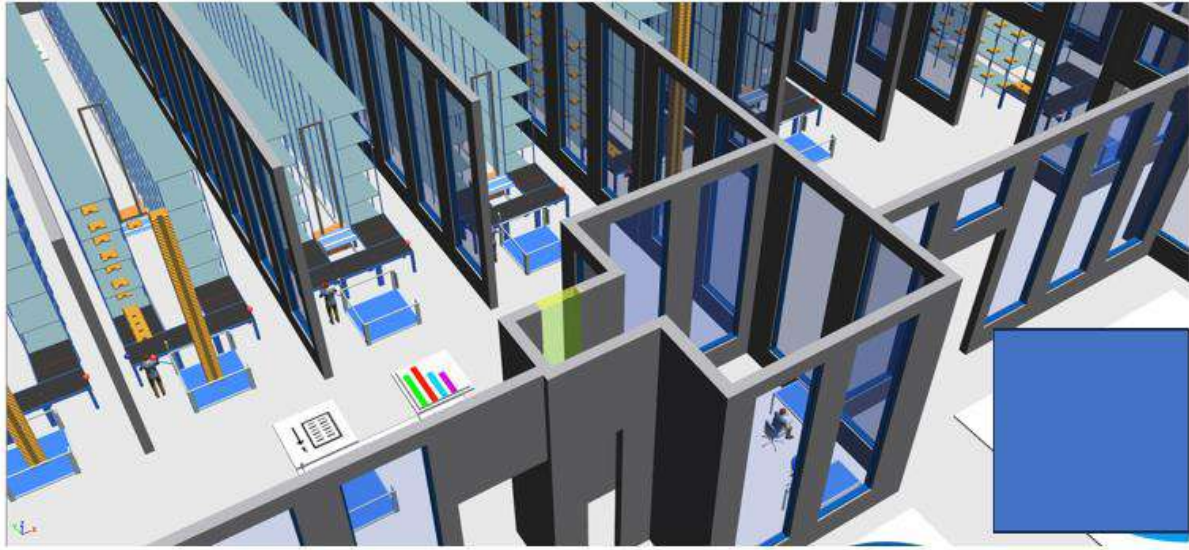


Figure 4. Optimized simulation model of the Calmar warehouse in 3D - internal layout

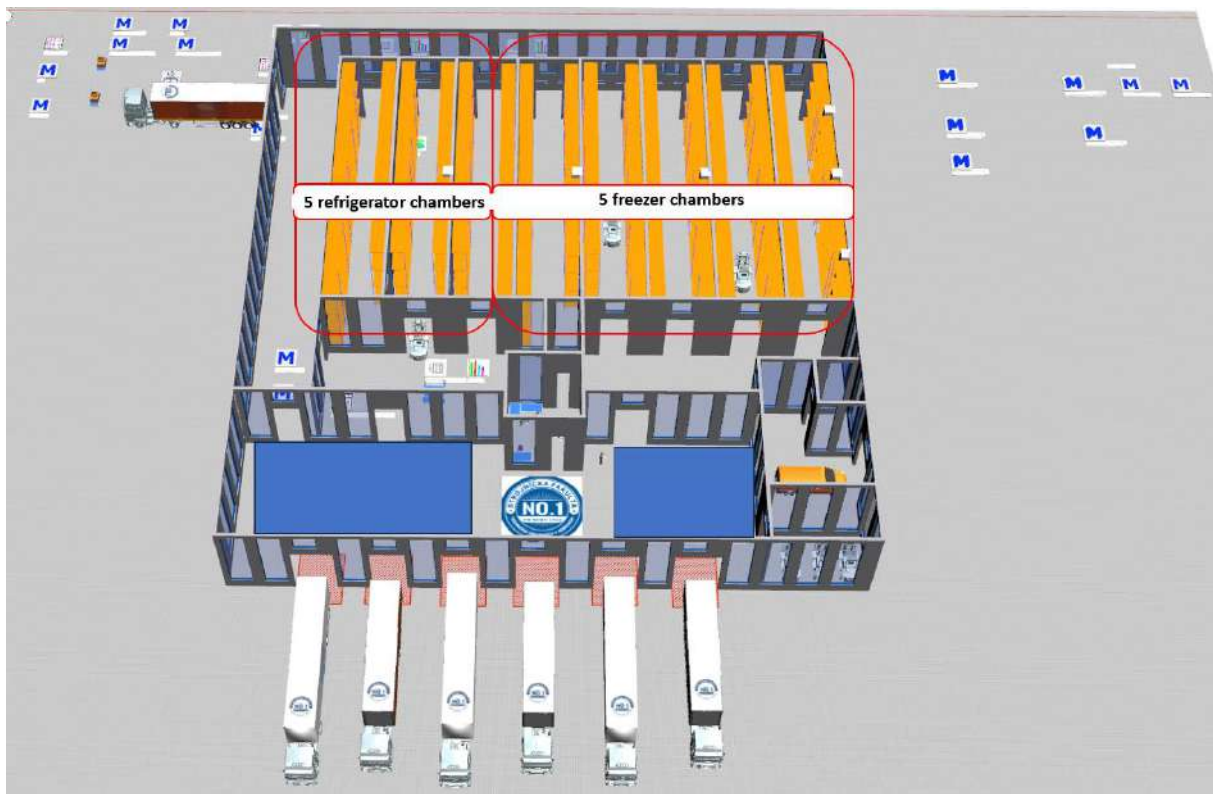


Figure 5. Optimized simulation model of the Calmar warehouse in 3D - view from above

In the presented study, the simulation software TX Plant Simulation was used in the planning phase, where a virtual model of a new warehouse for a selected company was modelled and tested. The requirements for production flexibility have increased, cost and timely delivery of products have become one of the key success factors. Procurement and inventory management have become limiting in balancing the tension between the customer's need for flexibility and the supplier's logistical performance while achieving economic efficiency and



stable and quality deliveries. It becomes necessary to correctly size the amount of inventory to be kept in stock. Due to the high impact on costs, the inventory level is an important logistical objective in procurement. The warehouse must provide a reserve for fluctuating requirements from customers, the distribution network, or its own production.

## 5. CONCLUSION

Shortening product life cycles and increasing product diversification and market globalization require a high level of organizational flexibility. For the food industry, where goods deteriorate rapidly, strategic decision-making must be based on comprehensive logistics coordination. In addition to ensuring quality and price competitiveness, factors such as delivery accuracy, on-time delivery, and the ability to respond in real time to changes in demand or disruptions in the distribution network are also coming to the fore.

Sustainable competitive advantages in this sector are only achievable if companies develop a strategic plan that is based on a deep analysis of internal resources, product specifications and market expectations. Such a plan must be supported by a coordinated approach between individual departments, the active use of analytical and simulation tools and constant performance monitoring in order to ensure a high level of adaptability. In addition, for products with a short shelf life, it is essential to systematically manage the flow of materials in the supply chain to minimize losses, maximize product freshness and meet strict regulatory requirements.

Sustainable competitive advantage is only possible if strategic planning includes a comprehensive connection between production, logistics and demand, supported by digital technologies such as simulation and predictive analytics tools. Their implementation allows not only to optimize existing processes but also to create more resilient and adaptive systems that can face the challenges of uncertainty, seasonality and strict hygiene or environmental regulations in the food sector.

## ACKNOWLEDGMENT

This article was created by the implementation of the grant project APVV-17-0258 “Digital engineering elements application in innovation and optimization of production flows”, APVV-19-0418 “Intelligent solutions to enhance business innovation capability in the process of transforming them into smart businesses”, VEGA 1/0508/22 „Innovative and digital technologies in manufacturing and logistics processes and system“, VEGA 1/0383/25 “Optimizing the activities of manufacturing enterprises and their digitization using advanced virtual means and tools”, KEGA 020TUKÉ-4/2023 “Systematic development of the competence profile of students of industrial and digital engineering in the process of higher education”, KEGA 003TUKÉ-4/2024 “Innovation of the profile of industrial engineering graduates in the context of required knowledge and specific capabilities for research and implementation of intelligent systems of the future“.

## REFERENCES

- Bangsow, S. (2010). Manufacturing simulation with Plant Simulation and SimTalk: Usage and programming with examples and solutions. Springer-Verlag.  
<https://doi.org/10.1007/978-3-642-05073-3>
- Bangsow, S. (2012). Use cases of discrete event simulation: Appliance and research. Springer.  
<https://doi.org/10.1007/978-3-642-28777-0>

- Bangsow, S. (2015). Tecnomatix Plant Simulation: Modeling and programming by means of examples. Springer. <https://doi.org/10.1007/978-3-319-19503-2>
- Fedorko, G., Molnar, V., Vasil, M., & Salai, R. (2021). Proposal of digital twin for testing and measuring of transport belts for pipe conveyors within the concept Industry 4.0. *Measurement*, 174, 108978. <https://doi.org/10.1016/j.measurement.2021.108978>
- Grznar, P., Gregor, M., Krajcovic, M., Mozol, S., Schickerle, M., Vavrik, V., Durica, L., Marschall, M., & Bielik, T. (2020). Modeling and simulation of processes in a factory of future. *Applied Sciences*, 10(13), 4503. <https://doi.org/10.3390/app10134503>
- Katana MRP. (2025, March 10). Perishable inventory: The best tools for expiry date tracking. <https://katanamrp.com/blog/perishable-inventory/>
- Marasova, D., Saderova, J., & Ambrisko, L. (2020). Simulation of the use of the material handling equipment in the operation process. *Open Engineering*, 10(1), 216–222. <https://doi.org/10.1515/eng-2020-0015>
- MRPeasy. (2025, March 10). What is a master production schedule (MPS)? With examples. <https://www.mrpeasy.com/blog/what-is-master-production-schedule/>
- Nyhuis, P., & Wiendahl, H.-P. (2009). *Fundamentals of production logistics: Theory, tools and applications*. Springer. <https://doi.org/10.1007/978-3-540-34211-3>
- Ptak, C., & Smith, C. (2016). *Demand driven material requirements planning (DDMRP)*. Industrial Press. ISBN 978-0-8311-9384-3
- Saniuk, S., Grabowska, S., & Straka, M. (2022). Identification of social and economic expectations: Contextual reasons for the transformation process of Industry 4.0 into the Industry 5.0 concept. *Sustainability*, 14(3), 1391. <https://doi.org/10.3390/su14031391>
- Straka, M., Khouri, S., Lenort, R., & Besta, P. (2020). Improvement of logistics in manufacturing system by the use of simulation modelling: A real industrial case study. *Advances in Production Engineering & Management*, 15(1), 18–30. <https://doi.org/10.14743/apem2020.1.346>
- Van Donk, D. P. (2001). Make to stock or make to order: The decoupling point in the food processing industries. *International Journal of Production Economics*, 69(3), 297–306. [https://doi.org/10.1016/S0925-5273\(00\)00058-0](https://doi.org/10.1016/S0925-5273(00)00058-0)



## **RELATION OF QMS VISION AND STRATEGY AND BALANCED SCORECARDS ACHIEVEMENTS OF HEIs IN INDUSTRY 5.0 ENVIRONMENT**

**Maja Glogovac**

*University of Belgrade, Faculty of organizational sciences, Serbia*

**Abstract:** The evolution from Industry 4.0 to Industry 5.0 reflects a growing recognition of the need to balance technological advancement with societal well-being. While Industry 4.0 primarily focuses on technological progress, Industry 5.0 introduces a more human-centered approach. For any industrial revolution to take root, it is important to be accepted by higher education, as the core pillar of any industry development. Accordingly, this paper aims to investigate the current achievements of higher education institutions (HEIs) related to their quality management system (QMS) vision and strategy in the context of the new industrial revolution. In this effort, the Balanced scorecards (BSC) model was used to assess the Industry 5.0 achievements of 374 HEIs in Serbia. ISO 9004:2018-based vision and strategy variable's relationship to BSC variables' were analyzed and proved using the regression analysis. The results can be significant for HEIs' management structures in creating a development path towards the adequate application of Industry 5.0.

**Keywords:** Industry 5.0, high education, Balanced Scorecards, QMS, strategy.

### **1. INTRODUCTION**

Over time, the world has faced several transformations in industrial systems (Broo et al., 2022; Babkin et al., 2022). Industrial revolutions entail societal progress characterized by evolutionary leaps in technological advancement (Ahmed et al., 2024). Given the scarcity of literature on the current industrial revolution (Industry 5.0), which is still in its beginning, and little is known about its applications, it is important to explore the focus of its application (Garrido et al., 2024; Carayannis & Morawska-Jancelewicz, 2022).

Unlike Industry 4.0, which has been criticized by many authors, theorists, and academics (Garrido et al., 2024), the current industrial era surpasses technologies and expands into human-centricity (Ivanov, 2023). The idea of Industry 5.0 is to create sustainability and optimize production systems (Ahmed et al., 2024). The main guideline for Industry 5.0 is

---

<sup>1</sup> Corresponding author: [maja.glogovac@fon.bg.ac.rs](mailto:maja.glogovac@fon.bg.ac.rs)

placing workers at the centre of educational services (Hashim et al., 2024). Given that Industry 4.0 did not address sustainability issues, Industry 5.0 emerged as the solution to sustainability concerns, with society viewing universities as the driving force. It is predicted that universities have to develop new strategies for integrating approaches to innovations and solutions for long-term sustainability (Hashim et al., 2024). Universities play a pivotal role in reshaping learning, thinking, and knowledge transmission, addressing the challenges of digital transformation, and constructing new societal paradigms for the current technological revolution (Taimur & Onuki, 2022). Many authors, academics, and researchers have displayed significant interest in researching and writing about Industry 5.0 (Babkin et al., 2022; Huang et al., 2022). However, there is still a lack of awareness of the benefits it brings, although the management of large organizational systems understands its potential value (Babkin et al., 2022).

Facing numerous challenges of the current industrial era, it is significant for all organizational systems to be adaptable and capable of measuring the effectiveness of their management systems. Thus, the sustainable success of quality management systems (QMS) requires the application of sophisticated management models (Glogovac et al., 2023). There is also room for integrated applications with some strategic models such as Balanced Scorecards (BSC) (Grabowska & Saniuk, 2022). Thus, this paper is aimed at investigating the BSC achievements of HEIs related to their quality management strategies in the Industry 5.0 environment.

After the introduction to Industry 5.0 in higher education, further literature review is dedicated to quality models in higher education: ISO 9004 and Balanced Scorecards, which were used for hypothesis development. Afterward, the methodology and results of the research were presented. Finally, the results, limitations of the study, and future research directions are discussed in the conclusions.

## **2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT**

The contemporary development of society, intertwined with social development, has created milestones known as industrial revolutions (Ahmed et al., 2024). Industrial revolutions have transformed the world and contributed to making industries more modern and productive (Broo et al., 2022). In the sense of technological advancement, Industry 4.0 is spread in all industries (Grabowska & Saniuk, 2022). Driven only by technology and technological progress, Industry 4.0 does not consider social issues and thus has been criticized by many authors (Leng et al., 2024). Consequently, Industry 5.0 emerged to establish human-machine cooperation (Miao et al., 2024). As a result of today's advancement of technologies, the economy of modern society is driven by the current industrial revolution (Kumar & Mallipeddi, 2022). Industry 5.0 gives new value to balance economic progress, referring to industrial revolutions and society as two complementary concepts (Huang et al., 2022), transitioning from a technological approach to sustainable societal development (Leng et al., 2024). As such, Industry 5.0 promotes the adaptability of technologies to human needs (Hashim et al., 2024; Huang et al., 2022), aimed at meeting societal needs and contributing to human well-being by placing them at the centre of integration with technologies (Carayannis & Morawska-Jancelewicz, 2022).

### **2.1. Higher Education and Industry 5.0**

Higher education, as the foundation of knowledge and a key driver of societal progress, is essential for any industrial revolution, which depends on HEIs' tendency towards the development of systematic approaches and theoretical domains, as well creation of innovative models for efficient practical application (Hashim et al., 2024). With the adoption of the new

concept of Industry 5.0, the significant changes in the global market pose a challenge for universities worldwide to create new methodological innovations and establish theoretical frameworks for the development of new models that can assist organizational systems and society as a whole (Carayannis & Morawska-Jancelewicz, 2022). In today's complex systems, technological and scientific progress is inevitable, with universities playing a key role in its development (Carayannis & Morawska-Jancelewicz, 2022). As a result, the considerable shifts in technological progress that have left their mark on the world have also impacted higher education, prompting it to address the emerging challenges arising from Industry 5.0 (Broo et al., 2022). Essentially, in adopting a wide range of knowledge exchange and information for the new challenge and changing mindset, HEIs must prioritize knowledge and skills (Broo et al., 2022). Implementation and use of new technologies, internet access, global databases in higher education, as well as self-learning, go beyond traditional methods of teaching and learning, bringing a range of potential benefits to students (Broo et al., 2022). Given the literature gap about the application of empirical evidence of Industry 5.0 in higher education, the paper of Hashim et al. (2024) contributes empirical insights and merges the theoretical and practical aspects of applying the concept of Industry 5.0 in higher education.

## **2.2. Quality models in higher education: ISO 9004 and Balanced Scorecards**

Customers today have greater expectations than ever in the past, so to remain competitive in the current industrial era, organisations need to improve their processes, use some business excellence models and demonstrate a high level of quality and performance (Araújo & Sampaio, 2013). The importance of managing quality at a high level in today's digital transformation era is also pointed out by Nguyen et al. (2022). Current trends indicate that educational organizations are trying to find innovative methods to enhance the quality of education through modern quality management approaches (Sütoová et al., 2022).

In line with this, it is inevitable for all universities to incorporate adequate strategic and QMS tools into the development process. In this context, the ISO 9004:2018 standard can offer clear direction for attaining long-term success (Glogovac et al., 2022). Since ISO 9004:2018 is a proven and one of the globally recognized maturity models for QMS, the elements of this model could serve as a framework for assessing the quality maturity level in a new industrial environment (Glogovac et al., 2022).

On the other side, there is significant room for integrating quality maturity models with ones that can serve for performance achievement measuring. In addition to the successful implementation of models for excellence in higher education, the successful adoption of the BSC in higher education is also noted (Serdar Asan, 2007). BSC is a tool for business performance measuring, developed by Kaplan & Norton (1996), that has gained increasing popularity and application in various industries over time (Kiriri, 2022). It considers performances through four perspectives: customer, internal processes, learning and growth, and financial (Kaplan & Norton, 1996). To achieve sustainability, HEIs can apply this model to meet the requirements of all stakeholders (Makki et al., 2023; Al-Bahi et al., 2021; Nazari-Shirkouhi et al., 2020). Considering the dynamic environment, HEIs could adopt the BSC as a comprehensive tool for performance evaluation to enhance them accordingly (Kiriri, 2022).

### 2.3. Hypothesis development

Quality management requires the integration of mission, vision, values, and culture, and in that regard, it is necessary to identify a clear strategy (Serdar Asan & Tanyaş, 2007). On the other hand, strategic measurement based on the application of the BSC perspectives also involves linking goals, mission, and vision into a single entity (Serdar Asan, 2007). Therefore, the BSC can serve as a strategic framework for aligning strategy and vision into a comprehensive whole (Serdar Asan, 2007). Implementing the BSC can facilitate the achievement of strategic objectives and alignment with the vision and strategy of organizations (Kiriri, 2022). Adopting the BSC enables organizations to evaluate strategies through tangible outcomes and achievable goals (Serdar Asan, 2007). Kaplan & Norton (1996) pointed out that vision and strategy are in relation to the BSC perspectives (Figure 1).

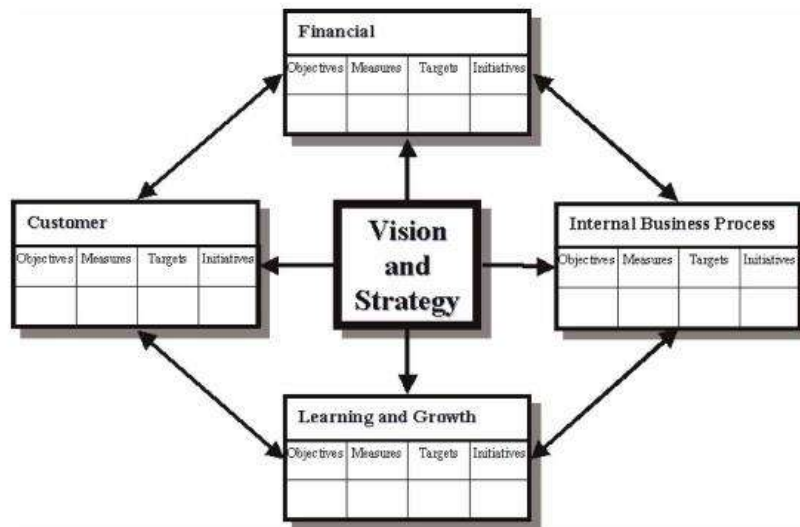


Figure 1. Vision and Strategy in relation to the BSC perspectives (Kaplan & Norton, 1996)

In achieving the strategic goals of HEIs, paying attention to customers and their satisfaction ranks at the top of the hierarchical ladder within the BSC perspectives (Stejskal et al., 2020). The customer perspective is seen as strongly related to the vision (Kiriri, 2022). Innovation, learning, and growth of HEIs also take one of the leading positions within the BSC perspectives (Stejskal, et al., 2020). This perspective entails innovation in the work of HEIs (Al-Bahi, et al., 2021), encompassing organizational knowledge, innovation in work, professional growth, and development of employees (Al-Bahi, et al., 2021). In the field of higher education, internal business processes also play a significant role in following the strategic map (Nazari-Shirkouhi, et al., 2020). The perspective of internal business processes focuses on coordinating business activities with the mission, vision, and strategic goals of higher education institutions (Kiriri, 2022). Translating mission and strategy into operational objectives in financial terms can contribute to increased financial resources (Kiriri, 2022). The financial perspective in HEIs can encompass funding sources, including government funding and student tuition fees (Serdar Asan, 2007). According to the recognised relations among HEIs quality strategies and Balanced Scorecard perspectives, the following hypotheses are addressed:

- H (1) QMS Vision and Strategy is correlated with the Customer Perspective of HEIs in the era of Industry 5.0.
- H (2) QMS Vision and Strategy is correlated with the Learning and Growth Perspective of HEIs in the era of Industry 5.0.

- H (3) QMS Vision and Strategy is correlated with the Internal Business Processes Perspective of HEIs in the era of Industry 5.0.
- H (4) QMS Vision and Strategy is correlated with the Financial Perspective of HEIs in the era of Industry 5.0.

### **3. DATA AND METHODOLOGY**

The research method used to collect data is an online questionnaire for employees in HEIs. It was conducted from November 2023 to March 2024 in 374 HEIs in the Republic of Serbia. The questionnaire is intended for employees at both public and private faculties and academies, established through the merger of high education institutions.

The first part of the questionnaire covers the demographic features of respondents, while the second part focuses on the ISO 9004:2018 QMS vision and strategy variables and the BSC perspectives in the context of Industry 5.0. Elements of the ISO 9004:2018 standard that stand for the QMS Vision and Strategy variable are: Relevant interested parties and their needs; External and internal organisational issues; Mission, vision, values, and culture; Leadership; Policy and strategy; Objectives; and Communication about policies and strategies. BSC perspectives that are covered in the research are: Customer; Learning and growth; Internal business processes; and Financial perspective.

ISO 9004:2018-based vision and strategy variable's relationship to BSC variables were analyzed using the Regression analysis.

### **4. RESULTS AND DISCUSSION**

Exploratory factor analysis was applied to reduce and structure a large number of observable variables into a smaller number of latent constructs, thereby achieving greater analytical clarity. KMO and Bartlett's tests are used to assess the suitability of the data for factor analysis. The results of the KMO test (0.984) and Bartlett's test ( $\chi^2=25672.999$ ;  $p<0.001$ ) confirm that the data are very suitable for factor analysis. The results of the factor analysis showed that a certain number of observable variables were reduced and structured into a smaller number of latent constructs. All values obtained by Exploratory factor analysis are given in Table 1. Subsequently, a Regression analysis was conducted on a sample of 374 respondents, which satisfies the recommended ratio of 10:1 between the number of respondents and the number of included observable variables, of which there were a total of 56 in this study. The independent factors investigated in the study are QMS vision and strategy. Factors such as Customer perspective, Learning and growth perspective, Internal business process perspective, and Financial perspective are treated as dependent variables in this model.

Cronbach's alpha coefficient (Nunnally, 1978) was used to determine the internal consistency of the instrument. The results of the reliability coefficients for all five groups of questions show values above 0.7, which meets the recommendations of authors such as Nunnally (1978) and Deng & Chan (2017), and are presented in detail in Table 2. These results indicate good internal consistency and reliability of all examined constructs. Correlation analysis was applied to examine the relationship between the two groups of questions. To quantitatively represent the relationship between these two constructs, the correlation coefficient was calculated. The obtained results show a high level of mutual correlation, which indicates a strong statistical relationship between the examined constructs. The values of the correlation coefficients are also presented in Table 2.

Table 1. Exploratory factor analysis (EFA)

Observable variables	Component				
	1	2	3	4	5
Customer perspective (CP)					
Q1	0.617				
Q2	0.626				
Q3	0.665				
Q4	0.676				
Q5	0.614				
Q6	0.646				
Q7	0.573				
Q8	0.569				
Q9	0.556				
Q10	0.617				
Q11	0.630				
Q12	0.616				
Learning and growth perspective (LGP)					
Q6		0.503			
Q7		0.524			
Q8		0.547			
Q9		0.591			
Q10		0.503			
Q11		0.530			
Q12		0.536			
Q13		0.531			
Q14		0.571			
Internal business processes perspective (IBPP)					
Q1			0.550		
Q2			0.614		
Q3			0.701		
Q4			0.678		
Q5			0.627		
Q7			0.618		
Q14			0.552		
Q15			0.568		
Q16			0.578		
Financial perspective (FP)					
Q1				0.530	
Q2				0.634	
Q3				0.587	
Q4				0.662	
Q5				0.734	
Q6				0.738	
Q7				0.638	
Q8				0.589	
QMS Vision and Strategy (QMS_VS)					
Q1					0.739
Q2					0.765
Q3					0.688
Q4					0.665
Q5					0.710
Q6					0.703
Q7					0.624



Table 2. Coefficient of Cronbach Alpha and the Correlation coefficient

Variables	Cronbach Alfa	CP	LGP	IBPP	FP	QMS_VS
CP	0.958	1				
LGP	0.959	0.884**	1			
IBPP	0.949	0.921**	0.917**	1		
FP	0.936	0.810**	0.848**	0.797**	1	
QMS_VS	0.958	0.817**	0.812**	0.796**	0.815**	1

After the Correlation analysis, Regression analysis was performed, which goes a step further and focuses on predicting the value of one variable based on the value of another (Ho, 2006). In other words, if the value of one independent variable is known, Regression analysis allows one to predict the behavior or value of the dependent variable with a certain degree of accuracy. The Regression analysis was applied in this study to determine the existence and strength of relationships between multiple variables. Specifically, the impact of QMS vision and strategy as independent variables on multiple dependent constructs that reflect different perspectives of HEIs was analyzed: Customer perspective, Learning and growth perspective, Internal business processes perspective, and Financial perspective. These constructs represent key dimensions of the performance of HEIs following the concept of the Balanced Scorecards.

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.817	0.667	0.666	0.546	0.667	7450.710	1	372	0.000
2	0.812	0.660	0.659	0.585	0.660	7210.085	1	372	0.000
3	0.796	0.634	0.633	0.576	0.634	6440.581	1	372	0.000
4	0.815	0.664	0.663	0.544319	0.664	7340.724	1	372	0.000

a. Predictor: (Constant), QMS\_VS  
b. Dependent Variables: CP, LGP, IBPP, FP

The result of the change in the coefficient of determination ( $R^2$ ) indicates the degree to which the variations in the dependent variables can be explained by the influence of the independent variable. In this case, as shown in Table 3, the independent variable QMS vision and strategy statistically significantly explains the variations in the dependent constructs, such as Customer perspective with 66.7%, Learning and growth perspective with 66.0%, Internal business process perspective with 63.4%, and Financial perspective with 66.4%.

Table 4. Coefficients beta regression

Model	Unstandardized Coefficients		Stand. Coef.	t	Sig.
	B	Std. Error	Beta		
CP	0.743	0.027	0.817	27.308	0.000
LGP	0.784	0.029	0.812	26.853	0.000
IBPP	0.728	0.029	0.796	25.389	0.000
FP	0.735	0.027	0.815	27.106	0.000

a. Dependent Variable: BMP

Further, the formulated hypotheses were tested using Regression analysis, to examine the impact of the QMS vision and strategy construct on four perspectives of the BSC: the Customer perspective, the Learning and growth perspective, the Internal business process perspective, and the Financial perspective. Table 3 and Figure 2 show the values of the beta

coefficients and the path of influence. The results of the analysis indicate a strong and statistically significant impact of the QMS vision and strategy on all four perspectives, with the most pronounced impact observed on the Customer perspective.

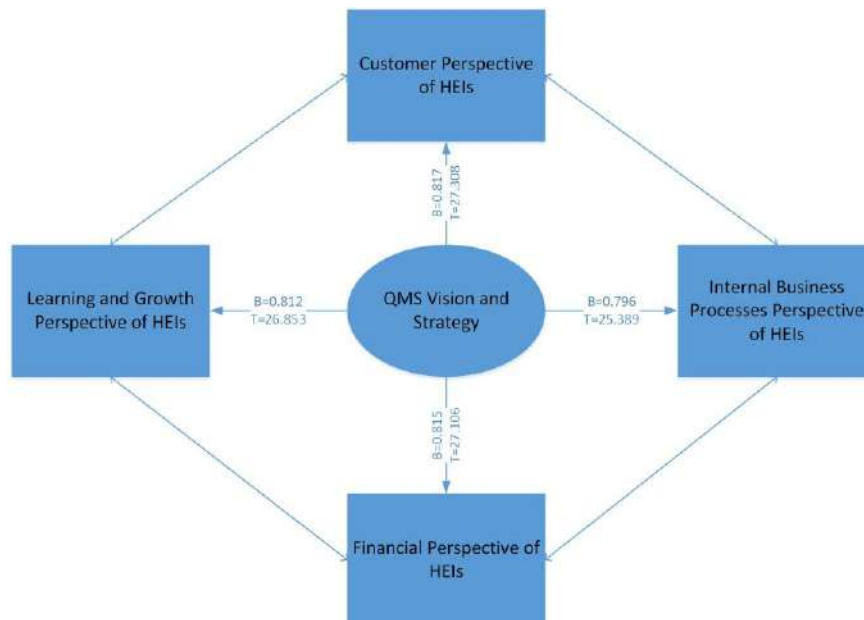


Figure 2. Results of Regression Analysis

## 5. CONCLUSION

The paper aimed to investigate the relationship between the QMS vision and strategy and the measurable performance of HEIs in the Industry 5.0 environment. On this occasion, the QMS vision and strategy were defined through the variables of the ISO 9004:2015 standard that relate to Relevant interested parties and their needs; External and internal organisational issues; Mission, vision, values, and culture; Leadership; Policy and strategy; Objectives; and Communication about policies and strategies. On the other hand, the achievements were categorized according to the BSC perspectives: Customer perspective, Internal business perspective, Learning and growth perspective, and Financial perspective.

The results of the statistical processing of the collected data indicate a significant relationship between the QMS vision and strategy and all four observed BSC performance perspectives. This indicates that even in today's context, which is directed towards Industry 5.0, the QMS vision and strategy can be a significant factor in the success of HEIs. It is important for higher education to follow the industrial revolution from its beginning and to adapt to it to ensure success in the new environment. Based on the results of this research, HEIs' management can be aware of the importance of adequately managing QMS vision and strategy in a new industrial era. Considering that this research has proved their connection with a large number of HEIs' performances, the importance of adequately defining and managing QMS in HEIs in the era of Industry 5.0 is highlighted. In addition to highlighting the relevance of QMS vision and strategy in the Industry 5.0 context, this research contributes to the existing body of knowledge by connecting quality management frameworks with organizational performance models in a new industrial context. It could serve as a practical basis for HEIs to strategically align their quality management initiatives with evolving industrial trends. Furthermore, the study provides a foundation for future empirical research aiming to deepen the understanding

of how integrated management approaches can enhance institutional resilience and competitiveness.

The limitations of this research relate to the territorial scope, so future research could include and compare results between countries depending on their degree of alignment with Industry 5.0. In addition, this research is limited only to the QMS vision and strategy as an independent variable, while future research could include other QMS elements. Also, future research could include ranking the impact of QMS elements on different performance achievements.

## REFERENCES

- Ahmed, I., Hossain, N. U. I., Fazio, S. A., Lezzi, M., & Islam, M. S. (2024). A Decision Support Model for Assessing and Prioritization of Industry 5.0 Cybersecurity Challenges. *Sustainable Manufacturing and Service Economics*, 100018. <https://doi.org/10.1016/j.smse.2024.100018>
- Al-Bahi, A. M., Abd-Elwahed, M. S., & Soliman, A. Y. (2021). Implementation of sustainability indicators in engineering education using a combined balanced scorecard and quality function deployment approaches. *Sustainability*, 13(13), 7083. <https://doi.org/10.3390/su13137083>
- Araújo, M., & Sampaio, P. (2013). Total Quality Management & Business Excellence. The path to excellence of the Portuguese organisations recognised by the EFQM model, *Total Quality Management & Business Excellence*, 25(5-6), 427-438, <https://doi.org/10.1080/14783363.2013.850810>
- Babkin, A., Shkarupeta, E., Kabasheva, I., Rudaleva, I., & Vicentiy, A. (2022). A Framework for Digital Development of Industrial Systems in the Strategic Drift to Industry 5.0. *International Journal of Technology*, 13(7). DOI: 10.14716/ijtech.v13i7.6193
- Broo, D. G., Kaynak, O., & Sait, S. M. (2022). Rethinking engineering education at the age of industry 5.0. *Journal of Industrial Information Integration*, 25, 100311. <https://doi.org/10.1016/j.jii.2021.100311>
- Carayannis, E. G., & Morawska-Jancelewicz, J. (2022). The futures of Europe: Society 5.0 and Industry 5.0 as driving forces of future universities. *Journal of the Knowledge Economy*, 13(4), 3445-3471. <https://doi.org/10.1007/s13132-021-00854-2>
- Deng, L., & Chan, W. (2017). Testing the difference between reliability coefficients alpha and omega. *Educational and Psychological Measurement*, 77(2), 185–203. <https://doi.org/10.1177/0013164416658325>
- Garrido, S., Muniz Jr, J., & Ribeiro, V. B. (2024). Operations Management, Sustainability & Industry 5.0: A Critical Analysis and Future Agenda. *Cleaner Logistics and Supply Chain*, 100141. <https://doi.org/10.1016/j.clscn.2024.100141>
- Glogovac, M., Ruso, J., & Maricic, M. (2022). ISO 9004 maturity model for quality in industry 4.0. *Total Quality Management & Business Excellence*, 33(5-6), 529-547. <https://doi.org/10.1080/14783363.2020.1865793>
- Glogovac, M., Ruso, J., Arsić, S., Rakić, A., & Milošević, I. (2023). Leadership for quality 4.0 improvement, learning, and innovation. *Engineering Management Journal*, 35(3), 313-329. <https://doi.org/10.1080/10429247.2022.2108668>
- Grabowska, S., & Saniuk, S. (2022). Assessment of the competitiveness and effectiveness of an open business model in the industry 4.0 environment. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(1), 57. <https://doi.org/10.3390/joitmc8010057>

- Hashim, M. A. M., Tlemsani, I., Mason-Jones, R., Matthews, R., & Ndrecaj, V. (2024). Higher education via the lens of industry 5.0: Strategy and perspective. *Social Sciences & Humanities Open*, 9, 100828. <https://doi.org/10.1016/j.ssaho.2024.100828>
- Ho, R. (2006). *Handbook of Univariate and Multivariate Data Analysis and Interpretation with SPSS*. Boca Raton, FL: Chapman & Hall/CRC.
- Huang, S., Wang, B., Li, X., Zheng, P., Mourtzis, D., & Wang, L. (2022). Industry 5.0 and Society 5.0—Comparison, complementation and co-evolution. *Journal of manufacturing systems*, 64, 424-428. <https://doi.org/10.1016/j.jmsy.2022.07.010>
- Ivanov, D. (2023). The Industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives. *International Journal of Production Research*, 61(5), 1683-1695. <https://doi.org/10.1080/00207543.2022.2118892>
- Kaplan, R. S., & Norton, D. P. (1996). Strategic learning & the balanced scorecard. *Strategy & Leadership*, 24(5), 18-24. <https://doi.org/10.1108/eb054566>
- Kiriri, P. N. (2022). Management of performance in higher education institutions: The application of the balanced scorecard (BSC). *European Journal of Education*, 5(1), 141-154. <http://dx.doi.org/10.26417/158crg70k>
- Kumar, S., & Mallipeddi, R. R. (2022). Impact of cybersecurity on operations and supply chain management: Emerging trends and future research directions. *Production and Operations Management*, 31(12), 4488-4500. <https://doi.org/10.1111/poms.13859>
- Leng, J., Zhu, X., Huang, Z., Li, X., Zheng, P., Zhou, X., ... & Liu, Q. (2024). Unlocking the power of industrial artificial intelligence towards Industry 5.0: Insights, pathways, and challenges. *Journal of Manufacturing Systems*, 73, 349-363. <https://doi.org/10.1016/j.jmsy.2024.02.010>
- Makki, A. A., Alqahtani, A. Y., Abdulaal, R. M., & Madbouly, A. I. (2023). A novel strategic approach to evaluating higher education quality standards in university colleges using multi-criteria decision-making. *Education Sciences*, 13(6), 577. <https://doi.org/10.3390/educsci13060577>
- Miao, J., Wang, Z., Wang, M., Garg, S., Hossain, M. S., & Rodrigues, J. J. (2024). Secure and efficient communication approaches for Industry 5.0 in edge computing. *Computer Networks*, 110244. <https://doi.org/10.1016/j.comnet.2024.110244>
- Nazari-Shirkouhi, S., Mousakhani, S., Tavakoli, M., Dalvand, M. R., Šaparauskas, J., & Antuchevičienė, J. (2020). Importance-performance analysis based balanced scorecard for performance evaluation in higher education institutions: an integrated fuzzy approach. *Journal of Business Economics and Management*, 21(3), 647-678. <https://doi.org/10.3846/jbem.2020.11940>
- Nguyen, T. A. V., Tucek, D., & Pham, N. T. (2022). Indicators for TQM 4.0 model: Delphi Method and Analytic Hierarchy Process (AHP) analysis. *Total Quality Management & Business Excellence*, 34(1-2), 220-234. <https://doi.org/10.1080/14783363.2022.2039062>
- Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw-Hill.
- Serdar Asan, Ş., & Tanyaş, M. (2007). Integrating Hoshin Kanri and the balanced scorecard for strategic management: The case of higher education. *Total Quality Management*, 18(9), 999-1014. <https://doi.org/10.1080/14783360701592604>
- Stejskal, K., Sayed, N., & Lento, C. (2020). Mapping stakeholder expectations of a publicly funded post-secondary institution: a balanced scorecard perspective. *Accounting and the Public Interest*, 20(1), 104-137. <https://doi.org/10.2308/api-19-002>
- Sütoová, A., Teplická, K., & Straka, M. (2022). Application of the EFQM Model in the Education Institution for Driving Improvement of Processes towards Sustainability. *Sustainability*, 14 (2022), 7711. <https://doi.org/10.3390/su14137711>

Taimur, S., & Onuki, M. (2022). Design thinking as digital transformative pedagogy in higher sustainability education: Cases from Japan and Germany. *International Journal of Educational Research*, 114, 101994. <https://doi.org/10.1016/j.ijer.2022.101994>



## INDUSTRY 5.0 IN THE NEW GLOBAL CIRCUMSTANCES OF MINING WITH RISK MAPPING

Slobodan Radosavljević \*

*RB "Kolubara" d.o.o., Svetog Save 1, 11550 Lazarevac, R. Serbia*

**Abstract:** Industry 5.0 represents a new evolutionary phase of process industrialization, which is based on the integration of advanced technologies with human capabilities, creating a synergy that enables greater personalization, flexibility and sustainability in production processes. In the context of mining, which faces global challenges such as: the need for smart mining technologies or completely redesigned technological processes (rapid changes), environmental pressures, legislative changes, security challenges and digital transformation, Industry 5.0 opens up new opportunities, but at the same time introduces and generates new risks. This paper investigates how the application of technologies and their techniques such as automation, artificial intelligence, Internet of Things (IoT) and robotics can partially or completely redesign technological mining operations on coal production and processing, increasing efficiency and safety, while simultaneously generating and multiplying a new format of the risk paradigm. Special attention is paid to risk mapping within the industrial framework of coal mining, with analysis of potential hazards and opportunities to reduce negative impacts through predictive analytics, digital twins and automated processes. Through the work, the complex dynamics of the relationship between new technologies and challenges in coal mining can be observed, offering strategies for effective risk management and improving sustainability in the emerging global conditions.

**Keywords:** Industry 5.0, mining, coal, processes, risks.

### 1. INTRODUCTION

This document Industry 5.0 marks a new approach in the development of industrial and production systems, which focuses on the integration of advanced technologies with human elements in order to achieve efficiency, sustainability and personalization. Unlike Industry 4.0, which was focused on automation and digitalization, Industry 5.0 emphasizes the cooperation between people and machines, creating a balanced work environment where technology, in addition to automating processes, also helps people to be more creative, safer and more

---

\* Corresponding author: drslobodanr@gmail.com

Slobodan Radosavljević, ORCID: 0009-0000-3223-9743

efficient. Mining, as one of the most dangerous and risky sectors in the industry, faces constant challenges when it comes to risk management. Classical approaches, which were mainly based on human experience and risk assessment in the field, are no longer sufficient in the modern environment that is rapidly changing due to the introduction of new technologies and changes in market and environmental conditions. Industry 5.0 offers the opportunity to redefine the risk management paradigm in mining, enabling the application of advanced technologies such as IoT, artificial intelligence (AI), automation and robotics. It is realistically possible to ask one of the questions how Industry 5.0 affects the management of process risks in mining and how modern approaches can help increase safety and reduce the negative impact on the environment, among others.

## **2. INDUSTRY 5.0 - BASIC CHARACTERISTICS**

Industry 5.0 essentially represents a new direction of development in the industry, which is based on a combination of advanced automation, digitalization and human creativity, with the aim of creating smart, flexible and sustainable production systems (Coelho et al., 2023).

Key features of Industry 5.0 include:

- Collaboration between humans and robots, (cobots): Industry 5.0 emphasizes close collaboration between workers and robots, (collaborative robots or cobots). While robots take over more difficult, repetitive or dangerous tasks, humans remain responsible for the creative, strategic and complex aspects of production.
- Product personalization: Industry 5.0 enables the production of products that are fully adapted to the needs and wishes of end users. This is achieved by using advanced technologies such as 3D printing and mass personalization of production lines.
- Sustainable development and green technology: Industry 5.0 emphasizes reducing the negative impact on the environment, using renewable energy sources, recycling and sustainability in production processes. The goal is for the production to be ecologically balanced/more acceptable and less energy intensive.
- Advanced digitalization and the Internet (IoT): Industry 5.0 uses advanced digitalization, including IoT, artificial intelligence (AI), and big data to optimize production processes, improve efficiency, and enable better real-time monitoring and analysis.
- Smart factories: Smart factories are the basis of Industry 5.0, which use digital technologies, automation and advanced analytics to manage production processes in real time, thereby increasing flexibility and efficiency.
- Focus on human values: Unlike Industry 4.0, which focused on automation and robotization, Industry 5.0 puts people at the center. The goal is for technology to enhance human creativity and well-being, not replace it entirely. This model insists on creating better working conditions, greater employee engagement and a better balance between technological innovation and human values.
- Adaptability and flexibility: Industry 5.0 enables faster adaptation to changes in the market and consumer demands, enabling production in smaller batches and with higher levels of personalization, while at the same time reducing the time required for production, (Ghobakhloo et al., 2023).
- Greater connectivity and integration: Through the integration of different technologies and systems, such as cloud computing, edge computing, and blockchain, Industry 5.0 enables better connectivity between different sectors and factories, creating a unique and efficient global production network.

- Training and skill development: As technologies evolve, so does the need for worker training. In Industry 5.0, organizations must invest in training their employees to prepare them to work in high-tech environments. Developing a culture of safety and innovation can also reduce human error and increase safety.
- Worker safety and health: Industry 5.0 puts the foregoing into focus on worker well-being, using technology to reduce physical stress, risk of injury, and improve the work environment. There are also new ways workers can use technology to improve their work performance while also having better working conditions.

The above basic features can be explained in detail, but in general they indicate that Industry 5.0 goes beyond automation and robotization, emphasizing the cooperation between people and technology, which creates a completely new, dynamic, sustainable and personalized production ecosystem, (Akundi et al., 2022; Fazal et al., 2022). At the same time, Industry 5.0 also represents a significant advance in risk management in mining, combining technology, human resources and sustainability to create a safer, more efficient and responsible working environment. This new paradigm allows companies to face the challenges and risks associated with modern mining more quickly and with better quality, quantitatively map them and define the best answers to them, (Kaswan et al., 2025).

### **3. CHARACTERISTICS OF SMART TECHNICAL SYSTEMS IN SURFACE EXPLOITATION OF COAL, SPECIFICITIES IN THE CONDITIONS OF NEW GLOBAL ENVIRONMENTS AND INDUSTRY 5.0**

Modern smart technical systems for surface mining of coal in the conditions of new global circumstances and Industry 5.0 bring numerous technological innovations that enable greater efficiency, sustainability, safety and environmental responsibility. These systems use advanced technologies such as automation, artificial intelligence, IoT (Internet of Things), predictive analytics, and sustainable energy technologies, which are integrated to improve all aspects of the manufacturing process, (Zhironkin & Taran, 2023).

Some of the key specificities of the work of technical systems on surface coal mining can be defined through:

- Autonomous transport systems: Autonomous transport systems (smart belt conveyors) are used in modern surface mining of coal. These systems can perform tasks without human intervention, reducing the need for workers in hazardous areas while increasing productivity and safety.
- Autonomous Technical Smart Mining Systems: Technical systems and mining machines can be programmed to operate within precise parameters, which improves the efficiency of the mining process and reduces the risk of human error.
- Predictive maintenance: AI algorithms can analyze data in real time about the state of technical systems and equipment and predict when a failure or need for servicing will occur, thus minimizing downtime and extending the life of the equipment.
- Production optimization: AI is used to analyze large amounts of data from sensors and IoT devices in order to optimize the dynamics of technical systems and equipment operation, improve production parameters and reduce the consumption of energy and other resources.
- Monitoring of technical systems, equipment and working conditions: Sensors built into the excavation equipment enable the monitoring of parameters such as temperature, vibration, level of energy consumption and stress on the machines, thus enabling timely intervention and preventing damage.



- Connection to centralized management smart systems: Sensors enable constant monitoring of the situation in the field, as well as interaction with central systems for data analysis, which enables decision-making in real time.
- Digital platforms for data management: In Industry 5.0, all operations in surface coal mining are connected through digital platforms that enable the integration of all aspects of business, from planning to production. These platforms enable better monitoring of production flows and resources (Usharani et al., 2022).
- Virtual models: By using digital twins, virtual models of surface mining operations can be created. These models enable the simulation of working conditions, the testing of new technologies, as well as the optimization of work without the need for physical testing in the field.
- Robotic Burial and Transport Systems: In modern mining operations, robotic systems can perform operations such as mining, transporting, cleaning and sorting coal, all under the strict supervision of a remote control system.
- Combination of robotics with technical systems and human labor: In Industry 5.0, humans and robots work together in tandem. Robots take over heavy, dangerous, and repetitive tasks, while humans manage more complex operations and make key decisions.
- Connectivity to other industrial sectors: Modern mining systems are increasingly connected to other industries, such as the energy industry and transportation. For example, data from mining operations can be linked to energy systems to better optimize coal production and distribution.
- Supply chain optimization: Digital platforms enable better tracking of the supply chain, from mining operations to end users, reducing losses and increasing the efficiency of coal transportation.
- Energy efficiency and use of renewable energy sources: Surface coal mining technologies are being developed that reduce energy consumption in mining operations, including the use of solar panels and other renewable energy sources to power mining equipment.
- Management of waste and emissions in the production process of surface coal mining: With the aim of reducing the negative impact on the environment, smart systems for waste management, monitoring CO<sub>2</sub> emissions and other pollutants are implemented. Pollution monitoring and environmental impact control are becoming key in every segment of coal production in question.
- Worker monitoring and protection: Worker health and safety monitoring technologies use sensors and wearable devices to monitor their vital signs and detect potential hazards in the field, such as high temperatures or the presence of hazardous gases.
- Remote control and operations: The use of remote machine control allows workers to manage difficult and dangerous operations from a safe distance, thus reducing their physical risk.
- Supporting sustainable practices and experiences in surface coal mining: In the modern mining industry, social responsibility is becoming a key factor. Mining companies implement technologies that not only reduce the environmental impact, but also create better conditions for the communities around the mine, including training for new technologies and providing economic support.

Modern smart technical systems for surface mining of coal, based on Industry 5.0, enable much more efficient, safe and sustainable management of mining operations. The use of

advanced technologies in surface coal mining, artificial intelligence, (IoT) and digitalization, enable the optimization of system operation and the reduction of negative impact on the environment, while at the same time providing better working conditions and more efficient operations (Trivedi et al., 2024; Zeb et al., 2022).

#### **4. NEW ASPECTS OF RISK MANAGEMENT IN MINING - SURFACE EXPLOITATION OF COAL IN THE CONTEXT OF DETERMINING INDUSTRY 5.0**

Industry 5.0 represents the latest phase of industrial development, which is based on cooperation between people and advanced technologies, and the goal is to create flexible, intelligent and sustainable production systems. In the context of mining, especially surface coal mining, industry 5.0 brings numerous challenges and opportunities for improving safety, productivity and sustainability (Massaro, 2023).

It is important to note that the latest smart technical systems in surface coal mining, combined with new global circumstances and the development of Industry 5.0, represent a challenge and an opportunity for the development of safer, more efficient and sustainable coal mining methods. This framework requires constant adaptation of technologies, workforce training and investment in innovation that will enable progress in the industry.

Mining is an industry that, traditionally, is recognized for high risks for technical exploitation systems, complete infrastructure logistics, workforce, environment and economy.

By introducing new modern smart technologies and risk management methodologies, the industry can become safer and more efficient, and at the same time respond to the global challenges of sustainability and environmental protection.

Industry 5.0 focuses on the integration of advanced technologies with the human factor to create a synergy between automation and creativity. In mining, this means the introduction of new technologies that can significantly improve safety, precision and sustainability in the coal mining process (Radosavljević et al., 2013).

Risk management in mining includes all processes related to the identification, analysis, assessment and minimization of risks that may arise during the exploration and surface exploitation of coal, its processing/grinding/shredding, delivery to thermal power plants and the use of coal in boilers for the production of electricity. Risks in mining can be technological, human, environmental and economic. Surface mining of coal, which means mining coal on the surface of the land/surface mining, faces specific challenges, such as soil collapse/instability and sliding of tailings mass on the excavation slopes, structural breaks of technical systems under full load conditions/experience from mining production practice, danger of explosions, emission of harmful gases and impact on local ecosystems (Radosavljević & Radosavljević, 2009).

The integration of advanced technologies into risk management strategies is becoming a key element in modern business and decision-making, as it enables organizations to recognize, analyze and respond to risks in a more efficient, faster and more accurate way.

- Predictive analysis: Ai can analysis historical data of technical systems and predict potential risks, such as collapses, structural breaks, unidentified downtimes, crashes, changes in the regulatory environment, and even natural disasters at work and exploitation sites. Based on these predictions, managers can make better informed decisions about preventive measures.
- Automation of risk assessment: Machine learning can automatically assess risks in real time, based on various variables, such as changes in the operation of technical systems, downtime, maintenance problems or deviations in prescribed regulations

related to business applications in mining, among other things, defined by certain standards for both production and risk management.

Given the huge volume of data available to organizations, technologies for analyzing big data (Big Data) are becoming crucial for risk identification. By using advanced analytics tools, organizations can:

- Analyzes data in real time: this technology enables quick detection of unforeseen events that can lead to risks, such as changes in the behavior of technical systems, complete infrastructural logistics as well as in certain sectors, maintenance and others.
- Use sophisticated and complex risk analysis models: using big data enables a deeper understanding of potential risks based on various data sources, leading to more accurate and comprehensive risk management strategies.

Blockchain is another advanced technology used in risk management, especially in sectors that require a high level of security and transparency, such as mining techniques and infrastructure logistics, maintenance and others. Blockchain works in the context of risk management on sitting determinations:

- Data transparency and immutability: Blockchain allows organizations to track transactions in real time and securely, reducing the risk of fraud and errors.
- Smart Contracts: The use of smart contracts reduces operational risks because it enables the automatic execution of contracts when predefined conditions are met, reducing human errors.

The Internet of Things allows devices to be connected to a network, which enables better monitoring and analysis of risks in real time. Some examples are:

- Real-time monitoring: IoT devices can monitor the state of technical systems, machines, infrastructural logistics and equipment at production locations, production plants, detecting potential technical problems or dangers that may cause risk. This enables timely interventions.
- Predictive maintenance: By using data from IoT devices, organizations can predict mapping and planning systems when maintenance is due, reducing the risk of unplanned downtime.

As organizations become increasingly digitized, the risk of cyber attacks increases. In the integration of advanced technologies, the implementation of modern cyber security tools becomes crucial:

- Use of advanced security systems: Using AI-based tools to detect anomalies in data traffic and prevent cyber attacks can significantly reduce the risks of hacking or other types of cyber threats.
- Cryptographic technologies: The implementation of advanced cryptographic techniques protects data and transactions, reducing the risk of data theft or manipulation.

Advanced software tools and simulations allow organizations to test their risk management strategies in different scenarios. By using methods such as Monte Carlo simulations, the potential consequences of various risks in various situations can be analysed.

- Simulations and analysis of "what-if" scenarios: These tools allow organizations to consider various possible scenarios and assess how they will affect the business, helping them to better prepare for uncertainties.

Robotic process automation (RPA) and other forms of automation can help reduce operational risks associated with human error or inefficiencies.

- Automation of repetitive tasks: By automating repetitive tasks (among others in mining, such as the work of technical systems on the surface exploitation of coal),

the risk of errors is reduced and efficiency is increased in the conditions of the spatial resource localities where the activities are performed.

- Reducing the risk of human errors: Automating complex or repetitive processes reduces the likelihood of human errors that can lead to critical and significant risks.

Integrating advanced technologies into risk management strategies enables organizations to improve the accuracy, efficiency and speed of their decisions. Using AI, machine learning, blockchain, IoT, big data, cyber security and other advanced technologies enables organizations to better predict, analyze and manage risks in an increasingly dynamic business environment. In this way, process smart technologies become a key tool for reducing uncertainty and minimizing potential risks (Radosavljević et al., 2009).

## **5. DIGITAL TOOLS AND SMART SOFTWARE SYSTEMS FOR ANALYSIS OF RISK AND INDUSTRY 5.0**

Risk mapping in mining is a process of identification, assessment and analysis of potential hazards and accidents that may affect the safety of technical systems, infrastructure logistics, workforce, assets and work locations with the immediate and remote environment. In modern industry, including mining, the introduction of Industry 5.0 means the integration of advanced technologies that enable more efficient, accurate and proactive risk analysis, as well as reducing the possibility of accidents. Industry 5.0 brings a new paradigm that connects people and machines in synergy to improve the safety, efficiency and sustainability of processes. Within the mining industry, risk mapping becomes more accurate and enables faster response to potential hazards with preventive and proactive prescribed procedures and actions.

Modern digital tools and smart risk analysis software systems use advanced technologies (artificial intelligence (AI), machine learning, data analytics and simulation) to enable the identification, assessment and management of risks in the mining industry. These tools help organizations recognize potential threats and opportunities, minimize potential losses, and make better managerial decisions. Some of the key modern Risk Analysis Systems with compatibility with Industry 5.0 are:

- Risk Watch: A platform that enables risk analysis and security assessment, as well as monitoring compliance with regulatory standards. Uses advanced analytics and automation to identify potential risks and assess business impact. Key functionalities: Automated risk assessments; Real-time reports; Tools for monitoring and optimizing security standards.
- Palantir: A powerful big data analytics software tool used in many industries. Palantir enables the analysis of complex data sets to identify hidden risks, trends and predictive models. Key functionalities: Ability to process huge amounts of data; Advanced Predictive Analytics and Risk Modeling; Data Visualization.
- @RISK: @RISK is a risk simulation tool that uses Monte Carlo simulation to assess the probability and impact of risks on business projects. This tool is particularly useful for estimates in projects involving financial analysis, resource management and budget optimization. Key functionalities: Simulations based on the Monte Carlo method; Visualization of results in graphs and reports; Integration with Microsoft Excel.
- RiskLens: RiskLens is a tool that enables organizations to quantify and analyze cybersecurity risks. Using a value-based methodology, RiskLens helps assess the various business impacts of potential cyber threats. Key functionalities:

Quantification of cyber risk in a financial sense; Integration with existing IT infrastructure management tools; Analysis of potential losses from cyber attacks.

- SAS Risk Management: SAS is one of the leaders in the field of data analytics, and their risk management tool uses advanced models to analyze and manage financial and operational risks. It is also used in mining for risk simulation and compliance with regulatory requirements. Key functionalities: Predictive analytics and scenario analysis; Compliance with regulatory requirements; Quantification of credit, market and operational risk (Kozub, 2025).
- Resilience360 (Logistics Risk): Resilience360 is a software system that focuses on risk assessment in supply chains for mining logistics infrastructure. The tool uses big data analytics to identify potential risks such as supply disruptions, natural disasters, political uncertainties and other global threats. Key functionalities: Monitoring of global risks in real time; Assistance in developing recovery strategies; Ability to customize analyzes for specific industries (Marzhan et al., 2022).
- Monte Carlo (Data Science Platform): A platform that uses advanced machine learning methods and simulations to analyze risks in business operations. It helps organizations accurately assess the impact of uncertainty and variation in data on business results. Key functionalities: Real-time data analysis; Predictive modeling and simulations; Data visualization and optimization suggestions.

## **6. INDUSTRY 6.0**

Industry 6.0 is a concept used to denote the next stage in the development of the industrial revolution, which goes beyond current models such as Industry 4.0. And industry 5.0. While Industry 4.0 is focused on the integration of digital technologies in production processes, Internet of Things (IoT), automation, artificial intelligence, and big data and Industry 5.0 focuses on the integration of advanced technologies with the human factor, so Industry 6.0, although still not widely defined or standardized, is generally considered as a development towards a more sustainable, ethical and humanistic industry (Das & Pan, 2022).

Some of the key aspects associated with Industry 6.0 include:

- Sustainable production: Emphasis on reducing the ecological footprint and using renewable energy sources.
- Artificial Intelligence and Human Factors: A combination of AI and human values to create a better work environment, as well as greater collaboration between humans and machines.
- Focus on social aspects: Incorporating more ethical and social considerations into business, such as labor rights, equality and health.
- Connectivity and Personalization: Advances in personalized products and services that better match the needs of individuals (Almusaed et al., 2023).

Industry 6.0 is more of a vision than a current reality, but it will certainly influence the future direction of industry and technology development (Chourasia et al., 2022).

## **7. RESULTS AND DISCUSSION**

New world global circumstances place industry 4.0 and industry 5.0 in the context of application in completely new framework paradigmatic relations. The situation in the world circumstances is quite specific with obvious needs for new instructions as well as new focuses

related to ways of application. A new integrative platform is needed, based on the foundations of the determination of the mentioned concepts, which will be valid in the world and which will be realistically possible to be further implemented with respect for all differences and developments. Therefore, a restart of the results of the application so far and a new integrative scheme are needed for further continuation. The poor in the world are still at the back, while the rich are progressing much faster and in general find it easier to navigate new industrial concepts. Serbia shares the fate of medium-developed countries. And the application of the concept of Industry 4.0 and 5.0 is at the very beginning, even when it comes to mining. Risk management has started, but still the procedures of analysis and minimization are not aligned with the mentioned concepts, so the results in a qualitative and comprehensive context are smaller.

## 8. CONCLUSION

Industry 5.0 represents a significant step forward in the development of the industrial sector, as it focuses on the synergy between the human factor, smart technologies and automation. In the context of mining, this revolution offers an opportunity to improve production processes, increase efficiency and safety, but also reduce negative impact and minimize risk. The implementation of advanced technologies can significantly improve operational processes and enable accurate risk mapping. In the new global circumstances, which include rapid changes in market conditions, risk mapping becomes crucial for the sustainability of mining. Industry 5.0 can improve risk analysis and assessment methods through sophisticated algorithms and simulations. However, the successful implementation of these technologies requires a serious approach in terms of workforce education, investment in infrastructure and the development of new policies that will enable the safe and sustainable management of mining resources. Also, it is important to emphasize the need for international cooperation in order to standardize technologies and approaches, thus ensuring the global competitiveness and sustainability of mining within Industry 5.0. Therefore, with proper risk mapping and application of innovations, Industry 5.0 can transform mining into a sector that is simultaneously profitable, safe and environmentally responsible.

## REFERENCES

- Akundi, A., Euresti, D., Luna, S., Ankobiah, W., Lopes, A., & Edinbarough, I. (2022). State of Industry 5.0-Analysis and identification of current research trends. *Applied System Innovation*, 5(1), 27. <https://doi.org/10.3390/asi5010027>
- Almusaed, A., Yitmen, I., & Almssad, A. (2023). Reviewing and integrating aec practices into industry 6.0: Strategies for smart and sustainable future-built environments. *Sustainability*, 15(18), 13464. <https://doi.org/10.3390/su151813464>
- Chourasia, S., Tyagi, A., Pandey, S. M., Walia, R. S., & Murtaza, Q. (2022). Sustainability of Industry 6.0 in global perspective: Benefits and challenges. *Mapan*, 37(2), 443-452. <https://doi.org/10.1007/s12647-022-00541-w>
- Coelho, P., Bessa, C., Landeck, J., & Silva, C. (2023). Industry 5.0: The arising of a concept. *Procedia Computer Science*, 217, 1137-1144. <https://doi.org/10.1016/j.procs.2022.12.312>
- Das, S., & Pan, T. (2022). A strategic outline of Industry 6.0: Exploring the Future. Available at SSRN 4104696. <https://dx.doi.org/10.2139/ssrn.4104696>
- Fazal, N., Haleem, A., Bahl, S., Javaid, M., & Nandan, D. (2022). Digital management systems in manufacturing using industry 5.0 technologies. In *Advancement in Materials*,

- Manufacturing and Energy Engineering, Vol. II: Select Proceedings of ICAMME 2021 (pp. 221-234). Singapore: Springer Nature Singapore.  
[https://doi.org/10.1007/978-981-16-8341-1\\_18](https://doi.org/10.1007/978-981-16-8341-1_18)
- Ghobakhloo, M., Iranmanesh, M., Tseng, M. L., Grybauskas, A., Stefanini, A., & Amran, A. (2023). Behind the definition of Industry 5.0: a systematic review of technologies, principles, components, and values. *Journal of Industrial and Production Engineering*, 40(6), 432-447. <https://doi.org/10.1080/21681015.2023.2216701>
- Kaswan, M. S., Chaudhary, R., Garza-Reyes, J. A., & Singh, A. (2025). A review of Industry 5.0: from key facets to a conceptual implementation framework. *International Journal of Quality & Reliability Management*, 42(4), 1196-1223. <https://doi.org/10.1108/IJQRM-01-2024-0030>
- Kozub, V. (2025). Problems and Solutions in Building Highly Loaded Software. *The American Journal of Engineering and Technology*, 7(03), 230-236. <https://doi.org/10.37547/tajet/Volume07Issue03-20>
- Marzhan, Y., Talshyn, K., Kairat, K., Belginova, S., Karlygash, A., & Yerbol, O. (2022). Smart technologies of the risk-management and decision-making systems in a fuzzy data environment. *Indonesian Journal of Electrical Engineering and Computer Science*, 28(3), 1463-1474. <http://doi.org/10.11591/ijeecs.v28.i3.pp1463-1474>
- Massaro, A. (2023). Process Mining in Production Management, Intelligent Control, and Advanced KPI for Dynamic Process Optimization: Industry 5.0 Production Processes. In *Perspectives and Considerations on the Evolution of Smart Systems* (pp. 1-17). <http://doi.org/10.4018/978-1-6684-7684-0.ch001>
- Radosavljević, S. and Radosavljević, M. (2009). Risk assessment in mining industry - Apply management. *Serbian Journal of Management*, Vol. 4, No. 1 pp. 91-104.
- Radosavljević, S., Dašić, P. and Radosavljević, M. (2013). Appendix specifics of risk management in mining. *Metalurgia International*, Vol. 18, Spe. Is. No. 8, pp. 59-68.
- Radosavljević, S., Lilić, N., Čurčić, S. and Radosavljević, M. (2009). Risk assessment and managing technical systems in case of mining industry. *Strojniški vestnik - Journal of Mechanical Engineering*, Vol. 55, No. 2, pp. 119-130.
- Trivedi, C., Bhattacharya, P., Prasad, V. K., Patel, V., Singh, A., Tanwar, S., ... & Sharma, G. (2024). Explainable AI for Industry 5.0: vision, architecture, and potential directions. *IEEE Open Journal of Industry Applications*. <https://doi.org/10.1109/OJIA.2024.3399057>
- Usharani, S., Manju Bala, P., Ananth Kumar, T., Rajmohan, R., & Pavithra, M. (2022). Smart energy management techniques in industries 5.0. *Hybrid Intelligent Approaches for Smart Energy: Practical Applications*, 225-252. <https://doi.org/10.1002/9781119821878.ch12>
- Zeb, S., Mahmood, A., Khowaja, S. A., Dev, K., Hassan, S. A., Qureshi, N. M. F., ... & Bellavista, P. (2022). Industry 5.0 is coming: A survey on intelligent nextG wireless networks as technological enablers. *arXiv preprint arXiv:2205.09084*. <https://doi.org/10.48550/arXiv.2205.09084>
- Zhironkin, S., & Taran, E. (2023). Development of surface mining 4.0 in terms of technological shock in energy transition: a review. *Energies*, 16(9), 3639. <https://doi.org/10.3390/en16093639>



## ENERGY TRANSITION, ENERGY STRATEGIES, GLOBAL ENERGY SECURITY AND POTENTIAL RISKS

Slobodan Radosavljević \*

*RB "Kolubara" d.o.o., Svetog Save 1, 11550 Lazarevac, R. Serbia*

**Abstract:** For a long time, the energy transition has been a central topic in global policy discussions across the world's various energy systems. The energy transition refers to the shift from traditional energy sources (such as oil, coal, and gas) to renewable sources (like solar, wind, and hydropower). This process is further supported by existing international agreements. Many countries are developing their own strategies and plans to meet energy-related objectives. However, the differing approaches to energy policy often lead to global disagreements, as countries have varying interests regarding resources, energy security, and climate obligations. Global energy security is emerging as a significant challenge in the international context. Rising energy demand, geopolitical tensions, market volatility, and the vulnerability of energy systems are putting immense pressure on global stability. Potential risks associated with the energy transition include an unequal distribution of resources and technologies between developed and developing nations, which could exacerbate global social and economic inequalities. Furthermore, a rapid transition to renewable energy without adequate infrastructure may lead to energy supply instability, higher prices, and potential social unrest. In addition, the security of emerging technologies-such as smart grids and the digitalization of energy systems-raises new concerns about data protection and cybersecurity. While the energy transition is essential for achieving global sustainability goals, it presents significant challenges that require careful management and international collaboration. Developed energy strategies must strike a balance between energy security, environmental objectives, and economic interests, while also minimizing the risks that come with transitioning to new energy sources. This balance forms the foundation for the analysis of the issues addressed in this paper.

**Keywords:** Energy transition, energy strategies, energy security, mining, global risks.

### 1. INTRODUCTION

The energy transition, global energy security, and the associated risks are critical issues in tackling the challenges of the 21st century. These topics are closely linked to sustainable development, climate change, technological innovation, and geopolitics, all of which shape the future of the global energy system. The energy transition refers to the shift from fossil fuels,

\* Corresponding author: drslobodanr@gmail.com

Slobodan Radosavljević, ORCID: 0009-0000-3223-9743



such as coal, to sustainable sources like solar, wind, hydro, and biomass, while also improving energy efficiency. This process presents technological, political, economic, and social challenges, requiring coordination across global initiatives, local actions, and consumer behaviors. National, regional, and global energy strategies are essential for guiding the transition to a sustainable energy future. These strategies, often backed by policies, subsidies, and innovations, aim to reduce carbon emissions, enhance efficiency, and ensure energy security, while encouraging investments in renewables and new technologies, (Dablander et al., 2025). Global energy security is becoming increasingly important, as disruptions in energy supply can destabilize the global economy and political relations. Many nations' dependence on fossil fuels from geopolitically unstable regions poses significant risks to energy stability. While the shift to renewable energy brings benefits, such as reduced emissions and job creation, it also presents challenges, including potential energy instability during periods of low renewable output, high infrastructure investment costs, and economic uncertainty for countries reliant on traditional industries. Energy security has also become a key factor in international relations, with the dominance of certain countries in energy production affecting both infrastructure and economic ties. Instability in oil- and gas-rich regions, combined with the impacts of global climate change, highlights the need for careful management of energy transitions. The risks associated with this shift-including supply insecurity, economic costs, social inequalities, and geopolitical tensions-could have far-reaching effects on the global economy and society, (Kuzemko et al., 2025).

## **2. SOME OF THE LATEST GLOBAL EXPERIENCES IN THE ENERGY TRANSITION**

The energy transition is a process that involves transforming the global energy system from reliance on fossil fuels to sustainable, environmentally friendly energy sources. This process began with the goal of reducing carbon dioxide emissions, combating climate change, conserving natural resources, and creating new economic opportunities. Global experiences with energy transitions offer valuable insights into how different countries are tackling the challenge of reducing emissions and increasing the share of renewable energy in the global energy mix, including the key initiatives and challenges they face.

Europe stands as a global leader in the energy transition, pioneering efforts to reduce carbon dioxide emissions. The European Union has set ambitious goals through the European Green Deal, aiming to make the EU climate-neutral by 2050. Key countries in this transition include: (Gatto et al., 2024).

Germany is one of the trailblazers of the energy transition, with its *Energiewende* (Energy Revolution) plan recognized as a model for other countries. Germany aims to reduce carbon dioxide emissions by 80-95% compared to 1990 levels by 2050 and to derive 80% of its energy from renewable sources. Key components of the plan include: Nuclear phase-out: Germany decided to shut down all its nuclear power plants by 2022; Coal phase-out: Germany is also committed to reducing its dependence on coal, though it faces significant social and economic challenges, particularly for regions reliant on this sector; Expansion of renewable energy: Germany has become one of the largest producers of energy from wind and solar power, (Sacco et al., 2024).

Denmark is recognized as a global leader in wind energy technology and generates a large portion of its energy from wind farms. Some of Denmark's key steps include: Ambitious 2050 goal; Denmark aims to become entirely independent of fossil fuels by 2050, relying mainly on renewable energy sources, particularly wind power; Decentralized energy systems:

Denmark focuses on decentralized energy systems, enabling citizens and small businesses to invest in energy technologies.

Ireland and Spain have made significant strides in implementing solar and wind energy systems. Both countries share the common goal of increasing the share of renewable energy in their total energy production: Ireland is focusing on reducing emissions in transport and households, investing in electric vehicle infrastructure, and expanding solar capacity. Spain has heavily invested in solar energy and aims to increase its renewable energy capacity to 74% of total energy production by 2030.

The USA, one of the largest producers of CO<sub>2</sub> emissions, faces substantial challenges in its energy transition. However, after withdrawing from the Paris Climate Agreement under the previous administration, the current administration of President Joe Biden has refocused policy on reducing emissions and increasing the share of renewable energy. Key initiatives include: Solar and wind energy: China, the largest producer and consumer of solar panels, is also a leader in installing wind energy capacity. The country plans to achieve carbon neutrality by 2060, a highly ambitious goal considering its rapid industrial development. Electric vehicles: China is the largest player in the electric vehicle sector and is introducing further incentives to boost production and sales of EVs. Coal and energy security: Although China is investing in renewables, it remains one of the largest consumers of coal. Balancing energy security and emission reduction, particularly in industrial sectors, is a significant challenge (Amin et al., 2024; Movsessian et al., 2025).

India is still in the developmental phase of its energy systems but is increasingly recognizing the need to transition to sustainable energy sources. Given its large energy needs and rapidly growing population, India faces considerable challenges related to energy efficiency and emissions reduction: Solar energy: India has made notable progress in expanding its solar capacity and plans to increase its renewable energy capacity to over 175 GW by 2030. The country is also focusing on decentralized systems and solar energy in rural areas. Coal and sustainability: While India remains dependent on coal for power generation, there is increasing pressure to reduce its reliance on coal by investing more in clean technologies and renewables, (Barragán-Ocaña et al., 2025).

Africa, with its vast natural resources, holds significant potential for renewable energy but faces numerous challenges related to infrastructure and financial resources. Many African countries, such as Kenya and Ethiopia, have already become pioneers in the use of geothermal and hydropower: Solar energy: Africa has enormous potential for solar energy, with countries like Morocco and South Africa investing in large-scale solar farm projects. Many African nations also use decentralized solar panel systems to supply energy to remote and rural areas. Geothermal energy: Kenya stands out as a leader in geothermal energy, with projects providing a significant portion of the country's energy consumption, (Chandra, 2025).

Global experiences in the energy transition show that while this process is long-term and challenging, it is also essential for the future of our planet. Each country faces its own specific challenges, but global cooperation and investment in technology, renewables, and energy infrastructure can help accelerate the transition. The coming decades are expected to be crucial in advancing the energy transition and achieving global climate goals.

### **3. ANALYSIS OF MODERN AND LATEST ENERGY STRATEGIES IN THE WORLD: CHANGES AND NEW APPROACHES**

World energy strategies have developed significantly over the last decades, positioning above all global challenges such as climate change, depletion of fossil fuels, growing energy consumption and the need for sustainable development. The analysis of past and latest energy

strategies is crucial for understanding global efforts to reduce carbon dioxide emissions, transition to renewable sources and ensure energy security. In previous decades, energy strategies around the world were based predominantly on fossil fuels of oil, coal and natural gas. These were the main components of the global energy system during the 20th century and the first decade of the 21st century, (Hassan & Gong, 2025).

Key features of the current strategies include; Energy security: Energy security was a priority, especially in the context of geopolitics and dependence on energy imports. Many countries have been developing strategies to diversify energy supplies, ensure the stability of energy supplies and reduce dependence on politically unstable regions; Centralized infrastructure: Production and distribution of energy in past decades was centralized in large energy systems. National power grids were overloaded, while energy storage capacities were minimal. The use of technologies to optimize energy distribution and energy efficiency was neglected; Focus on fossil fuels: Energy strategies relied on coal, oil, and natural gas because they were relatively cheap, readily available, and in large quantities. Countries invested in the development of infrastructure for the extraction, processing and distribution of these energy sources, and energy production was centralized, with large thermal power plants dominating the markets; Emissions and environmental impact: Climate change and the negative impact of fossil fuels on the environment were not in focus. Emissions of carbon dioxide (CO<sub>2</sub>) and other pollutants were high, while regulations in many countries were not strict enough to reduce emissions or prevent degradation of natural resources.

In the last decade, energy strategies have shifted to more sustainable and environmentally friendly models, relying on renewable sources, new technologies and global environmental protection goals.

The main features of the new energy strategies include: Transition to renewable energy sources: The biggest change in the new strategies is the transition from fossil fuels to renewable energy sources-solar, wind, hydro, geothermal, and even energy from biofuels. Solar panels, wind turbines and hydroelectric power plants are becoming the dominant sources, and technologies such as energy storage batteries enable the efficient use of these sources. New strategies include the use of decentralized energy production systems, where households and businesses can produce their own energy.

Sustainable energy policy and emission reduction: Climate change has become a central factor in the formulation of new energy strategies. Global goals like the Paris Agreement have set ambitious plans to reduce carbon dioxide emissions. Many countries, including the EU, China, the US and others, have set targets to reduce CO<sub>2</sub> emissions, increase the share of renewable energy sources and achieve "zero emissions" in the medium term. The EU plans to achieve net zero CO<sub>2</sub> emissions by 2050, and China by 2060 years.

Energy storage technologies and hydrogen: The development of efficient energy storage technologies, such as lithium batteries and hydrogen-based technologies, has become crucial to the success of new strategies. Energy from renewable sources is often continuous and varies during the day and seasons, and the ability to store energy allows continuity of supply. Hydrogen as an energy carrier is increasingly seen as a potential solution for sectors such as industry and transport.

Smart grids and digitization of energy systems: Infrastructure modernization through the development of smart grids and digital energy management systems has become crucial. Smart grids enable optimization of energy distribution, better integration of renewable sources and reduction of energy losses. Also, advances in artificial intelligence (AI) and the Internet of Things (IoT) enable automatic adjustment of energy consumption in real time.

Energy as a service and energy independence: The new energy strategy also focuses on greater access to energy for wider social groups. The concept of "energy independence" allows

communities to take control of their own energy production and distribution, thereby reducing energy dependency and increasing availability. Also, programs for energy efficiency in industry and everyday life are increasingly applied.

When analyzing the differences between the current and the latest energy strategies in the world, realistically new directions that will be implemented in the near future can be transparently positioned. It should be noted that energy strategies in most of the world's countries are mostly specific, appropriate to their own energy realities and realities with similar and almost at the same time common final goals and outcomes. Countries like the USA and China have the latest energy strategies of their own, and they in a certain way represent new strategic challenges both for them and for the entire world energy sector.

**Climate goals:** Previous strategies did not have a strong environmental component, while the latest strategies focus on reducing carbon dioxide emissions, reducing global warming, and protecting the environment. Global goals such as the Paris Agreement have set new standards for reducing emissions and transitioning to clean energy sources.

**Energy sources:** Previous strategies were largely based on fossil fuels, while new strategies recognize the need to switch to renewable sources. This transition is not only justified ecologically, but also becomes economically justified, considering the drastic drop in prices of technologies for the production of solar and wind energy.

**Decentralization and c autonomy:** Old energy strategies were directed towards centralized energy production and distribution, while new strategies are increasingly based on decentralization. This approach enables a greater degree of energy autonomy and reduces the risks associated with centralized systems.

**Technology and innovation:** While previous strategies focused on infrastructure projects that relied on existing technologies, new strategies use innovations in energy storage technologies, digitization and smart grid integration. These technologies enable greater efficiency and integration of renewable sources into the energy system.

**Environmental aspect and sustainability:** Old energy strategies neglected long-term environmental consequences, while new strategies have a clear focus on sustainability and environmental protection. Green plans and international agreements, such as the Paris Agreement, directly influence the shaping of modern energy policies that promote cleaner energy and reduce pollution.

The difference between the old and new energy strategies in the world is not only in technology and energy sources, but also in the philosophy of approach. While the old strategies were based on the economics of mass production and energy consumption, the new strategies are directed towards sustainability, energy efficiency and reducing the impact on the environment. Given the global challenges, such as climate change, the depletion of fossil fuels and energy resources, new approaches lay the foundations for a more secure and sustainable energy future, (Gajdzik et al., 2024).

#### **4. NEW TRENDS IN GLOBAL ENERGY SECURITY**

Global energy security has become a key issue in the modern world due to increasing challenges related to energy resources, changes in geopolitics, the development of new technologies and the need for sustainable development. In recent decades, energy security has been developing in the context of new trends that significantly affect global energy dynamics. Some of those trends are listed in the further part of the paper, (Ibekwe et al., 2024).

**Decarbonization and transition to renewable energy sources:** One of the most important trends is the global effort to reduce dependence on fossil fuels (such as oil, gas and coal) and switch to renewable energy sources (RES), such as solar, wind and hydropower. The goal of

reducing carbon dioxide emissions and achieving sustainable climate goals poses new challenges, but also opportunities for energy security. This trend leads to:

**Greater diversification of energy sources:** Using different renewable sources reduces dependence on a single source, thus increasing the stability and resilience of the energy system.

**New energy storage technologies:** The development of high-capacity batteries and other energy storage technologies is becoming crucial for the integration of unstable renewable sources (wind and solar) into the energy system.

**Geopolitical dynamics and energy crises** Geopolitical uncertainty, such as the war in Ukraine, sanctions against Russia, tensions in the Persian Gulf and trade disputes, significantly affect energy flows. In the last period it became clear that:

**Increased need for energy diversification:** Countries are looking for alternative energy sources and reducing dependence on one or a few suppliers. For example, European countries are increasingly turning to LNG (liquefied natural gas) from other countries (such as the US, Qatar, etc.) while also investing in renewables and nuclear power.

**Energy diplomacy and strategic alliances:** Countries are looking for ways to align their energy policies with strategic partners to ensure long-term energy security. Also, interest in energy resources in the Arctic and other geopolitically sensitive areas is increasing.

**Energy transition and decentralization of energy production.** The transition to clean energy leads to the development of decentralized energy production systems:

**Distributed energy systems:** Home solar panels, small wind turbines, battery storage systems and smart grids allow consumers to become energy producers as well. This trend reduces the need for large centralized plants, reduces distribution losses and increases resilience to energy supply shocks.

**Smart technologies:** Smart networks use advanced technology to monitor, control and optimize energy consumption and distribution. They enable more efficient operation of the energy infrastructure and better integration of renewable sources.

**Nuclear energy as a viable option.** Although the public occasionally opposes nuclear power due to safety concerns, there has been a resurgence of interest in nuclear power in recent years, particularly in the context of energy security and climate change. Nuclear energy offers advantages:

**Stability and low carbon dioxide emissions:** Nuclear power plants provide stable and emission-free energy that can help balance a system with a large share of renewable sources.

**New generations of nuclear reactors:** Small modular reactors (SMRs) and advanced technologies can make nuclear power safer and more economical, making it more attractive to many countries.

**Increased role of energy efficiency:** Energy efficiency becomes an important factor in ensuring energy security. Given the increase in energy consumption and the need to reduce carbon dioxide emissions, energy-saving strategies are becoming crucial for long-term development:

**Energy efficiency in industry and transport:** Many industrial and transport technologies are being improved to reduce energy consumption.

**Green cities and sustainable infrastructure:** Urban areas are becoming key foci for the implementation of energy-efficient solutions, such as smart buildings, green transport networks and energy-efficient heating and cooling systems.

**New forms of energy cooperation and trade:** World energy markets are becoming more and more connected, and international cooperation is becoming crucial for energy strategies. New forms of trade and infrastructure include:

**Regional energy blocs:** Taking into account technical and economic advantages, many countries are joining regional energy communities that facilitate energy trade and improve security of supply.

**Hydrogen trade:** This energy source, considered key to the decarbonisation of heavy industry and transport, is becoming an important part of international energy markets. The infrastructure for the production, storage and distribution of hydrogen is rapidly developing.

**Digitization and cyber security in the energy sector.** As energy systems become increasingly digitized and connected, protection against cyber attacks becomes critical for energy systems. New trends include:

**Integration of advanced IT solutions:** Digitization of the energy network enables better monitoring of consumption, optimization of resources and more accurate forecasting of consumption.

**Infrastructure cyber protection:** Protection against cyber/attacks on energy systems becomes crucial, as attacks can cause major disruptions in energy supply and have long-term economic consequences.

Global energy security is increasingly evolving within new trends that include decarbonization, decentralization, geopolitical changes, technological innovation, and changes in energy infrastructure. Countries and international organizations face challenges that require integrated strategies to ensure a stable and sustainable energy supply. Understanding and adapting to these trends will be key to the future of global energy security, (Kim et al., (2025).

## **5. RISK SYNERGY IN THE GLOBAL ENERGY TRANSITION- STRATEGIC AND SECURITY PERSPECTIVES**

Analyzing the synergy of risks in the context of energy transition, energy strategies and energy security in the world is a complex and demanding process, which requires knowledge of various aspects of energy, politics, technology, economy and international relations. In this context, we can identify key points of synergy of risks that may appear in the process of energy transition, as well as their impacts on energy strategies and global energy security. The energy transition represents the transition from traditional sources of energy, such as fossil fuels (coal, oil, gas), to sustainable sources of energy, such as renewable sources (solar, wind, hydro, geothermal energy) and nuclear energy. Although this transition is considered necessary to reduce carbon dioxide emissions and fight climate change, it carries certain risks, (Li et al., 2024). **Risks of energy transition:** **Technical uncertainty:** Many new technologies, such as energy storage (batteries), smart grids and infrastructure renewal, are still in the development or deployment phase. Their scalability, efficiency and security remain uncertain. **Economic risks:** Energy transitions require huge investments. Countries and companies unwilling to invest in new technologies may face significant economic problems, including reduced competitiveness, job losses in fossil fuel-dependent industries, and economic uncertainty during the transition period. **Political risks:** Changes in energy policies may be viewed unfavorably by interest groups dependent on fossil fuels. Also, international tensions over control of resources and technologies can cause political disagreements and trade wars, (Koval et al., 2025).

**Synergy of risks in energy strategies:** Developing strategies for the energy transition must take into account the interconnectedness of different types of risks and how they can reinforce or mitigate each other. Risk synergy occurs when the combination of different risks creates greater threats or challenges than if they were acting individually. **Risk of energy shortages and economic instability:** If energy strategies do not provide stable and affordable energy sources during the transition, energy shortages may occur that cause economic problems, especially in countries that rely on fossil fuels or have weak renewable infrastructure.

Geopolitical instability and energy security: Dependence on certain energy sources, such as oil and natural gas from politically unstable regions, can lead to geopolitical risks. Combined with global pressures to reduce emissions, conflicts over resources and technologies may arise. Risk of job loss and social instability: The energy transition can lead to job cuts in traditional industries such as coal mining and the oil industry. If social policies and workforce training are not effective, it can cause social unrest and undermine political stability in many countries, (Radosavljević et al., 2009; Radosavljević et al., 2013).

In order to minimize the risks associated with the energy transition, governments and international organizations must develop strategies that include the recognition and mitigation of risk synergies. This may include: Policies that promote cooperation and coordination: Given the global character of the energy transition, cooperation between countries and sectors becomes crucial. These include international agreements to reduce emissions, joint investments in research and development of new technologies, as well as the development of joint crisis management strategies. Innovation in energy efficiency technologies: Encouraging research and development in energy efficiency and new forms of energy storage can reduce the risk of supply instability. Approaches that include social justice: Developing policies that help workers and communities affected by the transition can reduce the risk of social unrest and enable a balanced transition to sustainable energy sources, (Radosavljević et al., 2022).

The potential synergy of risks in the context of energy transition, energy strategies and energy security in the world is complex, but can be mitigated through careful planning, global cooperation and the development of flexible, more resilient energy systems. Understanding the interconnectedness of risks and responding to challenges in a timely manner are key to ensuring a sustainable energy future, (Radosavljević et al., 2009).

## **6. RESULTS AND DISCUSSION**

Research shows that the energy transition, although crucial for reducing emissions and sustainability, brings challenges in terms of energy security. Countries that successfully combine renewable sources with stable fossil fuel reserves currently have the highest level of security of supply. Conversely, a rapid and unplanned transition can cause instability, especially in countries dependent on energy imports. Therefore, it becomes crucial to develop balanced energy mixes. Serbia strives to shape its energy mix in the new global conditions and increase its energy sovereignty. Based on the analysis of global experiences and modern energy strategies, several key guidelines have been identified that can contribute to the successful management of the energy transition: Long-term and integrated strategies; International cooperation; Diversification of energy sources; Digitization and modern infrastructure; A just transition; Energy efficiency and innovation and Cyber security and system resilience. These guidelines indicate the need to balance environmental goals, energy security and social sustainability. They are explained in more detail in the previous part of the paper. Their application can significantly contribute to a successful and stable energy transition at the global level. Global energy security depends on international coordination, technological progress and adapted local policies, while geopolitical tensions emphasize the need to diversify sources and strengthen cooperation.

## **7. CONCLUSION**

The energy transition is a complex but necessary process that has long-term consequences for the environment, economy and society as a whole. The transition to sustainable and renewable energy sources, as well as strengthening resistance to energy shocks,

are key goals of modern energy policy. In this context, the development of national and global energy strategies is essential for achieving the goals of the energy transition. These strategies must be comprehensive, long-term and flexible, bearing in mind that the energy sector requires significant capital investments and technically complex changes that cannot be realized in a short period of time. However, the energy transition is not without its challenges. Risks concerning global energy security are becoming more pronounced, especially when it comes to dependence on certain technologies and global supply chains, which can pose a serious threat to the stability of the energy system. These risks include not only the physical availability of energy sources, but also political security in their delivery. The energy transition, along with the development and implementation of smart and adaptive strategies, is the path to a sustainable energy future. Nevertheless, this process carries with it certain risks that must be proactively managed and reduced to acceptable thresholds, in order to ensure the long-term stability and security of the energy system.

## REFERENCES

- Amin, A., Yusoff, N. Y. B. M., Peng, S., Işık, C., Ullah, A., & Akbar, M. (2024). The influence of energy transition, and natural resources on carbon emissions in China: an augmented ARDL application. *Environment, Development and Sustainability*, 1-19. <https://doi.org/10.1007/s10668-023-04398-0>
- Barragán-Ocaña, A., Cecilio-Ayala, E., Silva-Borjas, P., Cortés-Ruiz, J. A., & Hernandez-Cardona, E. Y. (2025). Policies and sustainable energy transition in the global environment: Challenges for Latin America. *Heliyon*, 11(6). <https://doi.org/10.1016/j.heliyon.2025.e42295>
- Chandra, R. (2025). Out with the Old, in with the New? The Indian Public Sector's Role in the Energy Transition. *Studies in Comparative International Development*, 1-24. <https://doi.org/10.1007/s12116-025-09461-7>
- Dablander, F., Hickey, C., Sandberg, M., & Grin, J. (2025). Embracing sufficiency to accelerate the energy transition. *Energy Research & Social Science*, 120, 103907. <https://doi.org/10.1016/j.erss.2024.103907>
- Gajdzik, B., Wolniak, R., Nagaj, R., Žuromskaitė-Nagaj, B., & Grebski, W. W. (2024). The influence of the global energy crisis on energy efficiency: A comprehensive analysis. *Energies*, 17(4), 947. <https://doi.org/10.3390/en17040947>
- Gatto, A., Mattera, R., & Panarello, D. (2024). For whom the bell tolls. A spatial analysis of the renewable energy transition determinants in Europe in light of the Russia-Ukraine war. *Journal of Environmental Management*, 352, 119833. <https://doi.org/10.1016/j.jenvman.2023.119833>
- Hassan, S. T., & Gong, B. (2025). China's blueprint for a sustainable energy future: Analyzing the factors behind the climate change and globalized knowledge-based technological policies. *Energy*, 316, 134550. <https://doi.org/10.1016/j.energy.2025.134550>
- Ibekwe, K. I., Etukudoh, E. A., Nwokediegwu, Z. Q. S., Umoh, A. A., Adefemi, A., & Ilojiana, V. I. (2024). Energy security in the global context: A comprehensive review of geopolitical dynamics and policies. *Engineering Science & Technology Journal*, 5(1), 152-168. <http://dx.doi.org/10.51594/estj/v5i1.741>
- Kim, J., Jaumotte, F., Panton, A. J., & Schwerhoff, G. (2025). Energy security and the green transition. *Energy Policy*, 198, 114409. <https://doi.org/10.1016/j.enpol.2024.114409>



- Koval, V., Atstāja, D., Shmygol, N., Udovychenko, V., Hrinchenko, H., & Tsimoshynska, O. (2025). Strategic Management and Security Risk Assessment of Energy Systems. *Urban Science*, 9(2). <https://doi.org/10.3390/urbansci9020048>
- Kuzemko, C., Blondeel, M., Bradshaw, M., Bridge, G., Faigen, E., & Fletcher, L. (2025). Rethinking energy geopolitics: Towards a geopolitical economy of global energy transformation. *Geopolitics*, 30(2), 531-565. <https://doi.org/10.1080/14650045.2024.2351075>
- Li, B., Rahman, M. M., & Haneklaus, N. (2024). Assessing China's energy transition pathway: Insights from the synergistic effects of key drivers. *Energy Strategy Reviews*, 55, 101528. <https://doi.org/10.1016/j.esr.2024.101528>
- Movsessian, M. M., Oyewo, A. S., Aghahosseini, A., & Breyer, C. (2025). Enabling Central America's energy transition through renewable energy, energy citizenship, and regional integration. *Applied Energy*, 377, 124493. <https://doi.org/10.1016/j.apenergy.2024.124493>
- Radosavljević, S., Dašić, P., & Radosavljević, M. (2013). Appendix specifics of risk management in mining. *Metalurgia International*, 18(8), 59-68.
- Radosavljević, S., Ille, N., Radosavljević, M., & Radosavljević, I. (2022). Coal as a sustainable resource of serbia and risk potentials of world energy needs for energies. In *International May Conference on Strategic Management-IMCSM22,(1)* (pp. 310-320).
- Radosavljević, S., & Radosavljević, M. (2009). Risk assessment in mining industry: apply management. *Serbian Journal of Management*, 4(1), 91-104.
- Sacco, R. L., Megre, M., de Medeiros Costa, H. K., Brito, T. L. F., & dos Santos, E. M. (2024). Energy transition policies in Germany and the United Kingdom. *Energy Research & Social Science*, 110, 103460. <https://doi.org/10.1016/j.erss.2024.103460>



## INNOVATIVE APPROACHE TO FOREST MANAGEMENT IN THE CONTEXT OF THE SUSTAINABLE DEVELOPMENT GOALS

Ljiljana Brašanac-Bosanac<sup>1\*</sup>, Aleksandar Valjarević<sup>2</sup>, Uroš Durlević<sup>2</sup>, Milorad Šolević<sup>3</sup>  
Tatjana Ćirković-Mitrović<sup>1</sup>

<sup>1</sup>*Institute of Forestry, Belgrade, Serbia*

<sup>2</sup>*University of Belgrade, Faculty of Geography, Serbia*

<sup>3</sup>*MB University, Faculty of Business and Law, Belgrade, Serbia*

**Abstract:** The world and Europe face interlinked challenges that will intensify in the coming decades: increasing demand for food, water, materials and energy while mitigating and adapting to climate change and reversing environmental degradation, including biodiversity loss, nutrient emissions and land degradation. Although forest resources in Serbia are an important resource for economic growth, especially in rural areas, the traditional approach to their management and utilization is still predominant. This approach is characterized by its reliance on timber as the primary forest product, while other forest products are largely neglected and their economic valuation is often non-existent. In addition, a certain amount of wood biomass is left in the forest even though it could be economically exploited or offered to the market with minimal investment in infrastructure and technological solutions that would allow it to be used more effectively. Tackling these major challenges while promoting social, economic and environmental prosperity requires an innovative approach. Continuous transfer of know-how methods, capacity building in the field of forest management through the application of GIS and remote sensing technologies, climate smart forestry and the concept of circular bioeconomy is a possible way to improve the current situation in forestry and achieve some of the sustainable development goals.

**Keywords:** forest, environment protection, knowledge transfer, innovative approach, sustainability.

---

\* Corresponding author: [brasanlj@yahoo.com](mailto:brasanlj@yahoo.com)

Ljiljana Brašanac-Bosanac, ORCID: 0000-0002-3324-674X

Aleksandar Valjarević, ORCID: 0000-0003-2997-2164

Uroš Durlević ORCID: 0000-0003-3497-5239

Milorad Šolević, ORCID: 0009-0002-7935-0558

Tatjana Ćirković-Mitrović, ORCID: 0000-0003-2620-1751

## 1. INTRODUCTION

Global environmental problems cannot be viewed in isolation from the context of development. This fact indicates a need to define a more efficient methodologies, techniques and solutions in order to achieve the 17 goals of sustainable development (SDG). Each SDG including specific targets has the timeline until the year 2030 to bring in positive development globally. Since the concept of sustainable development represents the consensus of human, social, economic, technological, cultural development and preservation, balancing all these aspects should ensure human well-being. In the recent period the concept of sustainable development has become a prevailing philosophy (especially in EU countries), which is being imposed on developing countries through a series of practical measures and regulations and incorporated into the programs of multilateral organizations, particularly the UN system.

Forests and forestry make a strong and important contribution to achieving the Sustainable Development Goals. Forests are a renewable resource that provides wood, non-timber products and many ecosystem goods and services (Brašanac-Bosanac et al., 2014). They have a positive impact on air, water, soil, climate, flora and fauna, and the area in general, protecting settlements, buildings, roads and agricultural land from erosion, torrents, floods, avalanches, wind, etc. Despite their important role as planetary life support systems and significant progress in sustainable forest management, the global forest area continues to decline (SDG Report, 2024). New methods, measures and strategies, as well as multidisciplinary and innovative approaches, such as the use of geographic information systems and remote sensing technologies, climate-smart forestry and the concept of a circular bioeconomy, can balance the need for wood consumption and production, protect biodiversity and vitality and provide other important ecosystem and social services of forests in the environment.

The article explains what the concept of Climate-Smart Forestry (CSF) is and what is meant by the concept of the Circular Bioeconomy (CB). The importance of Geographic Information Systems (GIS) is also emphasized. Finally, the main principles and rules to be applied in forest management in the context of achieving the Sustainable Development Goals are presented.

## 2. LITERATURE REVIEW

Many authors were researching how canforest contribute to the achievement of sustainable development goals. According to Gustavsson et al. (2021) and Nabuurs et al. (2018), using wood sustainably for long-lived products that can substitute non-renewable, carbon-intensive materials, can help to decarbonize the global economy, which is one of very important SG goals. Nabuurs et al. (2013) indicate that forest growth declines in aging forests, which leads to diminishing removals of CO<sub>2</sub> from the atmosphere. Also, many existing climate impact studies suggest an increasing risk from abiotic and biotic disturbances (Seidl et al., 2017). Besides harvesting wood, active forest management allows for quicker and more controlled adaptation of forests to climate change (e.g., selection of tree species and provenances) to ensure resilience of forest ecosystems (Schoene & Bernier 2012).

Successful applying Climate-Smart Forestry strategies and of Bioeconomy concept need to balance short- and long-term sustainable development goals, as balancing the need for wood production, the protection of biodiversity, health and vitality and the provision of other important ecosystem and social services in a dynamic environment (Verkerk et al., 2020; Bowditch et al., 2020).

### **3. DATA AND METHODOLOGY**

The problem-oriented approach to the importance of forests and forestry for achieving sustainable development goals involved the use of numerous analytical tools to clearly identify opportunities, limitations and possible conflicts and to define measures to resolve them.

It is clear that we are in recent period facing a numerous set of challenges (COVID-19, climate changes, wars, earthquakes, etc) which directly impacted on sustainable development goals. These challenges cannot be tackled independently in one area or sector (e.g. economy, industry, forestry, agriculture, environmental protection, etc.).

The study was performed using the analysis method with descriptive, integral and participatory approaches. The importance of an innovative approach to this problem is related to identifying the set of indicators suitable to monitor the performance of the forest-based sector by applying the analysis method with a descriptive approach. The application of an integral approach meant the analyses of current laws, regulations, guidelines and recommendations on sustainable development. The introduction of new indicators and harmonization with European frameworks, policies and planning practices at all levels of decision-making was also applied.

Complex conditions and a multitude of conflicting interests and factors characterize forestry. To gain a deeper insight and assess the feasibility of the planned solutions, we therefore had to apply a participatory approach. This approach was achieved by analysing the legal and planning provisions on different aspects and sectors of forestry at the national level.

Different scientific methods were applied in the study following the needs and objectives of the research. To study the content of documents, content analysis was applied as a kind of partial analysis (Milosavljević & Radosavljević, 2008). Some authors (Bulmer, 1977; Neumann, 2014) classify content analysis into a group of nonreactive methods since it does not involve direct collection of data from the research subjects. Concerning specific scientific methods, the analytical method was used (Miljević, 2007) to study strategic and legislative framework. This research also included review analysis (Wunder et al., 2008) of the elements in the field of Climate-smart forestry and Circular bioeconomy.

The results and discussion presented in the paper are based on different international declarations, legal regulations and acts. The conclusions were based on collected literature data and knowledge transfer of researchers.

### **4. RESULTS AND DISCUSSION**

#### **4.1. Sustainable Development Goals**

The United Nations Sustainable Development Goals (UN SDGs), established in 2015, are a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030. These 17 interconnected goals provide a blueprint for a more sustainable future for all. The 17 SDGs are comprehensive and interlinked, spanning economic, environmental, and social needs (Figure 1).



Figure 1. Sustainable Development Goals (17) (Key Sustainability, 2023)

According to Ljesević (2001), the model of sustainable development is based on the following premises:

- economic and technological efficiency based on labour productivity and rationality;
- rational exploitation of natural resources and compliance with the possibilities of natural potentials and ecological capacities and geographical diversity of space;
- balanced demographic development and adequate spatial distribution of the population;
- social security and the possibility of meeting social needs;
- humaneness of development (satisfaction of educational, health, religious needs and rights);
- efficient use and protection of space, especially valuable territories that are of national and general social interest;
- possibility of satisfying cultural needs;
- protection and improvement of the environment in terms of the functioning of health, life and work, but also the cultural, aesthetic and recreational needs of the population;
- protection of natural and cultural-historical assets and other national and state-building values, both in the sense of satisfying scientific and educational needs, as well as in order to preserve biodiversity.

Forests are a major environmental entity and although forestry is not mentioned as a specific goal, it is included under the definition SDG15 titled ***Life on Land***. Within SDG15 sustainable management of forests (SFM) and conservation of terrestrial ecosystems with their biodiversity has been explicitly recognized. SDG15 aims to “protect, restore and promote

sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt/reverse land degradation and halt biodiversity loss”. But how do we measure development in different countries spread across different continents, for example in Asia, Europe and Africa, with the standard global SDG indicator scales? Again, forests being a central element with many of the other goals on poverty, hunger, health, industry, etc directly linked for development, this paper tries to bring out the links and synergies between the different goals with forests. Therefore, it is important to understand that all the SDGs are inter-related and progress of each goal directly or indirectly depends on the other.

#### 4.2. Importance of Forests

Beyond timber, forests provide various ecosystem services such as biodiversity conservation, climate regulation, water regulation and flood protection, soil protection and nutrient supply, pest control and pollination, etc. Forests provide natural carbon sinks and their products can substitute for emissions-intensive materials, thereby reducing emissions (Nunes et al., 2020).

Services can be grouped into provisioning services, supporting services, regulating services, and cultural services (Figure 2).

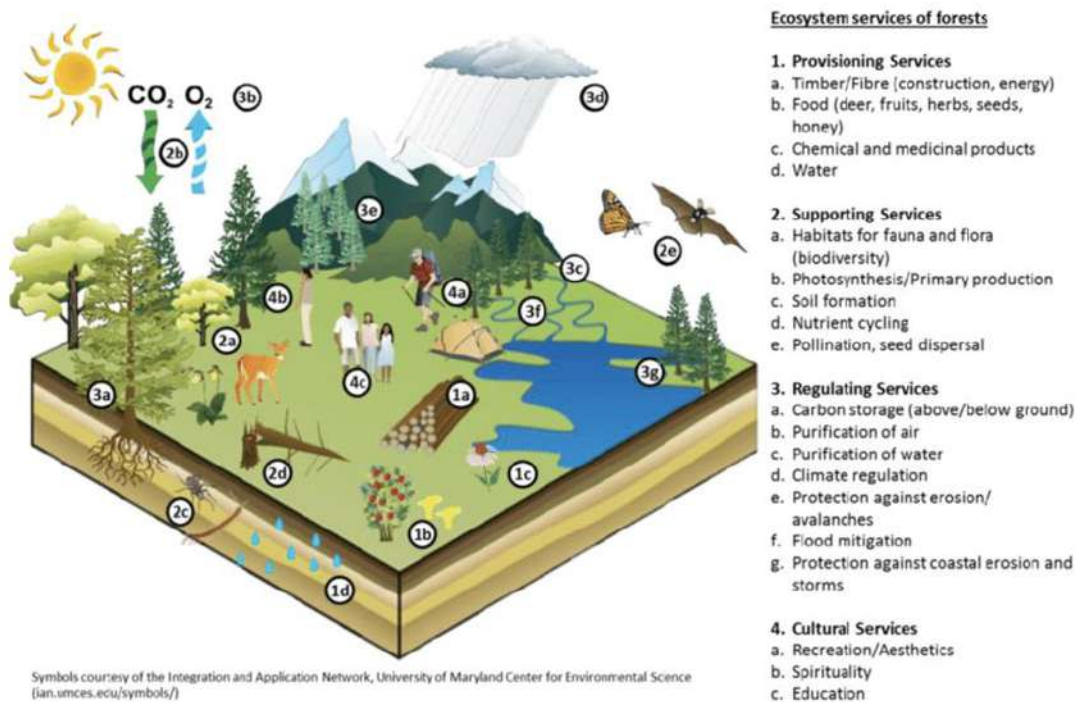


Figure 2. Ecosystem goods and services provided by forests (Holzwarth et al., 2020)

Forests have the primary source for non-food and non-feed renewable biological resources globally, play an important role and should therefore not be set-aside for storing carbon only. Emerging technologies and innovative approach of future functioning of forestry provide possibilities for using wood to produce a new range of biobased and renewable solutions that can replace fossil-intensive and non-renewable products, such as construction, chemicals, textiles or plastics. Therefore, a forest management that ensures a continued, sustainable flow of woody raw material is crucial to mitigate climate change and achieve sustainable development goals.





#### **GOAL 4: ENSURE INCLUSIVE AND EQUITABLE QUALITY EDUCATION**

Providing adequately education for teachers, children, youth and student's education about the importance of forests for environment and sustainability through professional development and continuous transfer knowledge.



#### **GOAL 6: ENSURE ACCESS TO CLEAN WATER FOR ALL**

Supporting (financial and capacity building) best forest management practices relating to water quality, and promotion of projects that help evaluate water quality and quantity in sustainable certified forest ecosystems.



#### **GOAL 12: ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS**

Supporting sustainable management of natural resources and the supply of ecosystem goods and services. Appropriate evaluation and emphasis on the added value of bio-based products and circular bioeconomy concept.



#### **GOAL 13: TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS IMPACTS**

Supporting research and grant making for improving forest management measures to identify best practices in well-managed forests to increase carbon storage and resiliency to climate change.



#### **GOAL 15: SUSTAINABLE MANAGED FORESTS, REDUCING DESERTIFICATION, REVERSING LAND DEGRADATION, PREVENTION BIODIVERSITY LOSS**

Supporting sustainable forests through community engagement and education to reduce deforestation and by promoting ecosystem health and protection of at-risk species.



#### **GOAL 17: STRENGTHEN MEANS OF IMPLEMENTATION AND REVITALIZE THE GLOBAL PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT**

More successful and productive collaboration of different stakeholders (government, public enterprises from forest sector, academic and research institutions, landowners, local communities, NGO) to promote shared goal of sustainable forests.

*Figure 3. Importance of forests and forestry-based sector in the pursuit of goals important for sustainable development*

### 4.3. Climate-Smart Forestry Concept

Climate-Smart Forestry (CSF) is an integral approach of sustainable forest management that focuses on forest management in response to climate change (Bowditch et al., 2020). The fundamental focus of the CSF concept is on adaptation, mitigation and social dimensions. CSF is being interpreted in a number of ways, which mostly focus on adaptive forest management, the decrease of GHG emissions, and effective carbon sequestration (Yousefpour et al., 2019).

Nabuurs et al. (2018) presented the following three pillars of the CSF approach:

- active forest management aiming to sustainably increase productivity and provide all benefits that forests can provide
- adapting forest management to build resilient forests
- reducing and/or removing GHG emissions to mitigate climate change.

According to Verkerk et al. (2020), the concept of CSF goes beyond forest management measures, including GHG mitigation opportunities of wood use, carbon storage and substitution in its targets:

- increasing carbon storage in forests and wood products, in conjunction with the provisioning of other ecosystem services;
- using wood resources sustainably to substitute non-renewable, carbon-intensive materials;
- enhancing health and resilience through adaptive forest management.

Achieving the goals of the Paris Climate Agreement requires a significant reduction in carbon dioxide emissions and increased removal through carbon sinks. In this context, Climate-Smart Forestry is a necessary, but still missing component in national strategies for implementing actions under the Paris Agreement. Successful Climate-Smart Forestry has important policy implications on finding the right balance between short and long-term goals, as well as between the need for wood production, the protection of biodiversity and the provision of other important ecosystem services. CSF thus can provide important co-benefits that are increasingly being recognized as essential for sustainable well-being. According to Roe et al. (2019, 2020), improved forest management measures can contribute to climate change mitigation and determine the composition of new forests in terms of tree species and provenances, and their rate of removing carbon from the atmosphere.

Climate-Smart Forestry measures can vary greatly from region to region due to the very different regional conditions in Europe. A “*one size fits all*” solution across Europe will not work. However, the use of locally adapted CSF measures, as indicated by several case studies conducted across Europe, can result in overall long-term emissions benefits or more stable forest conditions, better adapted to climate change (Nabuurs et al., 2018).

### 4.4. Circular Bioeconomy Concept

Very important role of forests is in a storage carbon and circular bioeconomy by being renewable, recyclable and energy efficient. In addition, forests provide raw materials for innovative bioproducts such as bioplastics, biofuels and biochemicals that replace fossil materials (Hetemäki et al., 2017).

The circular bioeconomy is a complex and dynamic system and thus decision-makers need new strategies and tools to steer and govern this complex system towards the desired outcomes. The literature review concludes that the key principle of the circular bioeconomy is the 4Rs framework (Reduce, Reuse, Recycle, Recover), in which the hierarchy between the Rs is a fundamental aspect. The first R (Reduce) is considered to take precedence over the second R (Reuse) and so on. This hierarchical relationship is closely linked to the “cascade” principle”,



which envisages the use of raw materials according to a priority based on potential added value (Ciccarese et al., 2014; Proskurina et al., 2016; Paletto et al., 2019).

The circular bioeconomy is seeking new ways of producing and consuming resources while respecting our planetary boundaries and moving away from a linear economy, based on extensive use of fossil and mineral resources.

The importance of a circular bioeconomy in the context of the sustainable development goals lies in its potential to contribute to climate change mitigation, socio-economic development and environmental protection over time by maintaining the value of bio-based products, materials and resources in the economy for as long as possible (Figure 3).



Figure 4. Impact of Circular Bioeconomy on UN Sustainable Development Goals (Startus-insights, 2021)

Bio-based products offer recyclable and biodegradable alternatives with applications in materials, engineering, agriculture, forestry and other sectors. By moving away from the take-make-dispose approach to coupling industrial growth with ecosystem preservation, circular bioeconomy adds societal value as well. Moreover, by restoring natural ecosystems and promoting decarbonization, it drives progress towards carbon-negative goals.

#### 4.5. GIS and Remote Sensing

Geographic Information Systems (GIS) play a significant role in the field of forestry and sustainable development, enabling efficient management of forest resources through accurate inventory, monitoring, and analysis (Zápotocký & Koreň, 2022). Thanks to its ability to link data from different locations, GIS enables adequate mapping of vegetation, identification of endangered species, and updating information in real-time (Puziene, 2024). Forestry experts use it to monitor changes in ecosystems over time, which is particularly important in the context of climate change and biodiversity conservation (Tariq et al., 2023; Wang et al., 2024). By combining satellite images and other geospatial data, GIS allows monitoring of large and difficult-to-reach areas with minimal effort (Liu et al., 2024). In addition, through complex analyses of different factors such as climate extremes, vegetation status, or CO<sub>2</sub> emissions, GIS allows a better understanding of the mutual influences within forest ecosystems (Durlević et al., 2025). This will enable experts to simulate different scenarios and make decisions based on spatial and temporal data, thus encouraging long-term planning and sustainable use of natural resources (Mishkin & Navarrete Pacheco, 2022).

## 5. CONCLUSION

The forests and forestry-based sector has a fundamental role in the pursuit of the following choices and objectives important for several sustainable development goals:

- ✓ the sustainable management of natural resources and the supply of ecosystem goods and services useful for human well-being;
- ✓ preservation of biodiversity;
- ✓ the sustainable patterns of production and consumption;
- ✓ improving the efficient use of resources– circular bioeconomy concept;
- ✓ reducing waste production and promote secondary raw material market;
- ✓ boosting sustainable forestry throughout the production and supply chain;
- ✓ applying the results of research, development, innovation and technology;
- ✓ supporting the competitive business environment;
- ✓ enabling and improves education, skills and awareness.

The management of carbon flows between reservoirs in the Earth's system forms the basis for climate change mitigation. Applying climate-smart forestry concept is needed to increase the total forest area and avoid deforestation, connect mitigation with adaption measures to enhance the resilience of global forest resources, and use wood for products that store carbon and substitute emission-intensive fossil and non-renewable products and materials.

The implementation of the innovative approaches and methods presented, such as GIS and remote sensing, climate-smart forestry and the concept of circular bioeconomy in forest management, will contribute to this:

***Strengthening cooperation*** - Better coordination in research, innovation and policy development.

***Attracting investments and financing*** - Joint performance increases the chances of obtaining support from funds.

***Knowledge sharing and capacity building*** – Connecting participants leads to more efficiency.

***Adapting to global trends*** - Aligning with European and international initiatives.

Continuous transfer of know-how methods, capacity building and implementation of the innovative approaches and methods in the field of forest management is a possible way to improve the current situation in forestry and achieve some of the sustainable development goals.

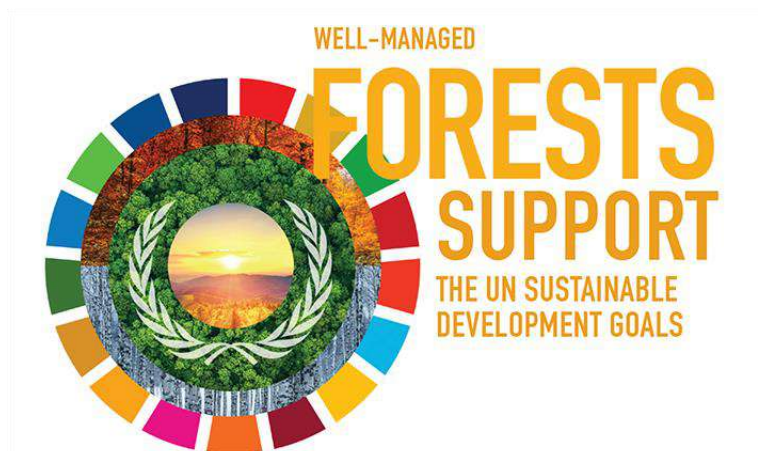


Figure 5: Forest support to the SDG (Sustainable Forestry Initiative, 2025)

## ACKNOWLEDGMENT

This study was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Contract No. 451-03-136/2025-03/ 200027

## REFERENCES

- Bowditch, E., Santopuoli, G., Binder, F., Río, M., Porta, N. Kluvankova, T., Lesinski, J., Motta, R., Pach, M., Panzacchi, P., Pretzsch, H., Temperli, C., Tonon, G., Smith, M., Velikova, V., Weatherall, A., Tognetti, R. (2020). What is Climate-Smart Forestry? A definition from a multinational collaborative process focused on mountain regions of Europe, *Ecosystem Services*, Volume 43, 101113, ISSN 2212-0416, <https://doi.org/10.1016/j.ecoser.2020.101113>.
- Brašanac-Bosanac, Lj., Ćirković-Mitrović, T., Rakonjac, Lj. (2014). Possibilities of establishing sustainable forestry in Serbia, *Journal Ecologica*, No. 75, p. 535-540, Scientific and Professional Society for Environmental Protection of Serbia "Ecologica", Belgrade, ISSN 0354-3285
- Bulmer, M. (1977). *Sociological research methods, An introduction*, second edition., Transaction Publishers, New Brunswick and London. 354.
- Ciccarese L., Pellegrino P., Pettenella D. (2014). A new principle of the European Union forest policy: the cascading use of wood products. *Italian Journal of Forest and Mountain Environments*, 5(69): 285-290. <https://doi:10.4129/ifm.2014.5.01>
- Durlević, U., Srejić, T., Valjarević, A., Aleksova, B., Deđanski, V., Vujović, F., & Lukić, T. (2025). GIS-Based Spatial Modeling of Soil Erosion and Wildfire Susceptibility Using VIIRS and Sentinel-2 Data: A Case Study of Šar Mountains National Park, Serbia. *Forests*, 16(3), 484. <https://doi.org/10.3390/f16030484>
- Gustavsson, L., Nguyen, T., Sathre, R., Tettey, U.Y.A. (2021). Climate effects of forestry and substitution of concrete buildings and fossil energy, *Renewable and Sustainable Energy Reviews*, Volume 136, February 2021, 10435, ISSN 1364-0321, <https://doi.org/10.1016/j.rser.2020.110435>.
- Hetemäki, L., Hanewinkel, M., Muys, B., Ollikainen, M., Palahí, M. and Trasobares, A. (2017). Leading the way to a European circular bioeconomy strategy. From Science to Policy 5. European Forest Institute. [https://efi.int/sites/default/files/files/publication-bank/2018/efi\\_fstp\\_5\\_2017.pdf](https://efi.int/sites/default/files/files/publication-bank/2018/efi_fstp_5_2017.pdf)
- Holzwarth, S., Thonfeld, F., Abdullahi, S., Asam, S., Da Ponte Canova, E., Gessner, U., Huth, J., Kraus, T., Leutner, B., Kuenzer, C., (2020). Earth observation based monitoring of forests in Germany: A review. *Remote Sensing* 12(21), 3570. <http://dx.doi.org/10.3390/rs12213570>
- Key Sustainability (2023). United Nations Sustainable Development Goals: Together we can make “Sustainable Future”. <https://www.keysustainability.com/united-nations-sustainable-development-goals-together-we-can-make-sustainable-future>
- Liu, L., Zhang, Q., Guo, Y., Li, Y., Wang, B., Chen, E., Li, Z., & Hao, S. (2024). Mapping Coniferous Forest Distribution in a Semi-Arid Area Based on Multi-Classifer Fusion and Google Earth Engine Combining Gaofen-1 and Sentinel-1 Data: A Case Study in Northwestern Liaoning, China. *Forests*, 15(2), 288. <https://doi.org/10.3390/f15020288>
- Ljesević, M. (2001). Sustainable development as a paradigm and meaning of planning, *Proceedings from the Scientific-expert meeting: Planning and normative protection of space and environment*, p. 21-31, Association of Spatial Planners of Serbia, Belgrade, ISSN 504.05.06 (082) (In Serbian)

- Miljević M. (2007). Methodology of scientific work - script, University of East Sarajevo - Faculty of Philosophy, Sarajevo (In Serbian)
- Milosavljević S., Radosavljević I. (2008). Basics of political science methodology, Službeni glasnik, Belgrade (In Serbian)
- Mishkin, M., & Navarrete Pacheco, J. A. (2022). Rapid assessment remote sensing of forest cover changes to inform forest management: Case of the Monarch reserve. *Ecological Indicators*, 137, 108729. <https://doi.org/10.1016/j.ecolind.2022.108729>
- Nabuurs, GJ, Verkerk, P.J. Schelhaas, MJ, Olabarria, J.R.G., Trasobares, A., Cienciala, E. (2018). Climate-Smart Forestry: mitigation impacts in three European regions. From Science to Policy 6. European Forest Institute. [https://efi.int/sites/default/files/files/publication-bank/2018/efi\\_fstp\\_6\\_2018.pdf](https://efi.int/sites/default/files/files/publication-bank/2018/efi_fstp_6_2018.pdf)
- Nabuurs, GJ., Lindner, M., Verkerk, P.J., Gunia, K., Dedda, P., Michalak, R., Grassi, G. (2013). First signs of carbon sink saturation in European forest biomass. *Nature Climate Change* 3: 792-796. <https://doi.org/10.1038/nclimate1853>
- Neuman, W.L. (2014). Qualitative and Quantitative Approaches, 7th edition., Pearson Inc., Harlow. 599.
- Nunes, L.J.R., Meireles, C.I.R., Pinto Gomes, C.J., Almeida Ribeiro, N.M.C. (2020). Forest Contribution to Climate Change Mitigation: Management Oriented to Carbon Capture and Storage. *Climate* 8(21). <https://doi.org/10.3390/cli8020021>
- Paletto A., Bernardi S., Pieratti E., Teston F., Romagnoli M. (2019). Assessment of environmental impact of biomass power plants to increase the social acceptance of renewable energy technologies. *Heliyon*, Volume 5, Issue 7, e02070. <https://doi:10.1016/j.heliyon.2019.e02070>
- Proskurina S., Sikkema R., Heinimö J., Vakkilainen E. (2016). Five years left – How are the EU member states contributing to the 20% target for EU's renewable energy consumption; the role of woody biomass. *Biomass & Bioenergy* 95: 64-77. <https://doi:10.1016/j.biombioe.2016.09.016>
- Puziene, R. (2024). Investigating Forest Cover Change Using Historical GIS Technologies: A Case Study with an Example of Jurbarkas District of the Republic of Lithuania. *Sustainability*, 16(11), 4825. <https://doi.org/10.3390/su16114825>
- Roe, S., Streck, C., Beach, R., Busch, J., Chapman, M., Daioglou, V., Deppermann, A., Doelman, J., Emmet-Booth, J., Engelmann, J., Fricko, O., Frischmann, C., Funk, J., Grassi, G., Griscom, B., Havlik, P., Hanssen, S., Humpenöder, F., Landholm, D., ... Lawrence, D. (2021). Land-based measures to mitigate climate change: Potential and feasibility by country. *Global Change Biology*, 27, 6025–6058. <https://doi.org/10.1111/gcb.15873>
- Roe, S., Streck, C., Obersteiner, M. et al. (2019). Contribution of the land sector to a 1.5 °C world. *Nat. Clim. Chang.* 9, 817–828. <https://doi.org/10.1038/s41558-019-0591-9>
- Schoene, D.H.F., Bernier, Y.P. (2012). Adapting forestry and forests to climate change: A challenge to change the paradigm, *Forest Policy and Economic*, Vol. 24, November 2012, 12-9. <https://doi.org/10.1016/j.forpol.2011.04.007>
- SDG Report (2024). The Sustainable Development Goals Report 2024. <https://unstats.un.org/sdgs/report/2024/>
- Seidl, R., Thom, D., Kautz, M. et al. (2017). Forest disturbances under climate change. *Nature Climate Change* 7, 395-402. <https://doi.org/10.1038/nclimate3303>
- Startus-insights (2021). How Circular Bioeconomy Closes the Production Loop with Biomass, Blog. <https://www.startus-insights.com/innovators-guide/how-circular-bioeconomy-closes-the-production-loop-with-biomass/>

- Sustainable Forestry Initiative (2025). SFI and the UN Sustainable Development Goals. <https://forests.org/sfi-and-sdgs/>
- Tariq, A., Jiango, Y., Li, Q., Gao, J., Lu, L., Soufan, W., Almutairi, K. F., & Habib-ur-Rahman, M. (2023). Modelling, mapping and monitoring of forest cover changes, using support vector machine, kernel logistic regression and naive bayes tree models with optical remote sensing data. *Heliyon*, 9(2), e13212. <https://doi.org/10.1016/j.heliyon.2023.e13212>
- Verkerk, P.J., Costanza, R., Hetemäki, L., Kubiszewski, I., Leskinen, P., Nabuurs, G.J., Potočník, J., Palahí, M. (2020). Climate-smart forestry: the missing link. *Forest Policy and Economic*, Volume 115, June 2020, 102164, <https://doi.org/10.1016/j.forpol.2020.102164>
- Wang, Z., Bi, Y., Lu, G., Zhang, X., Xu, X., Ning, Y., Du, X., & Wang, A. (2024). Monitoring Forest Diversity under Moso Bamboo Invasion: A Random Forest Approach. *Forests*, 15(2), 318. <https://doi.org/10.3390/f15020318>
- Wunder, S., Engel, S., Pagiola, S. (2008). Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. *Ecological Economics*, 65(4), 834-852.
- Yousefpour, R., Nabel, J.E.M.S., Pongratz, J. (2019). Simulating growth-based harvest adaptive to future climate change, *Biogeosciences*, 16, 241-254, <https://doi.org/10.5194/bg-16-241-2019>
- Zápotocký, M., & Koreň, M. (2022). Multipurpose GIS Portal for Forest Management, Research, and Education. *ISPRS International Journal of Geo-Information*, 11(7), 405. <https://doi.org/10.3390/ijgi11070405>





## WHOLE-BODY VIBRATION MEASUREMENT AT THE MINING MACHINERY OPERATOR'S WORKPLACE IN SMES

Vesna Spasojević Brkić<sup>1</sup>\*, Mirjana Misita<sup>1</sup>, Ivan Mihajlović<sup>1</sup>, Katarina Dimić Misić<sup>2,3</sup>,  
Martina Perišić<sup>1</sup>, Nemanja Janev<sup>1</sup>, Aleksandar Brkić<sup>4</sup>

*University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia*

*<sup>2</sup> Institute of General and Physical Chemistry Belgrade, Belgrade, Serbia*

*<sup>3</sup> Department of Chemical and Metallurgical Engineering, School of Chemical Engineering,  
Aalto University, Espoo, Finland*

*<sup>4</sup> Innovation Center of Faculty of Mechanical Engineering, Belgrade, Serbia*

**Abstract:** Increased mechanization in mining results in a larger number of workers being exposed to longer durations of whole-body vibration (WBV). Occupational exposure to vibration is associated with an increased risk of musculoskeletal pain in the back, neck, hands, shoulders, and hips; the development of peripheral and cardiovascular disorders and gastrointestinal problems; and it may even increase the risk of developing certain cancers. In that aim, in this survey, whole-body vibration exposure levels were measured during the shift at 22 mining machinery operators' workplaces in 3 surface mining. A triaxial accelerometer V31 was used to measure vibration exposure. Measurements were conducted in accordance with the procedures described in applicable standards in the field. The results indicate that the observed workplaces exceeded the action limit values according to the EU Directive 2002/44/EC, as well as the lower limit values of health risks according to the ISO 2631 standard. The lower limit value of health risk according to the ISO 2631 standard was exceeded at 50% of machines. The action value of WBV according to the EU Directive 2002/44/EC was exceeded in 36% of machines. The dominant vibrations were indicated along the X and Y axes. Operators on bulldozers and loaders are most often exposed to the harmful influence of WB vibrations. Research indicates that there is a risk of harmful impact of WBV that needs to be prevented and highlights the need for further research to identify the most critical risk factors and develop effective prevention and protection strategies for mining machinery operators' workplace risks caused by vibrations.

**Keywords:** Whole-body vibration, mining machinery, operator, SME.

\* Corresponding author: [vspasojevic@mas.bg.ac.rs](mailto:vspasojevic@mas.bg.ac.rs)

Vesna Spasojević-Brkić, ORCID: 0000-0003-4642-3482

Mirjana Misita, ORCID: 0000-0002-7039-0783

Ivan Mihajlović, ORCID: 0000-0002-9489-8207

Katarina Dimić Misić, ORCID: 0000-0002-6397-7711

Martina Perišić, ORCID: 0000-0002-8385-1593

Nemanja Janev, ORCID: 0000-0001-6710-7759

Aleksandar Brkić, ORCID: 0000-0002-3509-1032

## 1. INTRODUCTION

As one of the most important sources of raw materials to the global industry, the mining sector is expanding progressively each year, but it should not be neglected that it is also one of the most hazardous, due to the high accident rate, significant health hazards, and possible property damages (Bugarić et al., 2024; Spasojević et al., 2024). In the mining sector, 47% of all fatalities are caused by accidents involving mining machinery, but there are hardly any studies that take ergonomic and/or contextual aspects into account regarding the mining industry (Misita et al., 2024). According to Brocal et al. (2019), there is a substantial correlation between industrial and occupational risks, with the human component serving as the primary link between the two.

Vibration exposure at work has been linked to a higher incidence of musculoskeletal pain in the hands, shoulders, hips, back, and neck (Charles et al., 2018; Issever et al., 2003; Li et al., 2015). Additionally, it might play a role in the development of cardiovascular, peripheral, digestive, and even immunity disorders (Krajnak, 2018; Robbins et al., 2014; Song et al., 2019). Furthermore, more recent research indicates that vibration exposure at work may raise the risk of getting several types of cancer (Kia et al., 2020; Krajnak, 2018).

The small- and medium-sized enterprises (SMEs) sector is one of the primary areas of entrepreneurial activity in Western Balkan countries, with tremendous potential for growth (Rehman et al., 2019). Additionally, it is thought that SMEs boost the economy by transferring new technologies, boosting employment, and expanding production, among other things (Rehman et al., 2019). Because their business operations are carried out with limited resources, SMEs have specific management processes, such as those in Serbia (Ćočkalo et al., 2011). The social effects of mining have been more prevalent in social-scientific mining studies over the past ten years (Sydd et al., 2022), so SMEs with scarce resources deserve special attention. There are obstacles to implementing the circular economy in Serbia's mining industry, such as the requirement for technology investment and legal restrictions (Vujović et al., 2025), and that fact stresses the actuality of the topic by surveying Serbian SMEs in the mining sector.

Evidently, vibration at work has not been sufficiently examined till now, especially in Serbian SMEs in the mining sector. Accordingly, the aim of this paper is to assess whole body vibration (WBV) at the mining machinery operator's workplace in SMEs. Its structure is as follows: after the introduction, the previous research is examined in the second part; in the third part, measurement methodology and its results are presented, while in the last part, conclusions are presented.

## 2. PREVIOUS RESEARCH

The Society of Occupational Medicine (2023), in their study, provides an overview of the impact of WBV and hand-arm vibration syndrome on worker health, with a particular focus on risk assessment and worker protection guidelines. The results indicate an association of WBV with lower back pain, degenerative changes in the spinal vertebrae, decreased bone density, and increased risk of muscle wasting. The document also highlights that although there are standardized methods for measuring WBV, epidemiological evidence of its long-term health effects is limited. Similarly, a guide by Safe Work Australia (2016) draws on an analysis of previous research, health standards, and regulatory requirements to identify key factors influencing WBV and indicates musculoskeletal disorders, particularly in the lower back, as well as increasing the risk of fatigue, reduced concentration, and other health problems, and offers recommendations to reduce the risk, including technical measures (e.g., improving seating and suspension systems), administrative measures (e.g., limiting the duration of

exposure), and training workers to recognize and mitigate the effects of WBV. Both documents include different occupations and industry types, including mining machinery operators.

Besides recommendations given in publications such as the above-mentioned, the results of Sharma et al. (2020) recently show that heavy machinery operators are regularly exposed to high levels of vibration during eight-hour shifts, often exceeding the recommended limits of the ISO 2631/1-1997 standard. Sharma et al. (2020) also note that the effects of WBV are complex and exhibit non-linear behavior, and that due to the complexity, there are problems in properly understanding the entire physiological phenomenon.

Certain authors use triaxial accelerometers for WBV measurements, a few of them in the mining industry, as below.

Akinnuli et al. (2018) investigated the impact of WBV on a sample of 30 earthmoving machine operators in the construction industry, and the results indicated that WBV often exceeded recommended limits, with the daily vibration values of most subjects exceeding the permissible threshold of  $0.5 \text{ m/s}^2$ , with maximum recorded values of up to  $1.15 \text{ m/s}^2$ , which is twice the recommended limits. Authors of this study conducted WBV measurements using a GCDC X16-4 triaxial accelerometer on a bulldozer, excavator, grader, loader, vibratory roller, and backhoe. The results indicated that all values of vertical vibrations (Z axis) were within the Health Guidance Caution Zone (HGCZ), while horizontal vibrations (X and Y axes) were lower. However, in certain machines, such as backhoes and excavators, the WBV exceeded the exponential exposure limit (ELV), indicating the need for technical and ergonomic improvements. Furthermore, the Crest Factor (CF) was in most cases greater than 9, which indicates the presence of multiple impact shocks during operation. Chaudhary et al. (2019), in their study of 39 drill operators, examine the association between WBV exposure and various occupational and personal factors in Indian iron ore mines. The results showed that 70% of the operators were exposed to vibrations exceeding the recommended limits of the ISO 2631/1-1997 standard, with the dominant vibrations observed along the vertical (z) axis. Multivariate regression analyses showed that operator age, drill model, rock hardness, and material density were significant predictors of vibration exposure. Tekin (2022) evaluates the WBV exposure levels of mining machine operators in three different surface coal mines in western Turkey and compares them with ISO 2631/1-1997 standards and EU Directive 2002/44/EC (2022). The research sample included 41 different models and brands of mining machines, and factors such as machine type, duration of exposure, and dominant vibration axis were analyzed. The results showed that all operators were exposed to WBV below the limit value of  $1.15 \text{ m/s}^2$ , but 44% of operators were exposed to vibration above the action limit of  $0.5 \text{ m/s}^2$ . Bulldozer operators had the highest WBV values due to working on rough terrain, while excavator operators had the least exposure to vibration. Erdem et al. (2020) analyzed exposure to whole body vibration (WBV) in 105 mining truck drivers and showed that drivers are most exposed to vibration along the vertical (Z) axis but amplify it in the X and Y axes. Older trucks and vehicles with longer service lives produced higher WBV values. Chaudhary et al. (2015) in their study evaluated exposure to WBV using a triaxial seat accelerometer (Nor 1286) in 28 operators working on 10 drills from different manufacturers, and their results showed that more than 90% of the operators were exposed to WBV values above the upper limit recommended in the ISO 2631/1-1997 standard. Marin et al. (2017) conducted a study to characterize the WBV exposure using a triaxial seat accelerometer (Model 356B41, PCB Piezotronics, USA), using an 8-channel (DA-40) and 4-channel (DA-20) data recorder of 38 heavy mining vehicles in surface mines, and the results showed that the majority of mining vehicles exceeded the recommended WBV limits, with the dominant axis of vibration differing depending on the type of vehicle and working conditions. Mahamedi et al. (2021) conducted research to develop an automated system for measuring excavator productivity using deep learning and smartphone sensors, and



the results showed that a model based on the DNN algorithm with accelerometer, gyroscope, linear acceleration, and noise data achieves the highest accuracy of 99.78%. Sakinala et al. (2024) conducted a six-month survey in seven underground mines in India using a SV38V triaxial accelerometer on a sample of 81 operators, and the results showed that 88.92% of operators were exposed to WBV values above the lower ISO HGCZ limit (ISO 2631-5:2018, 2018) ( $0.45 \text{ m/s}^2$ ).

Previous studies show different measuring devices, methodologies used, and different results on different samples, and there is clearly a need for further research.

### 3. DATA AND METHODOLOGY

In this research, a triaxial accelerometer VM31 by Metra Mess und Frequenztechnik in Radebeul e.K. was used. To assess the vibrations acting on the human body, it is recommended to measure the interval RMS values along the X, Y, and Z axes, as well as their vector sum ( $a_w$ ). The VM31 device measures these four values simultaneously. In addition, it displays the current maximum RMS value (Maximum Transient Vibration Value, MTVV), which may indicate the presence of shock vibrations. MTVV is not necessarily the largest value among the individual RMS values for the X, Y, and Z axes, because these values are multiplied by weighting factors, which is not the case with MTVV. Whole body vibration measurement in the context of health risk assessment, a weighting filter  $W_d$  is used for the X and Y axes, and  $W_k$  for the Z axis, with weighting factors of 1.4 for X and Y, and 1.0 for the Z axis. Figures 1 and 2 show the frequency response curves of these filters in the VM31 device, in accordance with the ISO 8041-1:2017 standard.

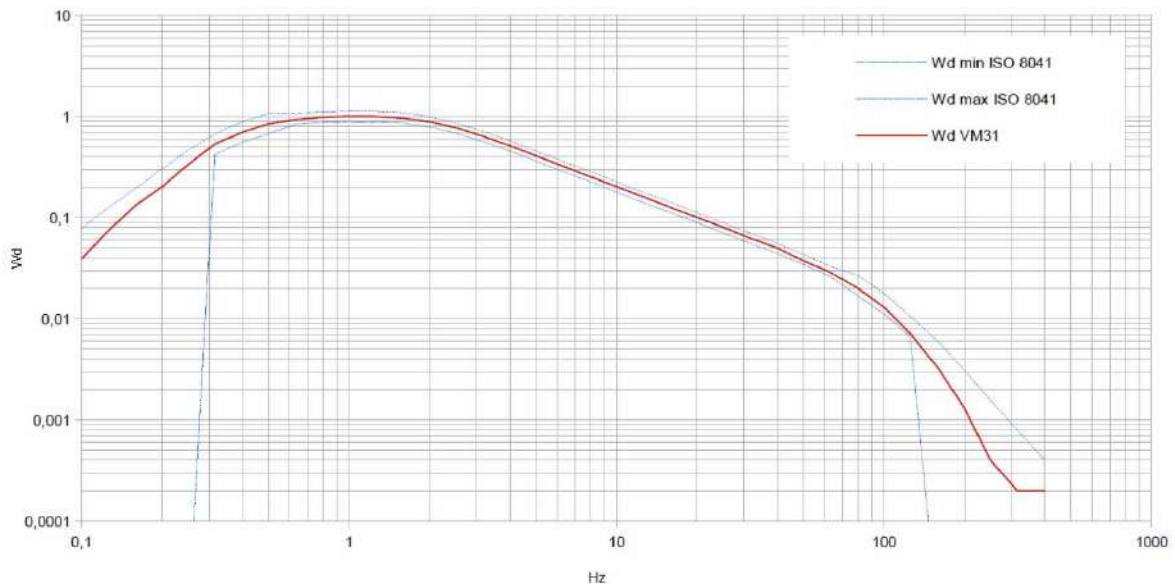


Figure 1. Whole-body weighting filter  $W_d$  (Instruction Manual VM31, 2023)

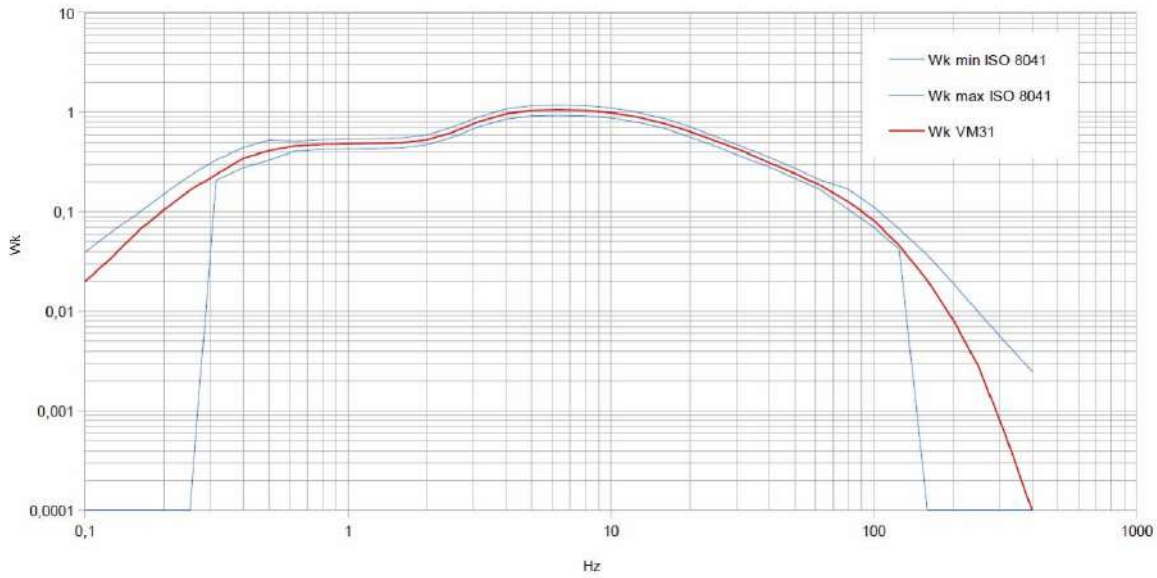


Figure 2. Whole-body weighting filter Wk (Instruction Manual VM31, 2023)

Vibration analysis for WBV is performed based on the formulas outlined in the ISO 2631/1-1997 standard. For each measurement, the frequency-weighted root mean square (WRMS) values along the X-, Y-, and Z-axes were individually calculated for each mining machine using Equation 1 (EU Directive 2002/44/EC, 2022):

$$a_{w,r.m.s} = \sqrt{\int_0^T a_w^2(t) dt} \quad (1)$$

where

$a_w(t)$  - WRMS acceleration at a particular time  $t$  (m/s<sup>2</sup>)

$T$  - Duration of measurement (seconds)

The individual RMS values of accelerations measured along the x, y, and z axes by the precision vibration meter are denoted as  $a_{wx}$ ,  $a_{wy}$ , and  $a_{wz}$ , respectively. For triaxial measurements, the peak accelerations (maximum instantaneous acceleration during the measurement period) are calculated in addition to the WRMS vector sum value (EU Directive 2002/44/EC, 2022):

$$a_{xyz} = \sqrt{(k_x * a_{wx})^2 + (k_y * a_{wy})^2 + (k_z * a_{wz})^2} \quad (2)$$

Given that the risk of damage varies along the three axes, WRMS accelerations ( $a_{wx}$ ,  $a_{wy}$ ,  $a_{wz}$ ) are computed by applying the appropriate weighting factors specified in ISO 2631/1-1997 ( $k = 1.4$  for the x-axis and y-axis,  $k = 1.0$  for the z-axis). The value of  $A(8)$  is determined using Equation 3 (EU Directive 2002/44/EC, 2022):

$$A(8) = \sqrt{\frac{1}{8} \sum_{n=1}^N a_{wn}^2 t_n} \quad (3)$$

The  $A(8)$  value is determined by considering the daily exposure times ( $t_n$ ) for each phase, the WRMS vibration for each phase ( $a_{wn}$ ), the number of phases ( $N$ ), and the estimated daily exposure equivalent to an 8-hour continuous exposure. These calculated values were then

used to assess the potential health risk to workers, utilizing the health guidance caution zone (HGCZ) in accordance with Annex B of the ISO 2631/1-1997 standard.

The sample included mining machines in SME at 3 locations (A, B, C), i.e., mines in the fields of surface mining of quartz sand, zinc and lead, and marble and granite, as in Table 1. WBV measurements were carried out on 22 mining machines there.

Table 1. Locations

Location	Surface mining	Company size
A	Quartz sand	medium
B	Zinc and lead	medium
C	Marble and granite	small

### 3. RESULTS AND DISCUSSION

Table 2 shows the results of WB vibration measurements using the VM31 measuring device. For each mining machine on which WB vibrations were measured, the duration of the measurement on a certain work task, the measured values on the X, Y, and Z axes, the dominant axis was determined, and the A(8) value was calculated.

Table 2. WBV measurement results

Location	Mining machine	kW	Year	Task	Duration (h)	$a_{wx}$ (m/s <sup>2</sup> )	$a_{wy}$ (m/s <sup>2</sup> )	$a_{wz}$ (m/s <sup>2</sup> )	$a_{wxyz}$ (m/s <sup>2</sup> )	Dominant axis	A(8) (m/s <sup>2</sup> )
A	Excavator	123	2018	1	3	0.17	0.27	0.13	0.34	y	0.26
				2	4.30	0.17	0.27	0.14	0.34	y	
A	Excavator	180	2024	1	5	0.33	0.27	0.30	0.52	x	0.31
				2	2.30	0.29	0.24	0.23	0.43	x	
A	Excavator	180	2024	1	7.30	0.13	0.10	0.11	0.20	x	0.13
A	Loader	140	2017	1	3	0.47	0.58	0.30	0.80	y	0.56
				2	4.30	0.54	0.58	0.39	0.88	y	
A	Bulldozer	120	2015	1	3	0.37	0.33	0.37	0.61	x,z	0.45
				2	4.30	0.52	0.48	0.51	0.86	x	
A	Bulldozer	160	2023	1	7.30	0.57	0.52	0.55	0.94	x	0.55
B	Excavator	370	2017	1	8	0.26	0.17	0.20	0.36	x	0.26
B	Excavator	370	2017	1	8	0.40	0.28	0.23	0.53	x	0.40
B	Excavator	316	2012	1	7.30	0.55	0.34	0.24	0.68	x	0.53
B	Loader	246	2017	1	7.30	0.40	0.42	0.23	0.62	y	0.41
B	Loader	251	2017	1	8	0.15	0.16	0.11	0.24	y	0.16
B	Dumper	386	2011	1	7.30	0.48	0.38	0.43	0.74	x	0.47
B	Dumper	250	2008	1	8	0.36	0.53	0.47	0.79	y	0.53
B	Bulldozer	268	2011	1	7.30	0.64	0.52	0.37	0.90	x	0.62
C	Excavator	220	2023	1	8	0.51	0.36	0.39	0.73	x	0.51
C	Excavator	202	2019	1	7.30	0.39	0.30	0.36	0.60	x	0.38
C	Dumper	298	2010	1	4	0.51	0.49	0.37	0.79	x	0.44
				2	3.30	0.38	0.35	0.25	0.57	x	
C	Dumper	298	2011	1	7.30	0.25	0.30	0.24	0.46	y	0.29
C	Dumper	298	2010	1	1	0.31	0.36	0.33	0.57	y	0.43
				2	6.30	0.43	0.46	0.42	0.75	y	
C	Dumper	248	2006	1	7.30	0.43	0.47	0.45	0.77	y	0.45
C	Loader	250	2020	1	7.30	0.51	0.55	0.32	0.81	y	0.53
C	Loader	250	2020	1	7.30	0.69	0.67	0.41	1.04	x	0.67

In Table 3, a summary analysis of mining machines by location and type. The results show the minimum, maximum, mean value, and standard deviation for groups of similar machines. How it is: "According to ISO 2631/1-1997, the frequency-weighted acceleration values corresponding to the lower and upper limits of the HGCZ (for 8 h of exposure) are 0.45 and 0.90 m/s<sup>2</sup>, respectively. According to EU Directive 2002/44/EC, a daily exposure action value (AV) of 0.5m/s<sup>2</sup> and a daily exposure limit value (LV) of 1.15m/s<sup>2</sup> (the frequency-weighted acceleration)" further show the percentage representation of the mean A(8) value for the relevant groups of machines in relation to the limit values given in ISO 2631/1-1997 and the EU Directive 2002/44/EC.

*Table 3. Summary analysis of mining machine measurement results by location and machine type*

The open-pit mine A								
Mining machines	Number of machines	A(8) (m/s <sup>2</sup> )			ISO 2631/1-1997 (8h exposure)		EU Directive 2002/44/EC (8h exposure)	
		Min	Max	Mean±SD	Below	Within	Below action value	Above action value, below limit value
Excavator	3	0.13	0.31	0.23±0.09	100%	-	100%	-
Loader	1	0.56	0.56	0.56±0.00	-	100%	-	100%
Bulldozer	2	0.45	0.55	0.50±0.07	-	100%	50%	50%
The open-pit mine B								
Mining machines	Number	A(8) (m/s <sup>2</sup> )			ISO 2631/1-1997 (8h exposure)		EU Directive 2002/44/EC (8h exposure)	
		Min	Max	Mean±SD	Below	Within	Below action value	Above action value, below limit value
Excavator	3	0.26	0.53	0.40±0.14	66,6%	33.3%	66.6%	33.3%
Loader	2	0.16	0.41	0.29±0.18	100%	-	100%	-
Dumper	2	0.47	0.53	0.50±0.04	-	100%	50%	50%
Bulldozer	1	0.62	0.62	0.62±0.00	-	100%	-	100%
The open-pit mine C								
Mining machines	Number	A(8) (m/s <sup>2</sup> )			ISO 2631/1-1997 (8h exposure)		EU Directive 2002/44/EC (8h exposure)	
		Min	Max	Mean±SD	Below	Within	Below action value	Above action value, below limit value
Excavator	2	0.38	0.51	0.45±0.09	50%	50%	50%	50%
Dumper	4	0.29	0.45	0.40±0.08	75%	25%	100%	-
Loader	2	0.53	0.67	0.60±0.10	-	100%	-	100%

Figure 3 shows the limit and action value of 8h exposure to WB vibrations according to EU Directive 2002/44/EC, the upper and lower health risk limit according to the ISO 2631/1-1997 standard, and the middle, lower, and upper limit values by machine groups and location.

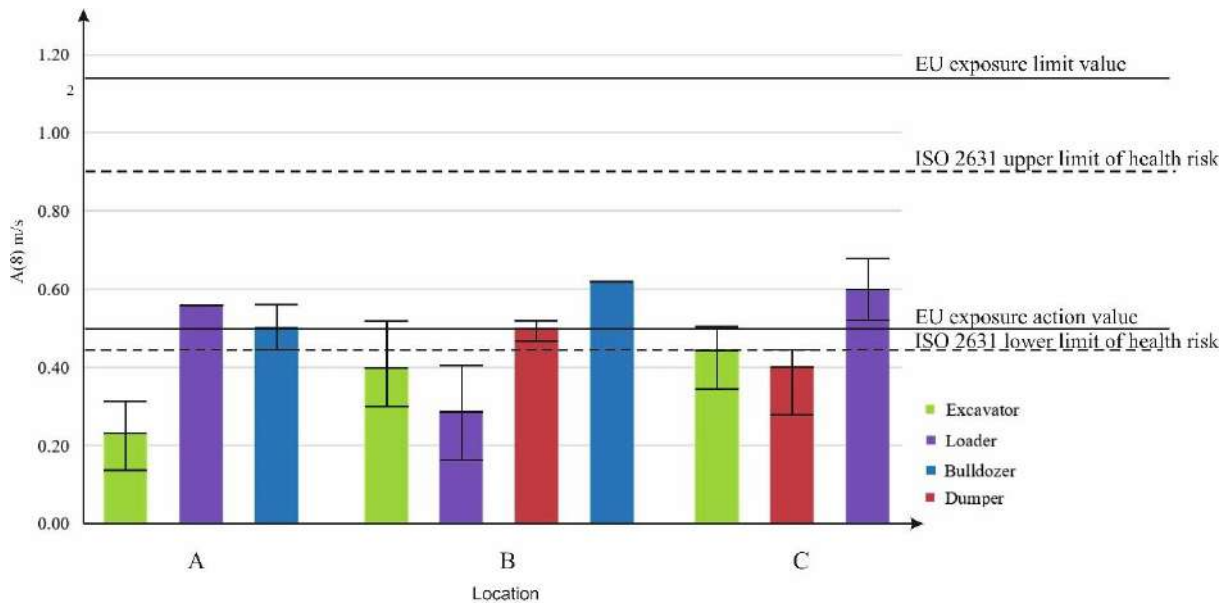


Figure 3. Mean value, upper and lower limit value of A(8) by location and type of mining machine in comparison with the existing regulations

The highest recorded WBV was recorded at the workplaces of bulldozers and loaders at location A, loaders at location C, and bulldozers and dump trucks at location B. No location exposed excavator operators to the harmful effects of WBV. The dominant vibration axes are mostly x and y, while vertical vibrations were dominant only on one of the 22 recorded machines.

#### 4. CONCLUSION

This paper fills an evidence-based research gap in the field. In this research, WBV was analyzed using a triaxial accelerometer V31 by Metra Mess und Frequenztechnik in Radebeul e.K. The goal of the research was to determine whether the action or limit values of WBV prescribed by the EU Directive 2002/44/EC were exceeded, as well as to determine whether the measured WBV were in accordance with the ISO 2631/1-1997 standard. The research was conducted at 3 locations of surface mines, and the research sample included 22 mining machines of the following types: excavator, bulldozer, and dumper. Operators' workplaces were recorded during one work shift in order to determine 8 hours of exposure to whole body vibration. The results indicate that the observed machines exceeded the action limit values according to the EU Directive 2002/44/EC, as well as the lower limit values of health risks according to the ISO 2631/1-1997 standard. On 11 observed machines (50% of the observed number of machines), the lower limit value of health risk according to the ISO 2631/1-1997 standard was exceeded. On 8 observed machines (36.5% of the observed number of machines), the action value of WB vibrations according to the EU Directive 2002/44/EC was exceeded. The dominant vibrations on the observed machines were along the x and y axes. Operators on bulldozers and loaders are most often exposed to the harmful influence of WBV.

The research indicates that there is a risk of the harmful impact of WBV on mining machines that needs to be prevented, and in relation to the reference literature, the proposal for the prevention of this risk advocates the implementation of an ergonomically adapted operator's seat that mitigates the mentioned vibrations. Future research direction could be sample enlargement and deeper analysis.

## ACKNOWLEDGMENT

This research was supported by the Science Fund of the Republic of Serbia, #GRANT No. 5151, Support Systems for Smart, Ergonomic and Sustainable Mining Machinery Workplaces – SmartMiner and by the Ministry of Science, Technological Development and Innovation of the RS no. 451-03-137/2025-03/200105, 451-03-436/2025-03/200051, 337-00-216/2023-05/244 - SAFECORNER and Eureka project No. 20495, Smart Toolbox for Mining Resilience, Sustainability and Financial Performance Improvement - SMARTMEN.

## REFERENCES

- Akinnuli, B. O., Dahunsi, O.A., Ayodeji, S.P., & Bodunde, O. P. (2018). Whole-body vibration exposure on earthmoving equipment operators in construction industries. *Cogent Engineering*, 5(1), 1507266. <https://doi.org/10.1080/23311916.2018.1507266>
- Brocal, F., González, C., Komljenovic, D., Katina, P. F., & Sebastián, M. A. (2019). Emerging Risk Management in Industry 4.0: An Approach to Improve Organizational and Human Performance in the Complex Systems. *Complexity*, 2019(1), 2089763. <https://doi.org/10.1155/2019/2089763>
- Bugarić, U., Spasojević Brkić, V., Petrović, N., Janev, N., & Perišić, M. (2024). A Risk Evaluation Of Bulldozer Downtimes and Its Economic Justification In Open-Pit Mines. IMCSM Proceedings - International May Conference on Strategic Management – IMCSM24, May 31, 2024, Bor, XX(1), 122–131. <https://doi.org/10.5937/IMCSM24012B>
- Charles, L. E., Ma, C. C., Burchfiel, C. M., & Dong, R. G. (2018). Vibration and Ergonomic Exposures Associated with Musculoskeletal Disorders of the Shoulder and Neck. *Safety and Health at Work*, 9(2), 125–132. <https://doi.org/10.1016/j.shaw.2017.10.003>
- Chaudhary, D. K., Bhattacharjee, A., Patra, A. K., & Chau, N. (2015). Whole-body Vibration Exposure of Drill Operators in Iron Ore Mines and Role of Machine-Related, Individual, and Rock-Related Factors. *Safety and Health at Work*, 6(4), 268–278. <https://doi.org/10.1016/j.shaw.2015.06.004>
- Chaudhary, D. K., Bhattacharjee, A., Patra, A. K., Upadhyay, R., & Chau, N. (2019). Associations Between Whole-Body Vibration Exposure and Occupational and Personal Factors in Drill Operators in Indian Iron Ore Mines. *Mining, Metallurgy & Exploration*, 36(3), 495–511. <https://doi.org/10.1007/s42461-019-0061-y>
- Ćočkalo, D., Đorđević, D., Sajfert, Z., & Bogetić, S. (2011). SMEs in the Republic of Serbia: The Developing Capacities. *Journal of Applied Engineering Science*, 9, 449–456. <https://doi.org/10.5937/jaes9-1131>
- Erdem, B., T. Dogan, & Duran, Z. (2020). Assessment of whole-body vibration exposure of mining truck drivers. *Journal of the Southern African Institute of Mining and Metallurgy*, 120(9), 547–559. <https://doi.org/10.17159/2411-9717/1146/2020>
- EU. 2002. European Parliament and Council Directive, 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual. Directive within the meaning of Article 16(1) of Directive 89/391/EEC. *Official Journal of the European Communities*. 177 pp.
- Human response to vibration—Measuring instrumentation—Part 1: General purpose vibration meters (ISO 8041-1:2017; Version 1). (2017). (Published)
- Instruction Manual, Human-Vibration Analyzer VM31, 2023 Published by: Manfred Weber, Metra Mess- und Frequenztechnik in Radebeul e.K. (2023).



- ISO 2631-1 1997 International Standards Organization, (ISO) ISO 2631–1. (1997). Mechanical vibration and shock. Guide for the Evaluation of Human Exposure to Whole-body Vibration —Part 1: General requirements. Part 1. ISO 2631/1-1997.
- ISO 2631-5 2018 International Standards Organization, (ISO) ISO 2631–5. (1997). Mechanical vibration and shock—Evaluation of human exposure to whole-body vibration—Part 5: Method for evaluation of vibration containing multiple shocks. Part 5. ISO2631/5-2018.
- Issever, H., Aksoy, C., Sabuncu, H., & Karan, A. (2003). Vibration and Its Effects on the Body. *Medical Principles and Practice*, 12(1), 34–38. <https://doi.org/10.1159/000068155>
- Kia, K., Fitch, S. M., Newsom, S. A., & Kim, J. H. (2020). Effect of whole-body vibration exposures on physiological stresses: Mining heavy equipment applications. *Applied Ergonomics*, 85, 103065. <https://doi.org/10.1016/j.apergo.2020.103065>
- Krajnak, K. (2018). Health effects associated with occupational exposure to hand-arm or whole body vibration. *Journal of Toxicology and Environmental Health, Part B*, 21(5), 320–334. <https://doi.org/10.1080/10937404.2018.1557576>
- Li, W., Zhang, M., Lv, G., Han, Q., Gao, Y., Wang, Y., Tan, Q., Zhang, M., Zhang, Y., & Li, Z. (2015). Biomechanical response of the musculoskeletal system to whole body vibration using a seated driver model. *International Journal of Industrial Ergonomics*, 45, 91–97. <https://doi.org/10.1016/j.ergon.2014.12.006>
- Mahamedi, E., Rogage, K., Doukari, O., & Kassem, M. (2021). Automating excavator productivity measurement using deep learning. *Proceedings of the Institution of Civil Engineers - Smart Infrastructure and Construction*, 174(4), 121–133. <https://doi.org/10.1680/jsmic.21.00031>
- Marin, L. S., Rodriguez, A. C., Rey-Becerra, E., Piedrahita, H., Barrero, L. H., Dennerlein, J. T., & Johnson, P. W. (2017). Assessment of Whole-Body Vibration Exposure in Mining Earth-moving Equipment and Other Vehicles Used in Surface Mining. *Annals of Work Exposures and Health*, 61(6), 669–680. <https://doi.org/10.1093/annweh/wxx043>
- Misita, M., Brkić, A., Mihajlović, I., Đurić, G., Stanojević, N., Bugarić, U., & Spasojević Brkić, V. (2024). Decision Support System for Mining Machinery Risk Mitigation Driven by Ergonomics and Contextual Theory. *Applied Sciences*, 14(15), Article 15. <https://doi.org/10.3390/app14156413>
- Rehman, N. U., Çela, A., Morina, F., & Gura, K. S. (2019). Barriers to growth of SMEs in Western Balkan countries. *Journal of Management Development*, 38(1), 2–24. <https://doi.org/10.1108/JMD-09-2018-0273>
- Robbins, D., Yoganathan, P., & Goss-Sampson, M. (2014). The influence of whole body vibration on the central and peripheral cardiovascular system. *Clinical Physiology and Functional Imaging*, 34(5), 364–369. <https://doi.org/10.1111/cpf.12103>
- Safe Work Australia: Guide to managing risks of exposure to carcinogens in the workplace. (2016). Safe Work Australia.
- Sakinala, V., Paul, P. S., & Moparthy, J. R. (2024). Assessment of HEMM Operators' Risk Exposure due to Whole-Body Vibration in Underground Metalliferous Mines Using Machine Learning Techniques. *Mining, Metallurgy & Exploration*, 41(4), 2143–2159. <https://doi.org/10.1007/s42461-024-01009-y>
- Sharma, A., Mandal, S., & Kumbhakar, D. (2020). Whole body vibration exposure and its effects on heavy earthmoving machinery (HEMM) operators of opencast mines – a review. *Journal of Mines, Metals and Fuels*, 68(7), 221–228.
- Song, N., Liu, X., Feng, Q., Xu, M., Lan, X., Li, M., Liu, R., Li, C., Dong, T., Wang, D., & Liu, S. (2019). Whole Body Vibration Triggers a Change in the Mutual Shaping State of Intestinal Microbiota and Body's Immunity. *Frontiers in Bioengineering and Biotechnology*, 7. <https://doi.org/10.3389/fbioe.2019.00377>

- Spasojević, B. V., Mihajlović, I., Nikolić, Đ., & Brkić, A. (2024). Smart, ergonomic and sustainable mining machinery workplaces: An overview of the SmartMiner project. XX International May Conference on Strategic Management – IMCSM24 Proceedings, vol. 20, iss. 1-Smart miner, 49–59. <https://doi.org/10.5937/IMCSM24005S>
- Sydd, O., Sairinen, R., Orenius, O., & Tiainen, H. (2022). Social Impacts of Modern Small-scale Mining: Case Studies from Serbia and Bosnia & Herzegovina. *Society & Natural Resources*, 35(8), 816–835. <https://doi.org/10.1080/08941920.2022.2079157>
- Tekin, A. (2022). Assessment of vibration exposure of mine machinery operators at three different open-pit coal mines. *Journal of the Southern African Institute of Mining and Metallurgy*, 122(5), 235–243. <https://doi.org/10.17159/2411-9717/1728/2022>
- The Society of Occupational Medicine: Hand-Arm Vibration Syndrome (HAVS) and Whole Body Vibration (WBV). (2023). The Society of Occupational Medicine. [https://www.som.org.uk/sites/som.org.uk/files/HAVS\\_and\\_Whole\\_Body\\_Vibration\\_Feb\\_2023.pdf](https://www.som.org.uk/sites/som.org.uk/files/HAVS_and_Whole_Body_Vibration_Feb_2023.pdf)
- Vujović, N., Alivojvodić, V., Radovanović, D., Štulović, M., Sokić, M., & Kokalj, F. (2025). Towards Circularity in Serbian Mining: Unlocking the Potential of Flotation Tailings and Fly Ash. *Minerals*, 15(3), 254. <https://doi.org/10.3390/min15030254>





## HAPS BETWEEN KESSLER SYNDROME, BENEFITS FOR HUMANITY, AND TECHNOLOGICAL CHALLENGES

Damir Ilić<sup>1\*</sup>, Vladimir Tomašević<sup>1</sup>, Tatjana Ilić-Kosanović<sup>2</sup>

<sup>1</sup>University “Union – Nikola Tesla”, The School of Engineering Management, Belgrade, Republic of Serbia

<sup>2</sup>University “Union – Nikola Tesla”, Belgrade, Republic of Serbia

**Abstract:** Kessler syndrome represents a significant threat to satellites in orbit and human endeavors in space exploration. The Earth's orbital environment hosts important infrastructures like the International Space Station and a high volume of satellites for communications, navigation, and Earth observation. The research aims to mitigate the dangers and potential impacts of Kessler syndrome by employing the latest technological innovations, specifically High-Altitude Platform Systems (HAPS), with carefully developed strategies for the survival and advancement of mankind. The study employs a hybrid SWOT-AHP method in designing the viable strategies for HAPS implementation in the context of Kessler syndrome. The key contribution of the research lies in demonstrating that, despite existing technological limitations, HAPS platforms can serve as viable alternatives to satellites made inoperable by Kessler syndrome. More significantly, by implementing the strategies suggested in this research, HAPS platforms can be transformed into multi-purpose systems with immense potential for a wide variety of applications in the event of cataclysmic events disabling orbital communications and navigation systems. Such platforms would be capable of functioning together with operational satellites or in a fully autonomous mode, thereby resolving key issues of Kessler syndrome.

**Keywords:** HAPS, Kessler syndrome, Satellites, SWOT-AHP, Strategies

---

\* Corresponding author: damir.ilic@fm.rs

Damir Ilić, ORCID: 0000-0003-1671-2785

Vladimir Tomašević, ORCID: 0000-0001-9845-2950

Tatjana Ilić-Kosanović, ORCID: 0000-0001-9813-7379

## 1. INTRODUCTION

HAPS are the aircrafts or balloons that have the ability to fly or hover in the stratosphere at altitudes of about 20 km. Their operations are carried out without a crew, completely autonomously, with the possibility of a constant presence above a specific area where the mission is carried out. One of the characteristics is the ability to take off and land, which allows the ground crew to periodically maintain and change the systems with which the system is equipped (GSMA, 2021). The functioning characteristics of the HAPS platform are officially defined in the ITU Radio Regulations (No. 1.66A) as “a station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth” (ITU, 2016, p 13.). There are a large number of satellites in Earth's orbit. These satellites can be grouped into three main categories: payloads, rocket engines, and debris associated with the launch or disintegration of a particular payload or carrier rocket. This last, most numerous grouping consists of objects that are in orbits that intersect with each other, thus increasing the probability of a collision between them. As satellites collide, additional fragments are created, the formation of which increases the probability of collisions with other satellites, which would further increase the number of debris exponentially. This chain reaction could lead to the creation of a large debris belt around the Earth (Kessler & Cour-Palais, 1978).). This phenomenon is called The Kessler syndrome, after NASA scientist Donald J. Kessler who studied this scenario. Considering that the low-intensity Kessler syndrome boundary has already been passed, a second massive ingestion of a large amount of orbital debris would further enhance its development, rendering the conduct of a space mission impossible (Doboš & Pražák, 2022).

## 2. LITERATURE REVIEW

### 2.1. High Altitude Platform Stations

Based on design, there are two basic categories of HAPS aircraft: lighter-than-air HAPS called aerodynes and heavier-than-air HAPS – also called aerostats (balloons, airships, dirigibles) (HAPS Alliance, 2024; Bagarić et al., 2025). Balloons in the form of HAPS have promising potential for efficient data collection and transmission compared to traditional methods such as satellites, towers or drones. They have the ability to provide critical connectivity to underserved or remote areas, improving modern communications. The advantage of balloon platforms over other high-altitude aircraft or stationary transmission bases lies in the breadth of their potential applications. They are characterized by a longer flight duration compared to other systems as well as independence from runways. Compared to UAS, balloons have a lower need for technical maintenance, and therefore landing. In addition, unlike ground telecommunications base stations, they can be easily relocated to adapt to a specific mission. When talking about the challenges of their application, there is the problem of maintaining their position and navigation within international airspace (van Wynsberghe & Turak, 2016; GSMA, 2021).

Airships are the largest platforms, and, as such, they are characterized by greater capabilities in terms of payload weight (several hundred kg), power (over 10kW) and flight autonomy (up to a year). What they have in common with HAPS platforms with fixed wings is precise control over platform positioning. On the negative side, the sheer size of these systems causes additional operational complexity (GSMA, 2021). Although most missions require

airships to maintain a fixed position at high altitudes, cruising in a specific direction is the primary mode of operation, especially for conducting target tracking and signal transmission tasks within a given area. It should be noted that the method of generation and the amount of energy consumption significantly affect the cruise coverage area and endurance of airships, which greatly affects their performance (Zhu et al., 2021).

HAPS platforms with fixed wings have the ability to precisely position and also have greater weight, available power and flight capabilities compared to balloons. On average, they can carry a load weighing several tens of kg and have a power of more than several hundred watts. They have the ability to perform missions for a longer period of time compared to balloons. With limitations in terms of payload weight and power requirements, they can remain in the air for several months. Hybrid approaches that represent a combination of aerostatic and aerodynamic configurations (GSMA, 2021). Tethered UAS HAPS Compared to balloons and classic aircraft, they have a number of advantages, primarily reflected in lower cost, shorter commissioning time, easier maintenance, increased mobility and a whole range of other parameters. It should be noted that a completely new generation of tethered UAS HAPS is being developed, and well-known companies are leading the way, including Elistair (France and the USA), Ziian (China), Drone Evolution (Great Britain) and Logos Technologies (USA) (Mittal et al., 2024).

Latency is a measure of time that refers to delays in communication systems. It is the time interval between the moment a signal or data leaves its source and the moment it reaches its final destination. HAPS (High-Altitude Platform Systems) have lower latency during signal transmission due to their lower altitude compared to satellites. Satellite communications include satellites in geostationary Earth orbit, satellites in medium Earth orbit, and low Earth orbit satellites, which include altitudes of 36,000 km, then 2000–36,000 km, and finally altitudes below 2000 km. The round-trip time (RTT) from the user to these satellites is approximately 240–280 ms, 54–86 ms, and 6–30 ms, respectively. In comparison, the RTT for HAPS is 360 ms and 680 ms to points within 50 km and 100 km radius, respectively (Takabatake et al., 2024).

The advantages of using HAPS include free deployment, low operating costs, the ability to perform maintenance during use, payload, and better performance for certain purposes due to lower altitude deployment, low propagation delay, wide angle, wide range of activated altitudes that can be used for broadband broadcasting, even in the event of a disaster. However, HAPS has disadvantages in terms of vehicle tracking, balloon technology that still requires further development, and stabilization of the antenna on board, which is still a challenging task (Mahardika Putro et al., 2023; Delgado et al., 2024). HAPS has the ability to provide extremely high data rates and wide coverage. The problem is the high probability of interference with various other terrestrial services (fixed, mobile, etc.). Therefore, HAPS transmitters are required to reduce their transmit power to meet the interference-to-noise ratio (INR) requirement to protect receivers of existing services. The problem is that if the transmit power from the HAPS aircraft is excessively reduced (the signal-to-interference-plus-noise ratio SINR of the HAPS downlink), this can lead to a complete loss of communication (Jo et al., 2022). Interference of communications in HAPS platforms is another major parameter that affects and limits system performance together with channel fading. Interference would cause problems such as crosstalk, call drops, or degradation of communication quality during communication, thus reducing user satisfaction with the service (Guan et al., 2019).

HAPS are considered by academic and industrial circles as future key enablers of the heterogeneous network vertical, which involves the integration of terrestrial networks with networks that are not located on the ground. When the mobile communications dimension is carefully considered, HAPS are capable of directly delivering services to terrestrial users

distributed within a radius of about 100 km (Maki et al., 2025). When considering terrestrial base stations (BS), they are certainly lower in altitude than HAPS with a much narrower coverage area, requiring a much larger number of base stations to achieve wide coverage. In other words, HAPS offer lower latency than satellites and wider coverage than terrestrial base stations (Guan et al., 2019). The design problems of HAPS are reflected in the fact that the aerodynamic frame of the aircraft needs to have a very long endurance in conditions where there is low air density in order to achieve a positive lift-to-drag ratio. For this reason, large wing spans are required, for which advanced composite materials are used (satisfactory resistance with low weight). In addition, large aerodynamic surfaces simultaneously provide a large surface area on which solar cells can be placed (e.g. Zephir-S has a wing area of 28 m<sup>2</sup>). However, due to undesirable physical properties such as very dynamic aero elasticity, it causes abnormal oscillations, which affect stability (Bagarić et al., 2025).

The most common solutions for powering airships are photovoltaic (PV) cells and rechargeable batteries. The low efficiency of photovoltaic cells poses a major problem for airship missions at high altitudes. In addition, the problem of developing high-energy-density rechargeable batteries and advanced power management systems to improve endurance has arisen (Xu et al., 2020). HALE spacecraft can replace or supplement the role of satellites for a number of missions, but at a lower cost. In addition, because the atmospheres of Mars and Venus are similar to those at high altitudes on Earth, solar-powered HALE spacecraft can be used to explore Mars and Venus (Gao et al., 2013). HALE aircraft in the HAPS role have the problem of how to meet the power requirements due to the weight of the rechargeable batteries. It should be noted that the weight of the batteries takes up about 50% of the total mass of the solar-powered HALE aircraft, therefore, for renewable energy, regenerative energy technologies such as solar cells, rechargeable batteries and energy management systems are key areas to achieve the desired long-term endurance (Gao et al., 2013). In order to improve telecommunication services, especially 5G Evolution and the upcoming 6G era, it is expected that HAPS will be actively used to transmit radio waves or broadcast radio waves as a base station (Hokazono et al., 2022).

The following Table 1. shows a comparison of the most important characteristics of satellite and HAPS systems:

*Table 1. Comparison table of different systems (GSMA, 2021)*

Coverage	System	Satellite for global coverage	Time per orbit (hours)	Time in site per gateway	Latency RTT (ms)	Mass (kg)	Life time (years)
Global coverage	GEO	3	24	Always	600/700	3500	15
	MEO	10-30	5-12	2-4 hours	<150	700	12
	LEO	100+	1.5	15 minutes	<50	5-1000	<5-7
Regional coverage	HAPS	1 aircraft ~ 12.731 km <sup>2</sup>		Always	<10	<320 (Ballon) <100 (Aircraft)	>5 (Ballon) >8 (Aircraft)

Application areas where HAPS has great potential for application are mobile telephony in the mobile service (MS), high-speed internet in the fixed service (FS), digital TV and news gathering in the broadcast service (BS) and other services such as remote sensing, radio broadcasting, traffic monitoring and weather monitoring (Park et al., 2008). The stratosphere is

a very inhospitable environment. It is characterized by low pressure and low temperatures (down to -65 C), jet stream winds blowing at speeds of 100 km/h, average wind speeds of 40 km/h, and the effects of gravitational waves and solar radiation. Key technological and regulatory drivers in this area include artificial intelligence and machine learning, the emergence of new materials, regulatory advances, advances in battery design and power management, new weather forecasting models, and finally public UAS acceptance (HAPS Alliance, 2023). HAPS have a number of advantages over satellites. HAPS can very well serve as a second type of range source. Since GNSS positioning performance degrades significantly in urban areas, deploying several HAPS as additional range would improve GNSS positioning performance. HAPS can indeed improve HDOP, VDOP and 3D positioning accuracy of legacy GNSS (Zheng et al., 2023).

## **2.2. The Kessler syndrome**

NASA makes a clear distinction between the terms space debris and orbital debris. Space debris includes both natural meteoroids and artificially created orbital debris. Orbital debris refers to any object that has been man-made and placed into orbit around the Earth and no longer serves a useful purpose. This includes defunct spacecraft, abandoned launch stages, mission-related debris, and fragmentation debris (Adamišinová, 2022). Orbital debris represents one of the most serious security threats to the sustainability of orbital systems. The reasons for this are reflected in the laws of orbital physics and as a result of the massive use of Earth's orbit by humanity for positioning various satellites (Doboš & Pražák, 2022). Earth's orbits are an extremely crowded space. As of January 2021, there were 3,372 operational satellites in orbit. When analyzed by orbit, 2,612 were in low Earth orbit (LEO), 136 in medium Earth orbit (MEO), 562 in geostationary orbit (GEO), and 59 in elliptical orbits (Doboš & Pražák, 2022). The company, SpaceX's Starlink, now accounts for nearly half of all satellite traffic. In February 2024, SpaceX announced that it would prematurely deorbit about 100 of its 5,500 satellites after discovering a design flaw that could make them a collision hazard, fueling fears of the Kessler syndrome, a catastrophic wave of satellite collisions (Clarke, 2024). The number of satellites is increasing steadily and by 2029, there could be at least 107,000 active satellites. In addition to functional systems, there is a significant amount of space debris in orbit. As of January 2021, the US Space Surveillance Network has tracked over 28,000 objects in orbit. It is estimated that there are already approximately 900,000 objects larger than 1 cm orbiting the Earth, of which approximately 34,000 are larger than 10 cm (Doboš & Pražák, 2022).

According to NASA experts, those pieces of debris that are at an altitude of 600 kilometers will fall back to Earth in a few years, pieces of debris that are at an altitude of 800 km will fall to Earth over the next few centuries, while those orbiting above 1,000 kilometers will circle the Earth for a thousand years or more (Clarke, 2024). In terms of solving orbital debris, the first step would be to stop generating new ones, while the second step would involve removing large pieces of debris that have the potential to create a cascading effect that Kessler's scenario implies (Kelvey, 2024). The National Academy of Sciences believes that the current state of orbital debris has already reached the so-called tipping point. "i.e., the total mass of debris currently in orbit has reached a threshold where it will continually collide with itself, with a further progressive increase in the amount of orbital debris. This increase will lead to an inevitable increase in spacecraft failures, further increasing the rate of growth of orbital debris (Adilov et al., 2018). A lot needs to go wrong for the Kessler syndrome to manifest, but things get considerably more complicated if nations continue to destroy satellites with missiles on purpose (Kelvey, 2024). The U.S. Air Force intercepts more than 25,000 pieces of space debris

larger than 10 centimeters each day, weighing in at about 9,000 metric tons. This dangerous debris orbits Earth at speeds of approximately 10 kilometers per second, or more than 22,000 miles per hour. Orbital debris collisions cost satellite operators an estimated \$86 million to \$103 million annually, and that number is sure to grow as each operator and each collision generates more debris (Scientific American, 2024).

Today, satellite losses due to collisions are quite rare, but it is worth noting that if the behavior in LEO changes, they will become a common occurrence every year. The long-term effect of the accumulation of debris is particularly alarming (Drmola & Hubik, 2018). The increase in LEO debris poses an extremely high threat to space operations, compromising the ability to launch new and maintain existing spacecraft in medium Earth orbit (MEO) where GNSS satellites primarily operate. Currently, MEO hosts a constellation of 31 active global positioning satellites (GPS), 35 active BeiDou satellites, 24+ Galileo satellites, 24+ GLONASS, 7 Indian Regional Navigation Satellite System and 7 Quasi-Zenith Satellite Systems (KZSS). The loss of satellite communications would cause far-reaching and incalculable consequences for various industries, including transportation, banking, energy, and military operations. (Mariappan & Crassidis, 2023).

Mariappan & Crassidis (2023) propose two categories of potential solutions emerge: short-term and long-term. In the short term, the focus is on deorbiting and burning debris that poses an immediate threat. The long-term approach focuses on recycling. Researchers have proposed innovative methods for recycling debris into powders that can be used as fuel, artificial soil, and other resources for space missions. The problem of orbital debris is reflected in the following:

1. Space agencies and private companies are sending more objects into space than ever before, creating a protected environment.
2. The aforementioned objects are a generator of debris, which can return to Earth or remain in orbit.
3. When the aforementioned debris falls to Earth, it can affect safety issues and cause contamination.
4. When the aforementioned debris remains in orbit, the aforementioned space debris increases further.
5. Since the debris moves at high speeds, debris impacts on existing objects (satellites) represent a source of new artificial space debris.
6. At the aforementioned high speeds developed by the aforementioned pieces and with current resources, artificial space debris is very harmful and/or potentially deadly in the event of an impact.

If nothing is done to change behavior in accordance with points 1-6, the consequences will be very negative for space exploration (Pla, 2023).

NASA believes that even small objects can cause some degree of damage:

- Most satellites can survive impacts from objects as small as ~1 mm, but individual components of the satellite system can be disabled or completely destroyed;
- Most satellites can sustain damage from objects as small as 1 cm;
- For every object that NASA is able to track (via radar or optical telescopes), there are incomparably more small objects that it is unable to track, which can cause significant damage to a spacecraft (Matney, 2023).

### **3. DATA AND METHODOLOGY**

For the purposes of the research, relevant literature was consulted, including high-quality academic articles in the field of HAPS implementation as well as material dealing with

the Kessler syndrome. Based on this literature, a SWOT analysis was conducted to identify key factors affecting the subject of the analysis, and then a TOWS matrix was formed to develop specific strategies based on the findings obtained from the SWOT analysis. Furthermore, by applying the hybrid SWOT-AHP method, a detailed prioritization of strategies was performed, allowing for an objective evaluation and ranking of HAPS implementation strategies in light of the Kessler syndrome according to their importance and potential impact on decision-making.

#### 4. RESULTS AND DISCUSSION

*Table 2. TOWS matrix of HAPS potential application in light of the Kessler syndrome*

	S	W
	<p>S1 HAPS missions are carried out below orbital zones that would be affected by the Kessler syndrome;</p> <p>S2 HAPS are relatively cheaper to position and maintain compared to satellites, with the ability to perform a variety of missions;</p> <p>S3 Continuous signal coverage of a narrow area where the mission is to be carried out;</p> <p>S4 Low signal latency;</p> <p>S5 Reconfigurable to handle different tasks.</p>	<p>W1 Limited coverage area compared to satellites;</p> <p>W2 Dependence on weather conditions in the stratosphere (wind, turbulence, solar radiation, cold...);</p> <p>W3 Vulnerable structure to various types of stresses;</p> <p>W4 Shorter service life compared to satellites;</p> <p>W5 Need for further improvement of energy sources.</p>
O		
<p>O1 Further process of improving battery technology;</p> <p>O2 Development of alternative forms of energy supply (hydrogen);</p> <p>O3 Possibility of taking over the role of satellites whose functioning is endangered by the Kessler syndrome for the realization of certain missions;</p> <p>O4 Further 5G and 6G integration enabling high-speed and low-latency connections;</p> <p>O5 Development of innovative materials used for the construction of HAPS.</p>	<p>SO1 Integration of production capacities of different HAPS manufacturers in order to develop more efficient systems</p>	<p>WO1 Development of hybrid systems that rely less on satellites and creation of regional networks that form a single global network</p>
T		
<p>T1 Legislation obstacles for HAPS application</p> <p>T2 Further development of orbital debris removal technology;</p> <p>T3 The risk of the Kessler syndrome is acceptable compared to the effort invested in further development of HAPS technology;</p> <p>T4 Challenges in terms of frequency spectrum allocation may pose obstacles to the deployment of HAPS;</p> <p>T5 High costs of developing a system with a satisfactory level of technology.</p>	<p>ST1 Development of HAPS regional Global Positioning Systems</p>	<p>WT1 Legislation enabling the active implementation of HAPS platforms</p>

Table 3. Local and global importance of SWOT factors

Factor	Importance of SWOT factors	SWOT subfactors	Local importance of SWOT subfactors	Global importance of SWOT subfactors
	0.195	S1 HAPS missions are carried out below orbital zones that would be affected by the Kessler syndrome S2 HAPS are relatively cheaper to position and maintain compared to satellites, with the ability to perform a variety of missions; S3 Continuous signal coverage of a narrow area where the mission is to be carried out; S4 Low signal latency; S5 Reconfigurable to handle different tasks.	<b>0.333</b> 0.079 0.174 0.275 0.138	0.065 0.015 0.034 0.054 0.027
	0.138	W1 Limited coverage area compared to satellites; W2 Dependence on weather conditions in the stratosphere (wind, turbulence, solar radiation, cold...); W3 Vulnerable structure to various types of stresses; W4 Shorter service life compared to satellites; W5 Need for further improvement of energy sources.	<b>0.412</b> 0.090 0.209 0.177 0.112	0.057 0.012 0.029 0.024 0.015
	<b>0.391</b>	O1 Further process of improving battery technology; O2 Development of alternative forms of energy supply (hydrogen); O3 Possibility of taking over the role of satellites whose functioning is endangered by the Kessler syndrome for the realization of certain missions; O4 Further 5G and 6G integration enabling high-speed and low-latency connections; O5 Development of innovative materials used for the construction of HAPS.	0.117 0.251 <b>0.364</b> 0.105 0.162	0.046 0.098 0.142 0.041 0.063
	0.276	T1 Legislation obstacles for HAPS application T2 Further development of orbital debris removal technology; T3 The risk of the Kessler syndrome is acceptable compared to the effort invested in further development of HAPS technology; T4 Challenges in terms of frequency spectrum allocation may pose obstacles to the deployment of HAPS; T5 High costs of developing a system with a satisfactory level of technology.	<b>0.369</b> 0.156 0.322 0.064 0.090	0.102 0.043 0.089 0.018 0.025

Based on the size of the obtained normalized weights, the order of strategy application can be defined as follows:

$$SO1 (0.310) \rightarrow WT1 (0.282) \rightarrow WO1 (0.255) \rightarrow ST1 (0.153). \quad (1)$$

The first strategy that would be implemented in order to fully exploit the HAPS potential in light of the Kessler syndrome is SO1 Integration of production capacities of different HAPS manufacturers in order to develop more efficient systems (0.310). The implementation of this strategy would lead to successful projects in the field of HAPS, which would influence the public and decision-makers to change the legal regulations in order to actively implement HAPS platforms, either independently or in cooperation with satellites. This would be followed by the following strategy WT1 Legislation enabling the active implementation of HAPS platforms (0.282), which would create conditions to support their deployment and integration into existing systems. Third strategy WO1 The development of hybrid systems that rely less on



satellites and the creation of regional networks that form a single global network (0.255) would enable greater resilience and redundancy, as well as improved connectivity. The last successive strategy ST1 Development of HAPS regional Global Positioning Systems (0.153) will enable more precise positioning, more reliable navigation, and improved communication in areas where satellite signals are not available due to the Kessler syndrome. Successive implementation of the four aforementioned strategies regarding HAPS potential application in light of the Kessler syndrome will reduce the damage associated with the phenomenon itself and enable alternative infrastructure for communication, navigation and observation, without relying on disabled satellites.

## 5. CONCLUSION

This study suggests that the implementation of appropriate strategies could significantly mitigate or even completely prevent the adverse effects of Kessler syndrome in certain contexts. The primary contribution of this research lies in highlighting the potential of high-altitude platform systems (HAPS) and advocating for increased investment in the development of technologies that would improve their effectiveness in addressing the challenges posed by Kessler syndrome. The shortcoming of this study is that there is a large gap between human technological capabilities and the desire to take urgent steps in this regard. It should be noted that the question is not whether Kessler syndrome will occur, but when it will occur and whether humanity will be prepared for such a scenario, especially in light of the launch of mega constellations of satellites. The potential consequences for human life and the future of space exploration require significant attention and justified concern.

## REFERENCES

- Adamišínová, A. (2022). European Space Traffic Management System: Micrometeoroids and space debris as a possible threat for future missions. MENDELU Working Papers in Business and Economics 79/2022. Mendel University in Brno
- Bagarić, T., Rezo, Z., & Steiner, S. (2025). High-Altitude Pseudo-Satellite platforms as support to air traffic management. *Transportation Research Procedia*, 83(1), 593–600. <https://doi.org/10.1016/j.trpro.2025.03.030>
- Clarke, K. (2024). Up in the sky. *U.S. Catholic*, 89(5), 42.
- Delgado, A., Domínguez, D., Gonzalo, J., & Escapa, A. (2024). Station-keeping HAPS mission through optimal sprint and drift trajectories. *Aerospace Science and Technology*, 152. <https://doi.org/10.1016/j.ast.2024.109365>
- Doboš, B., & Pražák, J. (2022). Master spoiler: a strategic value of Kessler Syndrome. *Defence Studies*, 22(1), 123–137. <https://doi.org/10.1080/14702436.2021.1997095>
- Drmola, J., & Hubik, T. (2018). Kessler Syndrome: System Dynamics Model. *Space Policy*, 44–45, 29–39. <https://doi.org/10.1016/j.spacepol.2018.03.003>
- Gao, Y., Qiao, Z., Pei, X., Wu, G., & Bai, Y. (2023). Design of Energy-Management Strategy for Solar-Powered UAV. *Sustainability* (2071-1050), 15(20), 14972. <https://doi.org/10.3390/su152014972>
- GSMA (2021). High Altitude Platform Systems: Towers in the Skies. <https://www.gsma.com/solutions-and-impact/technologies/networks/wp-content/uploads/2021/06/GSMA-HAPS-Towers-in-the-skies-Whitepaper-2021-1.pdf>
- Guan, M., Wu, Z., Cui, Y., Cao, X., Wang, L., Ye, J., & Peng, B. (2019). Multi-beam coverage and beamforming technology for high altitude platform station communication system.

- Eurasip Journal on Wireless Communications and Networking, 2019(1).  
<https://doi.org/10.1186/s13638-019-1622-y>
- HAPS Alliance. (2023). Unlocking the potential of the stratosphere. 32.  
[https://b5g.jp/w/wp-content/uploads/2024/02/international\\_doc18\\_2.pdf](https://b5g.jp/w/wp-content/uploads/2024/02/international_doc18_2.pdf)
- HAPS Alliance. (2024). Architecture Series Cell Towers in the Sky. [https://hapsalliance.org/wp-content/uploads/formidable/12/2024\\_HAPS\\_Reference\\_Architecture\\_Series\\_Cell\\_Towers\\_In\\_The\\_Sky\\_White\\_Paper.pdf](https://hapsalliance.org/wp-content/uploads/formidable/12/2024_HAPS_Reference_Architecture_Series_Cell_Towers_In_The_Sky_White_Paper.pdf)
- Hokazono, Y., Kishiyama, Y., & Asai, T. (2022). Studies toward Practical Application of HAPS in the Space RAN. NTT Technical Review, 20(12), 28–35.  
<https://doi.org/10.53829/ntr202212fa3>
- ITU (2016). Radio Regulations. <http://handle.itu.int/11.1002/pub/80da2b36-en>, p.13.
- Jo, S., Yang, W., Choi, H. K., Noh, E., Jo, H.-S., & Park, J. (2022). Deep Q-Learning-Based Transmission Power Control of a High Altitude Platform Station with Spectrum Sharing. Sensors, 22(4), 1630. <https://doi.org/10.3390/s22041630>
- Kelvey, J. (2024). Understanding the misunderstood Kessler Syndrome. <https://aerospacemercia.aiaa.org/features/understanding-the-misunderstood-kessler-syndrome/>
- Kessler, D. J., & Cour-Palais, B. G. (1978). Collision Frequency of Artificial Satellites: The Creation of a Debris Belt. J Geophys Res, 83(A6), 2637–2646.  
<https://doi.org/10.1029/JA083iA06p02637>
- Mahardika Putro, Y., Aditya Nugraha, R., Rachmat Nugraha, T., Christiawan, R., Bodhihanna, A., Pratama Ong, J., & Testarosa, M. R. (2023). Legal Issues Pertaining to High Altitude Platform Station Implementation in Indonesia as an Archipelagic State. Udayana Journal of Law and Culture, 7(2), 144–164.  
<https://doi.org/10.24843/UJLC.2023.v07.i02.p06>
- Maki, K., Tashiro, K., Ishikawa, T., & Hoshino, K. (2025). Downtilt Optimization of Array Antennas Based on Envelope Radiation Patterns for HAPS Service Links With Massive MIMO. IEEE Access, 13, 34307–34320.  
<https://doi.org/10.1109/ACCESS.2025.3543862>
- Mariappan, A., & Crassidis, J. L. (2023). Kessler's syndrome: a challenge to humanity. Frontiers in Space Technologies, 1–12. <https://doi.org/10.3389/frspt.2023.1309940>
- Matney, M. (2023). Misconceptions and Reality of Orbital Debris Risk. National Aeronautics and Space Administration. 50.  
[https://ntrs.nasa.gov/api/citations/20230014345/downloads/ASEC%202023%20Talk\\_Matney\\_final.pdf](https://ntrs.nasa.gov/api/citations/20230014345/downloads/ASEC%202023%20Talk_Matney_final.pdf)
- Mittal, N., Ivanova, N., Jain, V., & Vishnevsky, V. (2024). Reliability and availability analysis of high-altitude platform stations through semi-Markov modeling. RELIABILITY ENGINEERING & SYSTEM SAFETY, 252, 110419.  
<https://doi.org/10.1016/j.ress.2024.110419>
- Park, J. M., Ku, B. J., & Oh, D. S. (2008). "Technical and Regulatory Studies on HAPS," 2008 IEEE Globecom Workshops, New Orleans, LA, USA, pp. 1-5, doi: 10.1109/GLOCOMW.2008.ECP.105.
- Pla, A. H. (2023). Artificial space debris and Kessler syndrome. A limitation for humankind. Visions for Sustainability, 2023(20), 475–496. <https://doi.org/10.13135/2384-8677/7874>
- Scientific American. (2024). Space Trash Threatens the Global Economy 331(1), 82–83.  
<https://doi.org/10.1038/scientificamerican072024-4qcttshapigwtnom9uabhw>
- Takabatake, W., Shibata, Y., Hoshino, K., & Ohtsuki, T. (2024). Time-Efficient Neural-Network-Based Dynamic Area Optimization Algorithm for High-Altitude Platform

- Station Mobile Communications. Future Internet, 16(9), 332.  
<https://doi.org/10.3390/fi16090332>
- van Wynsberghe, E., & Turak, A. (2016). Station-keeping of a high-altitude balloon with electric propulsion and wireless power transmission: A concept study. *Acta Astronautica*, 128, 616–627. <https://doi.org/10.1016/j.actaastro.2016.08.017>
- Xu, Y., Zhu, W., Li, J., & Zhang, L. (2020). Improvement of endurance performance for high-altitude solar-powered airships: A review. *Acta Astronautica*, 167, 245–259. <https://doi.org/10.1016/j.actaastro.2019.11.021>
- Zheng, H., Atia, M., & Yanikomeroglu, H. (2023). Analysis of a HAPS-Aided GNSS in Urban Areas using a RAIM Algorithm.
- Zhu, W., Zhang, B., Zhang, L., Xu, Y., & Yang, K. (2021). Spatial path analysis for high-altitude solar-powered airship with maximum net energy. *Aerospace Science and Technology*, 117. <https://doi.org/10.1016/j.ast.2021.106922>



## INTEGRATING ENVIRONMENTAL MANAGEMENT INTO SUPPLY CHAIN STRATEGIES

**Stefan Ugrinov\*, Dragan Čočkalović, Mihalj Bakator, Mila Kavalić, Verica Gluvakov**

*University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Serbia*

**Abstract:** The paper examines how environmental management can be integrated into supply chain strategies while highlighting the necessity for sustainable practices in contemporary operation systems. The paper analysis focuses on essential aspects including environmental risk identification along with eco-efficiency measures and resource optimization strategies as well as regulatory compliance requirements together with stakeholder engagement methods and technological innovation processes. The paper introduces a theoretical framework organizing supply chain dimensions into four core elements with additional sub-element support to systematically improve performance and manage risks. The analysis shows the relationship between proactive risk assessment and advanced technology adoption which proves real-time monitoring and data analytics support adaptive management practices. This research examines how regulatory frameworks and stakeholder collaboration work together to increase transparency and accountability. Findings establish a base for scholarly research and real-world implementation by presenting organizational strategies that integrate economic goals with environmental preservation.

**Keywords:** Environmental Management, Supply Chain Strategies, Risk Assessment, Eco-Efficiency, Technological Innovation

### 1. INTRODUCTION

Current business research identifies environmental management integration into supply chain strategies as a vital research subject. The introduction explores multiple essential areas of this subject by presenting a framework which shows how environmental risks together with resource efficiency and technological innovations interact alongside regulatory frameworks inside supply chain processes. The examination of environmental risks within supply chains establishes the groundwork for in-depth conversations about organizational strategies to detect

---

\* Corresponding author: [stefan.ugrinov@tfzr.rs](mailto:stefan.ugrinov@tfzr.rs)

Stefan Ugrinov, ORCID: 0009-0000-7206-655X  
Dragan Čočkalović, ORCID: 0000-0003-2085-5420  
Mihalj Bakator, ORCID: 0000-0001-8540-2460  
Mila Kavalić, ORCID: 0000-0001-7053-2334  
Verica Gluvakov, ORCID: 0000-0003-1083-0203

and reduce possible negative impacts. The evaluation of environmental vulnerabilities across supply chain nodes including production, transportation, and distribution uses risk assessment techniques to identify potential degradation factors. Systematic risk evaluations and monitoring mechanisms are essential components that guide strategic decision-making and long-term sustainability planning.

Resource usage optimization serves as an essential component when environmental management principles are incorporated into supply chain strategies. Resource utilization efficiency requires implementing practices that reduce waste and improve energy and raw materials usage across the supply chain. Scientific studies investigate eco-efficiency measures that enable businesses to save costs alongside delivering environmental advantages (Mandych et al., 2023). The pursuit of resource optimization enables businesses to meet operational requirements while fulfilling sustainability goals by designing production processes that minimize energy usage and emissions and enhance recycling and material reuse (Harsanto et al., 2023). The commitment to eco-efficiency enables organizations to adopt sustainable growth models that integrate economic performance with environmental conservation.

Business organizations function under intricate regulatory systems both at the local and international levels that regulate environmental protection measures and resource management practices (Wang & Wright, 2021). Organizations must understand their responses to regulatory demands in order to build strategies that achieve compliance and use these regulations to gain competitive advantages. The development of thorough policies and practices that embody a collective dedication to environmental stewardship emerges from collaborating with a variety of stakeholders such as suppliers and customers as well as government bodies and community groups (Adams et al., 2023). Stakeholder relationship dynamics promote collaboration which aligns shared goals through transparent processes and accountable actions while jointly developing solutions that improve business performance alongside environmental results (Chopra et al., 2024).

The incorporation of innovative technologies in environmental management further enhances the ability of organizations to implement sustainable supply chain strategies. Technological advancements have provided new tools for real-time monitoring, data analysis, and decision support, which are essential for managing the environmental aspects of supply chain operations (Farajpour et al., 2022). The integration of digital systems, sensors, and automated reporting mechanisms facilitates the tracking of environmental performance indicators and supports proactive measures to address potential issues (Rodchenko & Prus, 2023). Emphasis on technological innovation within supply chains has led to the development of advanced analytical models that predict environmental impacts and optimize operational processes accordingly. Such innovations not only drive operational efficiency but also support broader strategic objectives by providing the data necessary to refine environmental management practices continuously.

This paper investigates how environmental management interacts with supply chain strategies by examining their interconnectedness in risk assessment, resource efficiency, regulatory compliance, and technological innovation. The analysis insists on the necessity for a comprehensive viewpoint to address these matters because environmental challenges present complex conditions which demand solutions that cover multiple operational aspects. By examining environmental risks in supply chains organizations gain understanding into potential vulnerabilities while emphasizing eco-efficiency highlights the importance of sustainable resource management practices. Organizational behavior emerges from the external pressures exerted through regulatory frameworks and stakeholder engagement alongside collaborative processes (Miah et al., 2024). The adoption of innovative technologies creates effective

pathways to improve environmental performance by utilizing data-driven decision-making processes.

The investigation of these elements forms a part of wider scholarly discussions which acknowledge the immediate need to tackle environmental challenges through global supply chain systems. Investigations in this field aim to identify effective strategies and develop models that synchronize economic needs with environmental considerations. Businesses can maintain a competitive edge by strategically allocating resources through risk management practices which also help lessen environmental impacts and enable resource optimization. Effective environmental management depends on operational practices shaped by regulatory compliance and stakeholder engagement which require the participation of multiple actors. Technological innovations demonstrate their ability to transform environmental management practices which further emphasizes the necessity for supply chain operations to maintain ongoing adaptability and learning. The study presents a complete analysis of the inclusion of environmental management within supply chain strategies and establishes a foundation for future empirical research and theoretical advancements to better understand sustainable business practices.

## **2. ASSESSING ENVIRONMENTAL RISKS AND IMPROVING ECO-EFFICIENCY IN SUPPLY CHAIN**

Modern logistics management relies heavily on environmental risk assessment in supply chains to evaluate potential environmental hazards throughout different operational stages. The method requires risk detection in production operations and transportation procedures along with storage facilities and waste handling systems (Ahi & Searcy, 2013). Businesses today understand that environmental risks permeate through entire supply chain networks which include suppliers, producers, and distributors rather than being limited to individual operational mistakes. The complex network of supply chain operations demands a thorough evaluation which assesses upstream and downstream effects to identify environmental risks throughout each stage (Sarkis, 2019). Comprehensive risk assessments help pinpoint vulnerabilities which may result in inefficient resource use and regulatory violations as well as damage to reputation. The analysis of environmental risks requires sophisticated tools and frameworks which generate both quantitative and qualitative insights about potential impacts' likelihood and severity (Autsadee et al., 2023).

Successful incorporation of environmental risk assessment into supply chain management requires companies to actively pursue ongoing monitoring and data collection activities. Advanced sensors together with remote monitoring systems and predictive analytics are working together to collect up-to-date data about environmental performance indicators. The technological integration enables dynamic risk management capabilities which can adjust to new threats as they occur. Organizations use these tools to trace their supply chain paths, pinpoint vulnerable points, and put in place preventative actions that reduce environmental harm (Aithal et al., 2021). Comprehensive risk assessment methods use scenario analysis and stress testing to understand potential disruptions in supply chains or environmental events throughout the network. The depth of analysis enables strategic planning to remain both informed and responsive to supply chain environmental management complexities.

Supply chain strategies that incorporate environmental management require equal focus on eco-efficiency advancement and resource optimization efforts (Lüdeke-Freund et al., 2019). Eco-efficiency describes an organization's capability to provide products and services that fulfill customer requirements while reducing resource use and environmental damage. The concept rests on the principle that organizations can synchronize economic and environmental

performance by employing intelligent design and enhancing processes (Noor Faezah et al., 2024). Supply chain management organizations achieve eco-efficiency by redesigning production processes and optimizing logistics while implementing sustainable practices that decrease waste and energy use. The integration of new process technologies alongside advanced material sciences and energy management approaches enables supply chains to achieve significant reductions in their environmental impact while maintaining their operational efficiency and profit generation.

Supply chain resource optimization reaches beyond energy and material conservation as it includes strategic resource allocation to boost system performance. Successful resource optimization depends on a comprehensive approach that combines production scheduling with inventory control and transportation logistics while also focusing on waste reduction. Modern organizations are shifting towards lean principles and circular economy models which focus on material reuse and recycling while reducing waste and improving product lifecycle management (França et al., 2017). Supply chain sustainability benefits from these practices because they optimize resource inputs and manage outputs to lessen environmental impact. The systemic resource optimization strategy enables organizations to reduce operational expenses and reach environmental goals simultaneously (Pieroni et al., 2019).

Detailed environmental risk assessments paired with strong eco-efficiency initiatives create a sustainable supply chain management framework. The two dimensions highlight proactive management strategies which solve current operational challenges while supporting long-term sustainability objectives. Through analytical tools and real-time monitoring systems organizations gain enhanced abilities to detect risks early and respond quickly to reduce potential environmental harm (Wong et al., 2024). The quest for eco-efficiency generates innovative solutions that deliver substantial improvement in resource use as well as waste management while boosting operational performance (Samir Gokarn & Thyagaraj S. Kuthambalayan, 2017). The combination of these practices demonstrates an organizational dedication to embedding environmental management as a core element of supply chain functions.

### **3. NAVIGATING REGULATIONS AND TECHNOLOGICAL INNOVATIONS IN ENVIRONMENTAL MANAGEMENT**

The successful integration of environmental management into supply chain strategies depends on environmental regulations and stakeholder engagement. Organizations must implement stricter compliance measures across their supply chains due to newly intensified environmental regulations at local, national, and international levels (Menke et al., 2021). Businesses must adjust their operational practices to stay compliant with dynamic regulatory standards related to emissions control, waste disposal procedures, water utilization practices, and various environmental effects (Holly et al., 2023). The current legal framework requires companies to establish systematic procedures to verify compliance at each stage of their supply chain operations. The process includes environmental audits together with certifications and reporting methods which function to maintain accountability and transparency within business operations. Organizations form specialized groups or partner with expert consultants to monitor compliance with environmental standards and regulations and quickly address any deviations (Zimon et al., 2020).

Engaging stakeholders emerges as a crucial factor in developing successful environmental management strategies. Environmental strategies within companies are shaped by the influence of diverse stakeholders such as suppliers, customers, regulatory bodies, local communities and investors. Collaborative efforts towards environmental goals require

stakeholder engagement to understand their expectations and concerns and to build cooperative relationships. Organizations can incorporate stakeholder feedback into their environmental management practices through active communication methods alongside consultation processes and participatory decision-making approaches. The inclusive approach enables organizations to discover environmental risks and improvement opportunities throughout their supply chain. The measures taken gain social acceptance and satisfy multiple interest groups needs which boosts organizational trustworthiness.

Environmental management requires building strong governance systems when regulatory compliance and stakeholder engagement become integrated. These structures enable synchronized collaboration between various departments and supply chain partners to integrate environmental considerations into strategic planning and operational decisions (Aluchna & Rok, 2019). The collaborative governance framework consists of joint committees along with inter-organizational partnerships and multi-stakeholder platforms that unite to solve environmental problems. These systems create common guidelines and best practices which synchronize stakeholder interests across the board. By building trust and transparency through stakeholder engagement, organizations can achieve regulatory compliance and promote advancements in their environmental performance.

Emerging technological solutions serve as critical components that enable supply chain strategies to advance environmental management. The development of new technologies transforms environmental performance monitoring and optimization processes (Kusi-Sarpong et al., 2022). Digital tools that offer advanced capabilities along with sensor networks and data analytics platforms are being used to monitor environmental indicators as they happen. The implementation of these technologies enables businesses to take proactive environmental management steps through real-time insights into resource usage and emission levels as well as waste generation data. Internet of Things (IoT) devices enable uninterrupted surveillance of environmental conditions throughout different supply chain stages (Jagtap et al., 2021). The tools detect departures from environmental standards and support the quick execution of corrective measures to minimize environmental hazards.

Technological innovations further support the automation of reporting and compliance processes, reducing the administrative burden associated with environmental management. Digital platforms enable seamless data collection, aggregation, and analysis, leading to more efficient reporting processes that meet regulatory standards. Machine learning algorithms and artificial intelligence (AI) systems are increasingly applied to forecast environmental impacts based on historical data and current trends (Akbari & Do, 2021). This predictive capability provides organizations with the opportunity to simulate different operational scenarios and assess the environmental consequences of various strategic decisions. The ability to model potential outcomes aids in designing supply chain processes that are both economically viable and environmentally sustainable.

Environmental management technology integration leads to improved communication and collaborative efforts between supply chain partners. Through digital platforms organizations share environmental performance data and best practices which establishes a collaborative environment that reaches across organizational limits (Sabeti et al., 2019). Supply chain partners who achieve better visibility of environmental performance can align their activities more efficiently so that advancements in one supply chain area receive support from corresponding changes in other areas. Blockchain technology is becoming a new trend in environmental reporting as it provides unchangeable records of performance and compliance that establish stakeholder trust. Openness in data sharing enhances environmental management systems while making supply chain operations both more durable and accountable (Kouhizadeh et al., 2021).



Innovative technology investments drive significant improvements in operational performance while delivering positive environmental results. The use of digital solutions in environmental management helps organizations fulfill their regulatory obligations while simultaneously ensuring effective stakeholder engagement. These technologies drive continuous improvement through data analysis while creating an innovative mindset that impacts the entire supply chain management landscape. Companies can measure their performance through enhanced monitoring and reporting capabilities which enable them to compare against industry benchmarks and pinpoint additional areas for improvement. The integration of technology serves as a critical force behind sustainable practices by transforming environmental management into an adaptive process that responds to evolving operational and environmental factors.

#### **4. THEORETICAL MODEL**

Environmental Risk Identification is affected by sourcing hazard assessment since it identifies specific raw material and supplier-related threats which could result in environmental damage. By understanding potential risks organizations can better manage risk mitigation efforts which in turn guides their decisions regarding Eco-Efficiency and Resource Optimization because hazard recognition leads to more cautious choices in materials and production methods. The process of mapping supply chain vulnerabilities requires pinpointing weak links which elevate environmental incident risks and leads to targeted strategy development through Regulatory Compliance and Stakeholder Engagement. Technological Innovation and Integration requires adaptive measures to manage external impact risks like climate change or extreme weather events through data-driven insights that enable prediction and response to these developing threats. The process of examining waste and pollution reveals inefficiencies which drives process improvements and compliance activities while examining historical environmental incidents provides lessons for effective stakeholder consultations and technology implementation to prevent future errors.

Reduction of process waste forms the core of Eco-Efficiency and Resource Optimization because it removes inefficiencies while reducing environmental impact. The sub-element connects with Environmental Risk Identification because inefficient waste management practices escalate pollution risks which require preventive action. Energy usage optimization enhances operational performance by meeting regulatory emissions requirements and supporting technological advances through real-time monitoring systems. Sustainable sourcing merges with Sourcing Hazard Assessment to select materials that pose minimal environmental risks. Lean inventory management minimizes surplus stock to prevent waste production while improving adherence to compliance requirements and aiding predictive analytics. Circular economy principles promote stakeholder partnerships to reuse materials and recycle resources while creating innovative solutions which improve advanced technology platforms that monitor resource flows.

Organizational behavior in environmental practices is shaped through compliance requirements which set standards for allowable practices and guide Environmental Risk Identification decision-making. The requirement drives organizations to adopt auditing systems that confirm compliance with standards while pushing for technological investments to make data reporting more efficient. The consultation process with stakeholders addresses supplier and community concerns and uncovers new opportunities for waste reduction and resource optimization. The practice of transparent performance communication builds trust which leads organizations to adopt digital platforms within their Technological Innovation and Integration processes that enable real-time tracking and sharing of environmental metrics. Through

collaborative governance structures stakeholders including regulatory bodies, suppliers and customers work together in forums that lead to joint solution development which assists in accurate risk identification and promotes ongoing eco-efficiency enhancements.

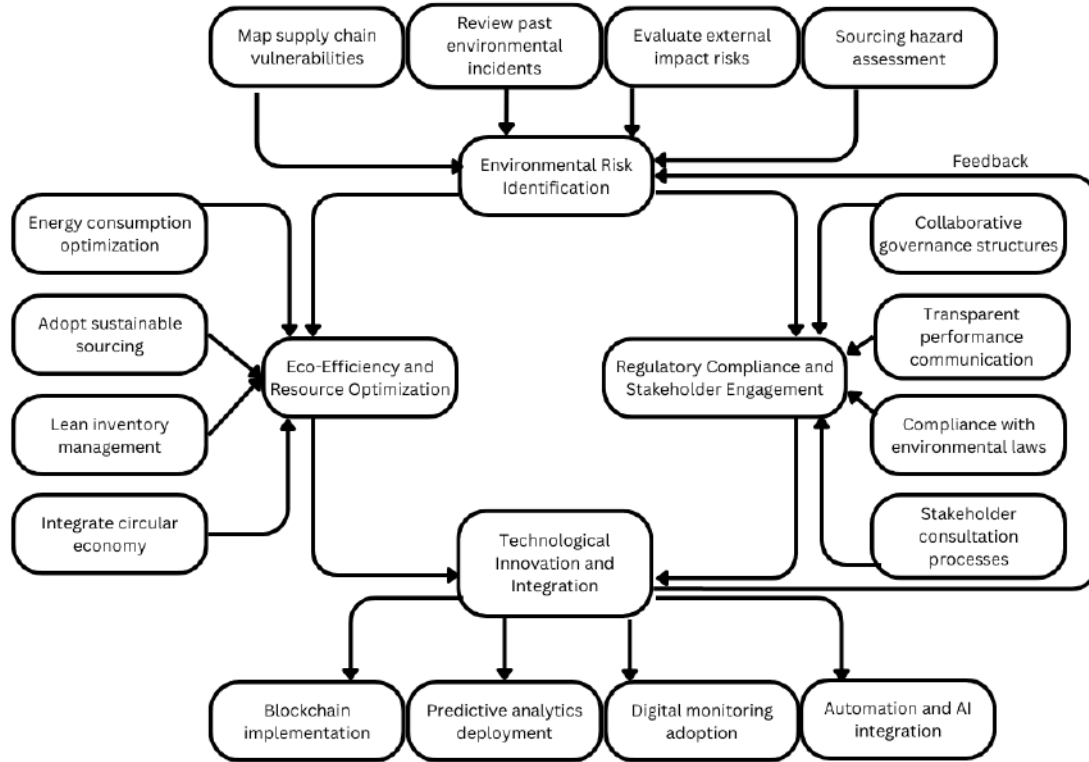


Figure 1. Theoretical model for integrating environmental management for supply chain strategies

The use of digital monitoring systems enables real-time environmental tracking which produces data that advances Environmental Risk Identification by revealing fresh risks and those that were formerly unrecognized. The integration of IoT devices enables detailed data collection on resource use and waste emissions which supports optimization processes according to Eco-Efficiency and Resource Optimization principles. The use of predictive analytics utilizes monitoring system data to predict potential risks and develop regulatory compliance strategies which allows organizations to make proactive operational adjustments. Environmental performance records gain security through blockchain implementation which builds stakeholder trust while enhancing performance communication transparency and governance collaboration. The integration of automation and AI connects different stages of the model by using data-driven improvements to optimize resources and reduce the need for manual supervision while improving compliance reporting and risk assessments.

## 5. CONCLUSION

Supply chain strategies that include environmental management establish a detailed framework to manage intricate environmental problems. Sustainable supply chain operations depend on a combination of thorough risk identification and practices that enhance eco-efficiency and optimize resource use. Through systematic supply chain mapping and precise

sourcing hazard assessments organizations can foresee environmental risks and execute specific mitigation strategies. Advanced monitoring systems along with data analytics drive a dynamic process that consistently improves risk management methods and boosts operational efficiency.

Research indicates that organizational behavior depends on regulatory compliance and stakeholder engagement while these elements establish clear governance mechanisms. Strengthened auditing methods and participatory consulting practices lead to the creation of policies that satisfy legal standards and meet the expectations of the community. Real-time adjustments and data-driven decision-making processes benefit significantly from technological advancements like digital monitoring systems, IoT integration, and predictive analytics. These integrated elements create a flexible supply chain system that adapts to environmental changes and promotes sustainability while establishing groundwork for future empirical studies.

## REFERENCES

- Adams, D., Donovan, J., & Topple, C. (2023). Sustainability in large food and beverage companies and their supply chains: An investigation into key drivers and barriers affecting sustainability strategies. *Business Strategy and the Environment*, 32(4), 1451–1463. <https://doi.org/10.1002/bse.3198>
- Ahi, P., & Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production*, 52, 329–341. <https://doi.org/10.1016/j.jclepro.2013.02.018>
- Aithal, A., Singh, M. K., Ray, P., & Duraipandian, R. (2021). An Integrated Approach to understand Supply Chain Optimization through the Lens of Technology. *Shanlax International Journal of Management*, 8(S1-Feb), 167–178. <https://doi.org/10.34293/management.v8iS1-Feb.3772>
- Akbari, M., & Do, T. N. A. (2021). A systematic review of machine learning in logistics and supply chain management: Current trends and future directions. *Benchmarking: An International Journal*, 28(10), 2977–3005. <https://doi.org/10.1108/BIJ-10-2020-0514>
- Aluchna, M., & Rok, B. (2019). Closing the Loop: Circular Economy Through Sustainable Innovation Lens. In N. Capaldi, S. O. Idowu, R. Schmidpeter, & M. Brueckner (Eds.), *Responsible Business in Uncertain Times and for a Sustainable Future* (pp. 19–36). Springer International Publishing. [https://doi.org/10.1007/978-3-030-11217-2\\_2](https://doi.org/10.1007/978-3-030-11217-2_2)
- Autsadee, Y., Jeevan, J., Mohd Salleh, N. H. B., & Othman, M. R. B. (2023). Digital tools and challenges in human resource development and its potential within the maritime sector through bibliometric analysis. *Journal of International Maritime Safety, Environmental Affairs, and Shipping*, 7(4), 2286409.
- Chopra, S. S., Senadheera, S. S., Dissanayake, P. D., Withana, P. A., Chib, R., Rhee, J. H., & Ok, Y. S. (2024). Navigating the Challenges of Environmental, Social, and Governance (ESG) Reporting: The Path to Broader Sustainable Development. *Sustainability*, 16(2), 606. <https://doi.org/10.3390/su16020606>
- Farajpour, F., Hassanzadeh, A., Elahi, S., & Ghazanfari, M. (2022). Digital supply chain blueprint via a systematic literature review. *Technological Forecasting and Social Change*, 184, 121976. <https://doi.org/10.1016/j.techfore.2022.121976>

- França, C. L., Broman, G., Robèrt, K.-H., Basile, G., & Trygg, L. (2017). An approach to business model innovation and design for strategic sustainable development. *Journal of Cleaner Production*, 140, 155–166. <https://doi.org/10.1016/j.jclepro.2016.06.124>
- Harsanto, B., Primiana, I., Sarasi, V., & Satyakti, Y. (2023). Sustainability Innovation in the Textile Industry: A Systematic Review. *Sustainability*, 15(2), 1549. <https://doi.org/10.3390/su15021549>
- Holly, F., Kolar, G., Berger, M., Fink, S., Ogonowski, P., & Schlund, S. (2023). Challenges on the way to a circular economy from the perspective of the Austrian manufacturing industry. *Frontiers in Sustainability*, 4, 1243374. <https://doi.org/10.3389/frsus.2023.1243374>
- Jagtap, S., Duong, L., Trollman, H., Bader, F., Garcia-Garcia, G., Skouteris, G., Li, J., Pathare, P., Martindale, W., Swainson, M., & Rahimifard, S. (2021). IoT technologies in the food supply chain. In *Food Technology Disruptions* (pp. 175–211). Elsevier. <https://doi.org/10.1016/B978-0-12-821470-1.00009-4>
- Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021). Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. *International Journal of Production Economics*, 231, 107831.
- Kusi-Sarpong, S., Mubarik, M. S., Khan, S. A., Brown, S., & Mubarak, M. F. (2022). Intellectual capital, blockchain-driven supply chain and sustainable production: Role of supply chain mapping. *Technological Forecasting and Social Change*, 175, 121331.
- Lüdeke-Freund, F., Gold, S., & Bocken, N. M. P. (2019). A Review and Typology of Circular Economy Business Model Patterns. *Journal of Industrial Ecology*, 23(1), 36–61. <https://doi.org/10.1111/jiec.12763>
- Mandych, O., Babko, N., Pasemko, G., Girzheva, O., & Taran, O. (2023). Circular economy model: Generating benefits for sustainable development. *Economic Analysis*, 33(1), 252–257. <https://doi.org/10.35774/econa2023.01.252>
- Menke, C., Hüsemann, M., & Siems, E. (2021). Stakeholder Influence on Sustainable Supply Chain Management: A Case Study of a German Apparel Frontrunner. *Frontiers in Sustainability*, 2, 735123. <https://doi.org/10.3389/frsus.2021.735123>
- Miah, M., Szabó-Szentgróti, G., & Walter, V. (2024). A systematic literature review on green human resource management (GHRM): An organizational sustainability perspective. *Cogent Business & Management*, 11(1), 2371983. <https://doi.org/10.1080/23311975.2024.2371983>
- Noor Faezah, J., Yusliza, M. Y., Chaudhary, R., Ramayah, T., & Fawehinmi, O. (2024). Green human resource management and employee ecological behaviour: The mediating role of green commitment. *Social Responsibility Journal*, 20(6), 1157–1176. <https://doi.org/10.1108/SRJ-07-2023-0399>
- Pieroni, M. P. P., McAloone, T. C., & Pigosso, D. C. A. (2019). Business model innovation for circular economy and sustainability: A review of approaches. *Journal of Cleaner Production*, 215, 198–216. <https://doi.org/10.1016/j.jclepro.2019.01.036>
- Rodchenko, V., & Prus, Y. (2023). DIGITAL TECHNOLOGIES IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT. *Facta Universitatis, Series: Economics and Organization*, 191. <https://doi.org/10.22190/FUEO230517012R>
- Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of*

- Production Research*, 57(7), 2117–2135.  
<https://doi.org/10.1080/00207543.2018.1533261>
- Samir Gokarn & Thyagaraj S. Kuthambalayan. (2017). Analysis of challenges inhibiting the reduction of waste in food supply chain. *Journal of Cleaner Production*, 168, 595–604. <https://doi.org/10.1016/J.JCLEPRO.2017.09.028>
- Sarkis, J. (Ed.). (2019). *Handbook on the sustainable supply chain*. Edward Elgar Publishing.
- Wang, Y., & Wright, L. A. (2021). A Comparative Review of Alternative Fuels for the Maritime Sector: Economic, Technology, and Policy Challenges for Clean Energy Implementation. *World*, 2(4), 456–481. <https://doi.org/10.3390/world2040029>
- Wong, E. K. S., Ting, H. Y., & Atanda, A. F. (2024). Enhancing Supply Chain Traceability through Blockchain and IoT Integration: A Comprehensive Review. *Green Intelligent Systems and Applications*, 4(1), 11–28. <https://doi.org/10.53623/gisa.v4i1.355>
- Zimon, D., Madzik, P., & Sroufe, R. (2020). The Influence of ISO 9001 & ISO 14001 on Sustainable Supply Chain Management in the Textile Industry. *Sustainability*, 12(10), 4282. <https://doi.org/10.3390/su12104282>



## THE ROLE OF DIGITALIZATION IN SHAPING THE WORKING FUTURE OF OLDER EMPLOYEES IN SERBIA

Andelka Stojanović \*, Milica Veličković, Sanela Arsić

*University of Belgrade, Technical Faculty in Bor, Serbia*

**Abstract:** The proliferation of digital technologies has caused significant changes across various domains, particularly impacting businesses and workplaces. This transformation has considerably altered the way the labor market and economy operate. Also, digitalization presents a significant challenge for older workers, as it demands a specific set of knowledge and skills that must be continuously updated and upgraded. On the other hand, the lack of digital competencies encourages digital marginalization and the exclusion of certain social groups that are digitally deprived. Age is not an obstacle to using digital technologies, but older people often face certain difficulties when using them. As people age, the demand for various social services (health and social protection, education, finance, and others) has grown, but many of these services are only available online nowadays. Therefore, the problem of digital inclusion for the older population has become a significant area of social policy concern and presents a substantial challenge for policymakers. This study analyzes the impact of digitization on the older workforce in Serbia. Data from the Republic Statistical Office and the Eurostat database were reviewed to gather information. Findings from Serbia suggest that digital technologies create some barriers for older adults due to limited access to the labor market and inadequate opportunities for acquiring institutional support.

**Keywords:** Digitalization, Older employees, Digital skills, Serbia

### 1. INTRODUCTION

Digitalization challenges multiple segments of modern society, including business and workplaces. Implementing Information and Communication Technologies (ICT) in business accumulates numerous impacts on companies through the organizational changes, inter-organizational relations, supply chains and labor market (Hetmańczyk, 2024). ICT technologies can reduce employment in certain sectors, mainly due to the automation of manual and routine tasks. At the same time, new employment opportunities are opening up in other segments, both

---

\* Corresponding author: [anstojanovic@tfbor.bg.ac.rs](mailto:anstojanovic@tfbor.bg.ac.rs)

Andelka Stojanović, ORCID: 0000-0001-7254-4646

Milica Veličković, ORCID: 0000-0002-4332-2216

Sanela Arsić, ORCID: 0000-0002-1957-566X

through the creation of new occupations and the increased productivity of new technologies (Albinowski & Lewandowski, 2024). On the other hand, skills such as information and data literacy, the ability to process and manage data, communication and collaboration through digital platforms, digital content creation, and analytical skills are recognized as key to survival and advancement in an increasingly dynamic world of work (Feijao et al., 2021).

The digital transformation is having a significant impact on the working population, especially on older and more mature workers. Based on statistics and trends, it is evident that the contribution of older workers to the digital transformation process is significant. In the European Union, the share of individuals over 55 years of age is projected to reach 40.6% by 2050. In addition, life expectancy at birth in the EU is estimated to be 81.5 years in 2023. With an increasingly older population and longer life expectancy, the EU's old-age dependency ratio is expected to reach 52.10% by 2023. To address demographic shifts, many countries are raising the retirement age in an effort to keep older people in the workforce for longer (Eurostat, 2020). Older workers are at the same time affected by numerous policies that aim to reduce job insecurity and develop resilience to the negative impacts of digitalization. The negative impact of digitalization on older employees is mainly marked by difficulties in acquiring adequate digital skills as well as limited success of training and various outcomes.

Several studies investigate changes in the work environment and the adaptation of employees to the new situation (Mondolo, 2022; Filippi et al., 2023; Křížková et al., 2024). The national socio-economic context is important for understanding the impact of digitalization on the workforce because it determines many factors that can both contribute to and slow down these inevitable processes (Janeska & Lozanoska, 2021). Above all, computer skills and the level of digital literacy affect the likelihood that an employee will have to change jobs due to digitalization and make it easier for them to find new employment if they are displaced. Nevertheless, the dominant sectors in the country can determine the level of digital transformation, as well as the active employment policies and support measures for employees and the population during the digitalization process. A significant influence can also come from the culture of change acceptance within a society, as well as the overall level of knowledge and education, and prevailing attitudes toward learning and education (Bejaković & Mrnjavac, 2020).

In the national context, the effects of digitalization can differ significantly from country to country depending on economic development. Taking into account the pace of digital transformation at the global level, it is necessary to conduct research that addresses these aspects at the national levels. This research analyzes the degree of digitalization in business in Serbia and the effects on older employees with a special focus on adapting digital competencies and skills. The research aims to identify the extent to which companies and employees in Serbia are ready to respond to the demands of the digital age. The research also aims to fill the perceived gap in the literature, especially in the domain of empirical studies that deal with the impact of digitalization on work at a national level.

For the purposes of analysis, this research used secondary, officially available data from the Statistical Office of the Republic of Serbia (SORS) and data from the Eurostat database. These sources provide relevant and comparable statistical information. In the second step of the analysis, Serbia's position regarding the digital literacy of older employees and their orientation in the digital society is examined compared to neighboring countries.

## **2. IMPACT OF DIGITALIZATION ON BUSINESSES**

In the research of Savić et al. (2019) it was determined that although most business owners and/or managers in Serbia believe that digital transformation is significant, only 20%

of companies have a clear digital transformation strategy defined and 5% have created teams that would specifically deal with the company's digital transformation. The level of digitalization in business has changed significantly during and after the COVID-19 pandemic. Today's data shows that the number of companies that have their own internet presentation and online trade channels is continuously increasing, and in 2024, it was 85%; it is important to emphasize that this percentage is significantly higher in large companies, 97.2%, while it is significantly lower in small enterprises. However, all companies in Serbia have and use the internet in their business (SORS, 2025). A fifth of all companies employ ICT experts, of which the percentage in large companies is 75.1%, while in small companies, it is only 18.3% (SORS, 2025).

Large companies, as a goal of digital transformation, particularly emphasize improving productivity, improving user experience, and facilitating decision-making. Regarding obstacles to digital transformation, most companies (a quarter) encountered administrative barriers. Among other obstacles, companies highlight unclear market needs, insufficient financial opportunities and a lack of trained personnel for the digital transformation of companies (Restrepo-Morales et al., 2024).

When considering the use of ICT in companies, data from the Eurostat database is used. In order to monitor the influence of digital technologies in business and at what level certain European countries are, the Digital Intensity Index (DII) was created, which consists of 12 indicators of the use of ICT and e-commerce in companies. According to this index for the year 2024, Serbia occupies a favorable position in terms of enterprises with a very low digital intensity index with only 13.8% of enterprises (Figure 1), which is better than the European average of 26.3%, much better than the results of countries in the region (Croatia 35.7%, Montenegro 34.6%, Bosnia and Herzegovina 48.5%, Romania 30.1%, Hungary 41.5%, Bulgaria 49.1% and Greece 45.9%). On the other hand, when looking at enterprises with a very high digital intensity index, Serbia also has a good position with 9.1%, while the EU average is 7.2%. The most developed countries in all categories are Denmark, Sweden and Finland.

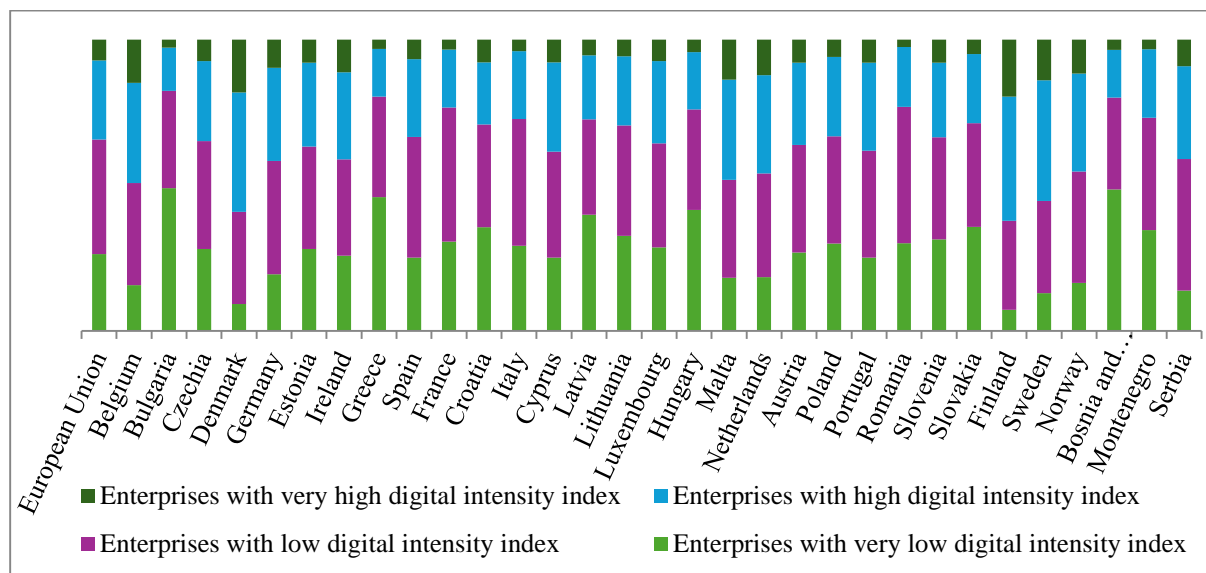


Figure 1. Digital Intensity. Source: Eurostat (ISOC\_E\_DIIN2)

Five indicators of critical digital skills are used to analyze individuals' level of digital skills: information and data literacy skills, communication and collaboration skills, digital content skills, safety skills and problem-solving skills. If we compare Serbia's position to that



of other European countries, we can observe that it is quite distant from the EU average (Figure 2). The EU has 55.6% of individuals possessing basic or above basic digital skills, whereas, in Serbia, the percentage is only 33.6%. Serbia's level of digital skills is in line with the surrounding countries, as the whole region is situated towards the back of Europe (Bosnia and Herzegovina 30.1%, Bulgaria 35.5%, Türkiye 33.1%, Romania 27.7%, and Albania 23.3%). However, Serbia's position in the case of individuals with no overall digital skills, with a rate of 2.6%, is more favorable than the EU average of 3%.

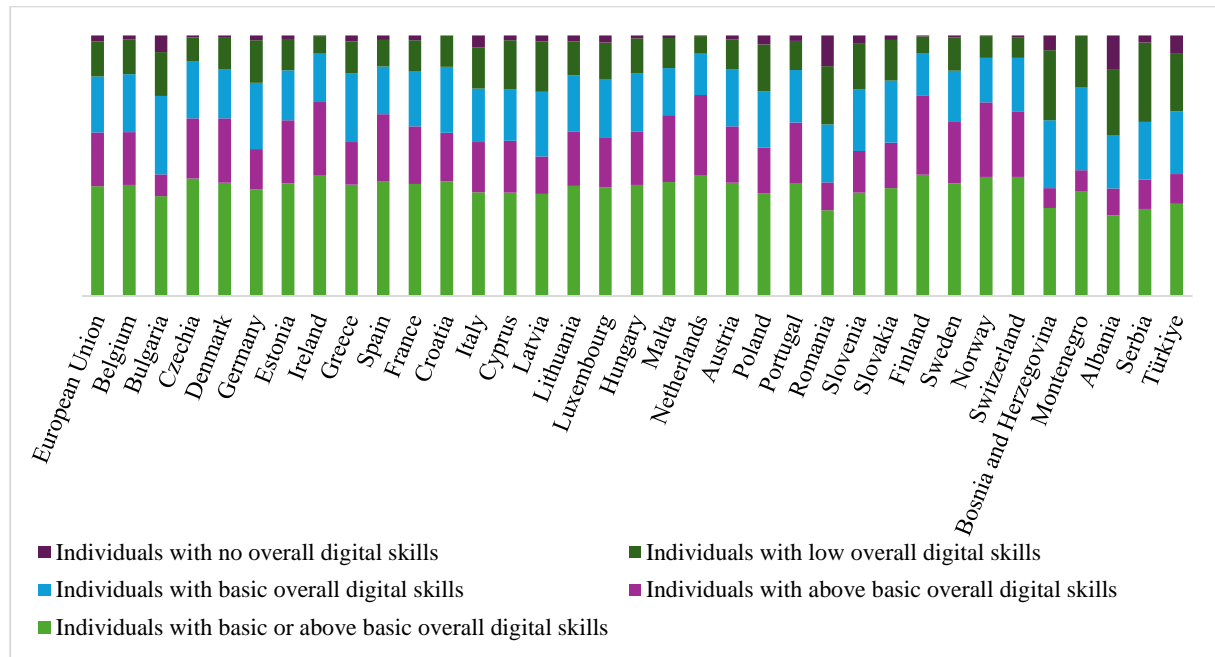


Figure 2. Individuals' level of digital skills. Source: Eurostat (ISOC\_SK\_DSKL\_I21)

Companies must provide adequate training to their employees to effectively adapt to the changes brought about by ICT without losing valuable, experienced employees. Therefore, besides vocational training, improving employees' ICT skills represents a significant challenge and need. As expected, the highest percentage of companies belonging to the ICT sector provide ICT training to their employees, where the EU average is 66.5%, while in Serbia, it is 64% (Figure 3). In other sectors, the intensity of ICT use is somewhat lower, and the percentage of companies that provide their employees with ICT training is lower. In the manufacturing sector in Serbia, the share of companies that take care of employees' ICT skills is 13.9%, which is a result that is lower than the EU average of 22.8%. The leading countries in which companies provide ICT training, observing all business activities (without the financial sector), are Finland, Belgium and Denmark, with 38.3%, 36.8%, and 35.2%, respectively. When looking at the category of all activities, without the financial sector, Serbia's position is much more favorable than the countries in the region.

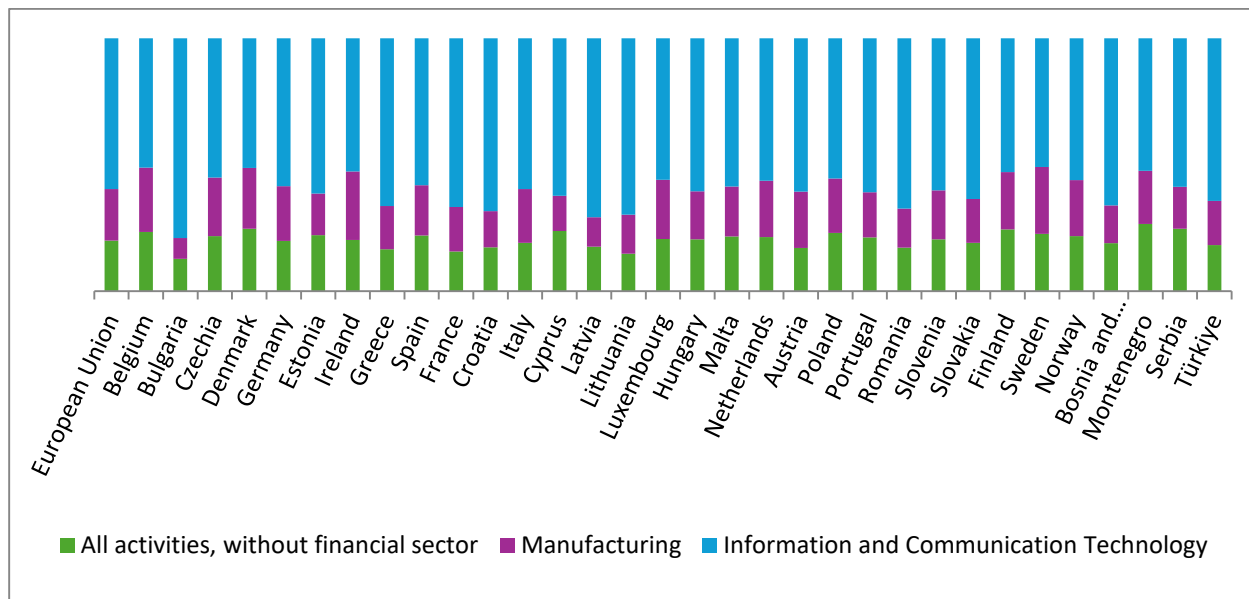


Figure 3. Enterprise provided training to their personnel to develop their ICT skills. Source: Eurostat (ISOC\_SKE\_ITTN2)

The Republic of Serbia has a relatively good institutional and normative foundation for digital transformation. Two strategies are especially important in digitalization: The Strategy for the development of digital skills from 2020 to 2024 and the Strategy for the development of information society and information security in the Republic of Serbia from 2021 to 2026 (Ministry of Trade, Tourism and Telecommunications of the Republic of Serbia, 2020; Government of the Republic of Serbia, 2021). These documents contain numerous measures to facilitate digital transformation and empower the population and companies for digital inclusion, ICT accessibility and utilization. The Centre for Digital Transformation (CDT) at the Serbian Chamber of Commerce plays an important role in supporting the digital transformation of the Serbian economy. CDT has so far implemented numerous programs aimed at enabling more than 1000 companies from the SME sector in Serbia to improve their business, ending in 2023. These initiatives are further expanded within the framework of the Industrial Policy Strategy of the Republic of Serbia for the period 2021-2030 (Ministry of Economy of the Republic of Serbia, 2020).

### 3. IMPACT OF DIGITALIZATION ON THE AGEING WORKFORCE

According to the latest data from the Statistical Office of the Republic of Serbia (SORS, 2025), in 2024, 88.8% of households in the Republic of Serbia were covered by a broadband internet network and had an internet connection in their households. When considering the devices used, 73.4% of households own a computer, 53.9% own a laptop, and 95.9% own a mobile phone. The data indicate certain differences related to the presence of ICT in urban and other types of settlements. Furthermore, 14.2% of the population has never used a computer, while 7.3% has never used the Internet.

The data indicate that 91.4% of employed people used a computer in the last three months, and even 99.1% used the Internet during the previous three months, compared to the unemployed, where the use of computers and the Internet was 70.8% and 95.2%, respectively (SORS, 2025).

When it comes to the assessment of digital skills and knowledge of older employees in Serbia, the Eurostat database is also used. Digital skills were assessed for individuals aged 55 to 64, identifying activities performed three months prior to data collection. Digital literacy measures provided by Eurostat consist of essential components: Level of computer skills, and Evaluating data, information, and digital content. The position of Serbia is compared to the EU average. The Level of computer skills measure consists of nine indicators, as presented in Figure 4.

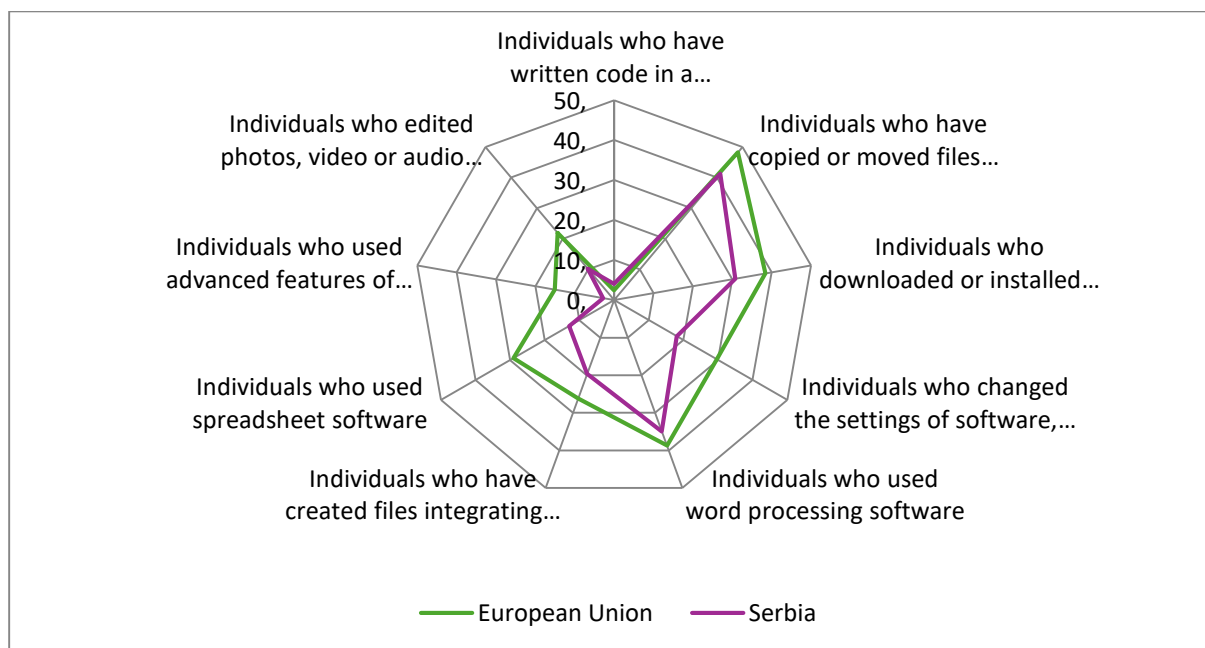


Figure 4. The Level of computer skills. Source: Eurostat [ISOC\_SK\_CSKL\_I21]

The data analysis reveals that the elderly population of 55 to 64 years from Serbia lags behind their European counterparts in many skills. For example, cloud technology was used by 48.2% in the EU, while in Serbia, that percentage was 41.3%. Even in those categories related to basic digital skills, such as creating files integrating elements such as text, pictures, tables, charts, animations or sounds, older people from Serbia demonstrated lower skill levels with 19.6%, compared with 26.2% in the EU. Therefore, it can be concluded that many older people in Serbia have significant gaps in digital skills and are likely employed in jobs that require the use of digital technologies. Many of these workers may have fragmented knowledge. They may be familiar with using a mobile phone but not with using software, applications, or devices or analyzing data.

Another vital digital competence is the ability to evaluate the reliability of data and information that may be encountered in a digital environment. The Eurostat database contains several indicators, six of which have been analyzed and presented in Figure 5.

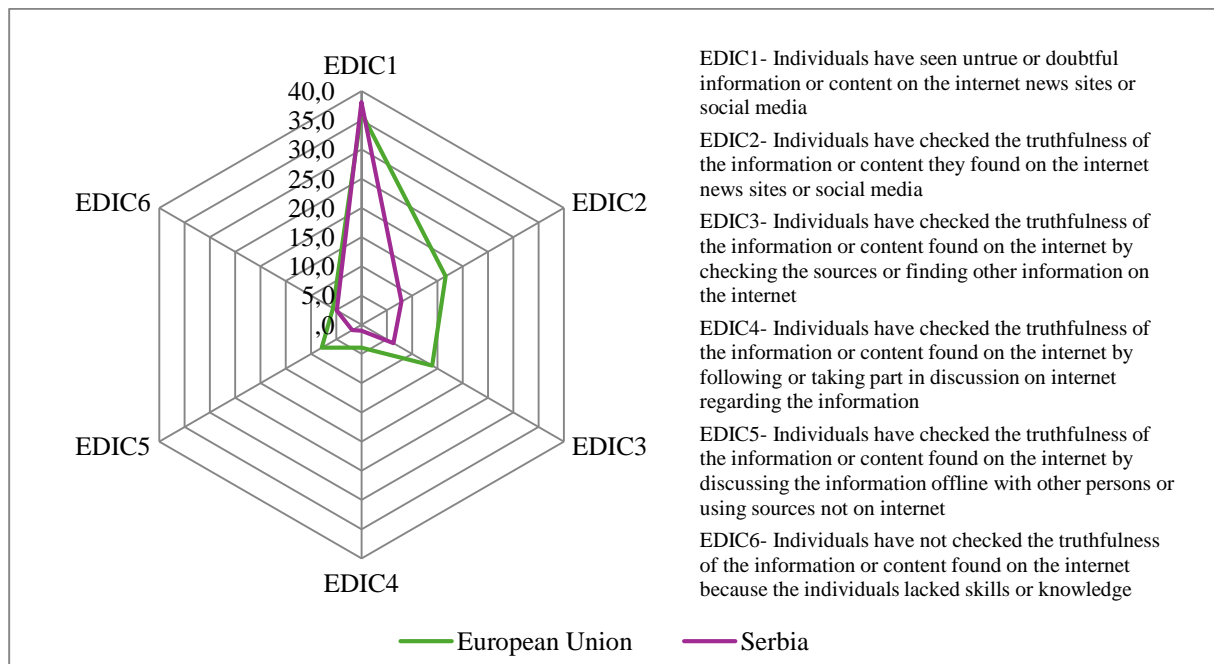


Figure 5. Evaluating data, information and digital content. Source: Eurostat [ISOC\_SK\_EDIC\_I21]

In the field of digital security, assessing content is essential for recognizing potential threats and vulnerabilities. Individuals must strive to enhance their knowledge and improve their skills to critically evaluate and effectively navigate the vast data and information available today. Mastering this skill can enhance career growth and success, in addition to improving privacy. The data shows that most people do not check the truthfulness of the information or content found on the Internet, with older individuals being less likely to do so than younger people. When looking specifically at Serbia's position in this area, it has lower results than the EU.

Therefore, there is a significant gap in the level of digital literacy that can be solved by improving the digital literacy of the older population through specific training. Also, at workplaces, overcoming digital challenges and mitigating job loss for older workers requires continuous occupational and digital technology training. Older people often have specific goals they want to achieve when starting some kind of training, whether to fulfill personal or social needs or meet job requirements. Older individuals, in particular, may feel pressured to be digitally literate, so undergoing training is not without its difficulties.

In order to further analyze the position of Serbia, a comparison was made in relation to countries in the region of both aspects, the Level of computer skills and Evaluating data, information and digital content using the EDAS method. The EDAS (Evaluation Based on Distance from Average Solution) method is a well-known multi-criteria decision analysis (MCDA) technique based on ranking alternatives according to the total deviation values from the average solution. The author Ghorabae et al. (2015) gives a detailed description of the steps of applying the EDAS method used in this research. The data for the initial decision matrix used to evaluate Serbia's position are from the Eurostat database. Obtained results are presented in Figure 6.

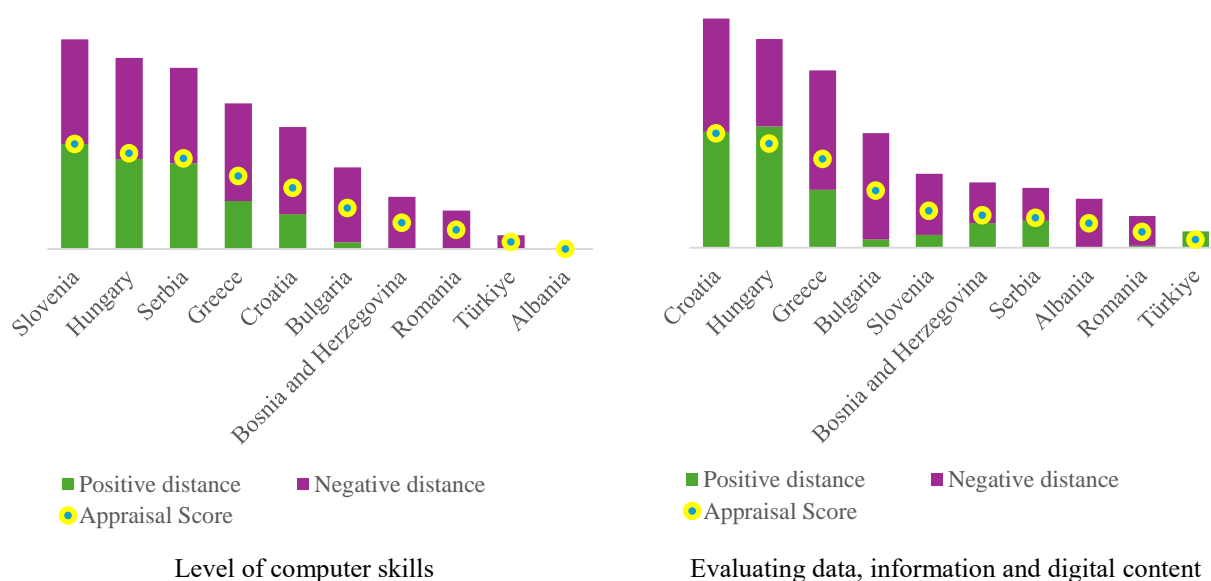


Figure 6. Results of comparative analysis

Compared to the European Union average, Serbia lags in developing computer skills among older employees, as well as in the domain of data and digital content assessment. The analysis of countries in the region indicates that Slovenia and Hungary lead in both observed segments of digital literacy, while Serbia ranks third, surpassing other neighboring countries in computer skills. Croatia has made significant progress, positioning itself as the leading country in the region, towards evaluating data, information, and digital content. In this segment, Serbia is ranked in the lower tier of the rankings (Figure 6).

#### 4. CONCLUSION

The Republic of Serbia has made significant progress in developing a legal framework for digital transformation and ICT accessibility. Several strategic and legal documents on digitalization have been enacted to support the population's digital transformation and digital literacy. However, there is no clearly defined legal source that deals with the older working population.

Serbia has allocated significant resources to digitization in recent years, and the process has progressed very successfully. The annual surveys conducted by the Statistical Office of the Republic of Serbia demonstrate consistent improvement. However, it is important to note that these surveys do not simultaneously include data on age groups and employment status; therefore, the data from another source needed to be used. Compared to the EU average, Serbia is slightly lagging in the overall digital skills of individuals. Also, the older population in Serbia, aged 55 to 64, who are still able to work, generally exhibit lower levels of digital skills compared to their peers in the EU.

On the other hand, Eurostat's findings reveal that businesses in Serbia demonstrate high levels of digital intensity, outperforming the EU average. This shows a strong position in the digital economy and the country's potential for innovation and further technological adoption within the business sector.

Addressing the digital divides noticed in Serbia and enhancing overall digital literacy is crucial. Attention should be given to older individuals in order to raise their awareness about

the significance and advantages of digitalization and the main challenges of digital transition. These results point to the need for more targeted policies and programs to strengthen digital competences in Serbia, especially among the older working population in the form of targeted training for work and strengthening critical thinking in a digital environment.

The implementation of these measures can ensure that Serbia converges more quickly to the European average, reduce the digital exclusion of older groups, and empower all employees to confidently use and critically evaluate digital content. In this way, older employees are more likely to maintain their productivity, retain their positions in the labor market, and build resilience against job displacement. This contributes to more inclusive and future-ready work environments that value lifelong learning and adaptability.

## ACKNOWLEDGMENT

The research presented in this paper was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the funding of scientific and research work at the University of Belgrade, Technical Faculty in Bor, according to contract with registration number 451-03-137/2025-03/ 200131

## REFERENCES

- Albinowski, M., & Lewandowski, P. (2024). The impact of ICT and robots on labour market outcomes of demographic groups in Europe. *Labour Economics*, 87, 102481. <https://doi.org/10.1016/j.labeco.2023.102481>
- Bejaković, P., & Mrnjavac, Ž. (2020). The importance of digital literacy on the labour market. *Employee Relations*, 42(4), 921–932. <https://doi.org/10.1108/ER-07-2019-0274>
- Eurostat. (2020). *Ageing Europe – statistics on population developments*. [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing\\_Europe - statistics on population developments](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_population_developments)
- Eurostat. (2025) *Database*. <https://ec.europa.eu/eurostat/data/database>
- Feijao, C., Flanagan, I., Van Stolk, C., & Gunashekar, S. (2021). *The global digital skills gap: Current trends and future directions*. RAND Corporation, Santa Monica, CA.
- Filippi, E., Bannò, M., & Trento, S. (2023). Automation technologies and their impact on employment: A review, synthesis and future research agenda. *Technological Forecasting and Social Change*, 191, 122448. <https://doi.org/10.1016/j.techfore.2023.122448>
- Ghorabae, M. K., Zavadskas, E. K., Olfat, L., & Turskis, Z. (2015). Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS). *Informatica*, 26(3), 435–451. DOI: <http://dx.doi.org/10.15388/Informatica.2015.57>
- Government of the Republic of Serbia. (2021). *Strategy for the development of information society and information security in the Republic of Serbia for the period from 2021 to 2026*. <https://arhival.mtt.gov.rs/extfile/sr/35315/Information%20Society%20and%20InfoSec%20Strategy%202021-2026111.pdf>
- Hetmańczyk, P. (2024). Digitalization and its impact on labour market and education: Selected aspects. *Education and Information Technologies*, 29, 11119–11134. <https://doi.org/10.1007/s10639-023-12203-8>

- Janeska, V., & Lozanoska, A. (2021). Impact of digitalization on the labour market: The case of North Macedonia. *Economic Analysis: Applied Research in Emerging Markets*, 54(1), 24–40. <https://www.library.iien.bg.ac.rs/index.php/ea/article/view/1343>
- Křížková, A., Pospíšilová, M., & Dudová, R. (2024). New technologies, older workers in banking and nursing. *New Technology, Work and Employment*, (in press). <https://doi.org/10.1111/ntwe.12319>
- Ministry of Economy of the Republic of Serbia. (2020). *Industrial Policy Strategy of the Republic of Serbia for the period 2021–2030*. <https://privreda.gov.rs/sites/default/files/documents/2021-08/Industrial-Policy-Strategy-2021-2030.pdf>
- Ministry of Trade, Tourism and Telecommunications of the Republic of Serbia. (2020). *Strategy of digital skills development in the Republic of Serbia for the period 2020–2024*. <https://arhiva.mtt.gov.rs/en/download/Strategy+of+Digital+Skills+Development+in+the+Republic+of+Serbia+for+the+period+2020-2024.pdf>
- Mondolo, J. (2022). The composite link between technological change and employment: A survey of the literature. *Journal of Economic Surveys*, 36(4), 1027–1068. <https://doi.org/10.1111/joes.12469>
- Iris University
- Restrepo-Morales, J. A., Ararat-Herrera, J. A., López-Cadavid, D. A., & Camacho-Vargas, A. (2024). Breaking the digitalization barrier for SMEs: A fuzzy logic approach to overcoming challenges in business transformation. *Journal of Innovation and Entrepreneurship*, 13(84). <https://doi.org/10.1186/s13731-024-00429-w>
- Savić, N., Lazarević, J., Kukić, Z., & Marinković, E. (2019). Digital transformation: Challenges for companies in Serbia. *Ekonomika preduzeća*, 67(1–2), 101–114. <https://doi.org/10.5937/EkoPre1808101S>
- Statistical Office of the Republic of Serbia (SORS). (2025). *Statistical data*. <https://data.stat.gov.rs/>





## A COMPARATIVE STUDY ON STUDENT INTENTIONS IN BULGARIA, ROMANIA AND SERBIA TO START FAMILY BUSINESSES

Daniel Pavlov<sup>1</sup>, Silvia Puiu<sup>2</sup>, Milica Veličković<sup>3\*</sup>

<sup>1</sup> University of Ruse “Angel Kunchev”, Bulgaria;

<sup>2</sup> University of Craiova, Romania;

<sup>3</sup> University of Belgrade, Technical faculty in Bor, Serbia.

**Abstract:** Family businesses are of great importance for the wider economy and competitiveness of individual economies. In developed countries, family business represents a backbone of economic development. In recent years, family businesses in transition countries have attracted increasing attention from researchers, because the process of transition has caused major changes in the political, economic and cultural life of these countries. The key problem of family businesses represents generational transfer, which is often difficult to overcome. Students' interest in starting family business after graduation is traditionally very low. So, the main objective of INTERGEN (The intergenerational family businesses as a stress management instrument for entrepreneurs) research group (members of this group are from nine countries) was to determine the factors which can significantly help to explain the students' willingness to engage in any entrepreneurial activity, including family business, and to overcome possible obstacles. This paper presents the comparative results of the survey conducted in three countries, Bulgaria, Romania and Serbia.

**Keywords:** entrepreneurial intentions, family support, Bulgaria, Romania, Serbia.

### 1. INTRODUCTION

In 2018, twelve universities from six countries founded an international academic network, dedicated to international comparative studies on student intentions towards family businesses, under the name INTERGEN. At the beginning of 2025, this academic network is already in nine countries – Albania, Bosnia and Herzegovina, Bulgaria, Iran, Poland, Romania, Russia, Serbia and Uzbekistan, with the support of over 40 scientists from these regions. Their academic network is entitled “The intergenerational family businesses as a stress management

---

\* Corresponding author: [mvelickovic@tfbor.bg.ac.rs](mailto:mvelickovic@tfbor.bg.ac.rs)

Daniel Pavlov, ORCID: <https://orcid.org/0000-0002-4515-2206>

Silvia Puiu, ORCID: <https://orcid.org/0000-0002-3967-3726>

Milica Veličković, ORCID: <https://orcid.org/0000-0002-4332-2216>



instrument for entrepreneurs”, and their well-known example to illustrate the intergenerational businesses linkages is (Bakracheva et al., 2020; Pavlov et al., 2017):

The grandparents produce grapes.

The parents produce wine (including the grapes of their parents);

The children create an online shop, and they also sell the grapes and the wine of their relatives.

The main focus of the INTERGEN academic network is to study the students' intentions regarding intergenerational family business among two or three generations.

This paper is a part of an international study to present students' intentions towards family businesses in three Danube countries. The findings are based on joint research in three academic institutions from the INTERGEN network – the University of Ruse “Angel Kunchev”, Bulgaria; the University of Belgrade, Technical faculty in Bor, Serbia and the University of Craiova, Romania.

The article begins with some theoretical background about the family business. An important part is given to the findings on the students' intentions in these three HEIs.

In this study, we check our thesis, which is: *Students from South-East Europe have similar intentions when they think of attracting the support from their friends, parents and other relatives in case they have an idea to produce a low-technology product/service and their capability.*

We have elaborated three hypotheses to check the thesis:

Hypothesis 1: Students with ideas to produce a low-technology product/service are capable of attracting the trust of their clients.

Hypothesis 2: Students need support from their relatives and best friends to start their business.

Hypothesis 3: Students can convince their parents to give them some seed capital to start the business.

The finding could be useful to those scientists who study the family businesses in South-East Europe.

## **2. FAMILY BUSINESS**

Family businesses are businesses created and managed by members of the same family. According to the European Commission (n.d.), these types of businesses account for “60% of all companies in Europe”. Some of them are small and medium enterprises (SMEs), but others have become large companies widely recognised at an international level. There are numerous opportunities for funding family businesses, European Union encourages the formation of these companies. Many of the funds are especially targeting SMEs. Even if funds are sometimes accessible, family businesses face significant challenges in their activities. Among these we can mention: the dynamics of the family as a social structure; the lack of knowledge regarding funding opportunities; the lack of the initial capital needed to start the business; changes in the youngsters' intentions to continue the family legacy if the company is already settled; the economic and financial crisis which affects severely small companies; the political and social instability in the country; not keeping up with the technological advancements, sometimes due to lack of strategy and perspectives, other times because of lack of funds to incorporate new technology; changes in the market structures and the needs and wants of the consumers for the products and services offered by the family businesses.

Galeone et al. (2023) emphasise the need to incorporate digitalisation in family businesses while also making efforts to preserve the culture and traditions that make a family business unique and appreciated in the community. These changes should be embraced to raise

the competitive advantage of such businesses. With newer generations of youngsters who were raised during the technological boom and have always been connected, things can move faster in this direction. The challenge would be for them to still maintain the identity of the business created by former generations, especially for those family businesses that passed from generation to generation.

Zapata-Cantu et al. (2023) emphasise that family businesses can have more flexibility when the context requires it because they are smaller and usually the members have common values and interests, which help them to better tackle the vicissitudes. Calabro et al. (2021, p. 1) highlight the resilience of these companies during the pandemic and mention that “succession, innovation and family governance” explain the power of family businesses in times of crisis. Miroshnychenko et al. (2024) mention not only the higher resilience but also the higher financial results of family businesses compared to other types of companies during the pandemic. This can be explained by their higher adaptability.

Czakó et al. (2023) show that the cultural and economic specifics of the country influence the younger generation in their intentions to start a business, which we appreciate can be applied to family businesses too. Even if there are similarities, the background in which youngsters are educated and develop as adults is influential for their future intentions. Some specific challenges are also mentioned by Haynes et al. (2020, p. 70), who mention the need for continuous innovation, but also the higher challenges faced by “women, minorities, and immigrants”. The fact that family businesses can be a solution for many immigrant families is also presented by Puiu (2018). The advantages created by family businesses for their members and the communities are important. Thus, they can provide a safety net in terms of financial support, but they can also be a good practice for sustainability and circular economy (Pavlov et al., 2025).

### **3. DESIGN OF THE SCIENTIFIC RESEARCH**

In 2018, the scientists elaborated a questionnaire to conduct comparative research in the academic year of 2018/2019 with 38 questions, which were in regard to the purpose of the INTERGEN academic network – to support different efforts to preserve the family respectfully.

In 2020, the questionnaire was improved, and some new questions were added, reaching a total number of 57 statements. It was used to collect responses in 2020/2021, then in 2023/2024 and recently in 2025, too. The database of INTERGEN allows for the comparison of students’ intentions from different aspects, such as: gender (male and female), education level (bachelor's and master's), age (from 18 to over 60), field of education (business, technical, pedagogical, etc.), etc.

In this study, we check the three hypotheses by some related questions:

Hypothesis 1: Students with ideas to produce a low-technology product/service are capable of attracting the trust of their clients. We will check it by the responses on “Question 9. If I produce a low-technology product/service, I will still be capable of attracting the trust of my clients to me”.

Hypothesis 2: Students need support from their relatives and best friends to start their business. We will check it by the responses from “Question 10. To start something, I need the support from my relatives and best friends”.

Hypothesis 3: Students can convince their parents to give them some seed capital to start the business.

The research questionnaire has been designed under the efforts of the international academic network INTERGEN. In this article, we present the responses to three questions,

which are to check our hypotheses: We will check it by the responses from “Question 11. I can convince my parents to give me some seed capital for my business”.

Students could answer the questions by using a Likert scale:

1 is NO

2 is Rather No

3 is N/A

4 is Rather Yes

5 is YES

The responses were collected by online communication, using e-mails and Messenger. Then they were stored in an Excel table.

Different students were invited to participate in the survey in every country. There were no restrictions about their gender, age, political background, ethnic origin or other forms of discrimination. About their field of education:

In Bulgaria, most of the respondents are from the Faculty of Business and Management.

In Romania, all respondents are in the study area “Art and humanities”.

In Serbia, all respondents are from the study area “Engineering, manufacturing and construction”.

In the next section, we present some of their responses.

#### 4. FINDINGS

In total, the study in the three universities has received answers from different respondents (see Table 1):

In 2021, the total number of respondents from the three universities is 593, where 448 are females and 145 males.

In 2023, the total number of respondents from Bulgaria and Romania is 783, where 602 are females and 181 are males. These findings are for the Bulgarian and Romanian students.

In 2025, the preliminary findings at the University of Ruse are the base of 222 responds, where 163 are from females and 59 from males. We will use their data to compare with the previous years.

*Table 1.* Number of respondents by country and years.

Country	Bulgaria, Ruse			Romania, Craiova		Serbia, Bor
Years	2021	2023	2025	2021	2023	2021
Females	220	452	163	154	150	74
Males	69	130	59	46	51	30
Total	<b>289</b>	<b>582</b>	<b>222</b>	<b>200</b>	<b>201</b>	<b>104</b>

Source: authors' survey

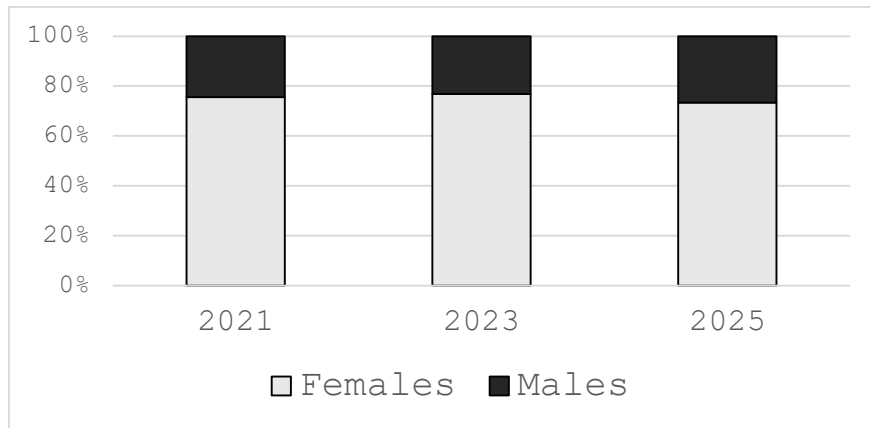


Figure 1. Share of respondents by years and gender.

Figure 1 shows that in the three years and in the three universities, the female respondents were the majority due to their academic field of study.

About Question 9, the data in Table 2 and Figure 2 show that there are some differences between the Bulgarian respondents, compared to the Romanian and Serbian students.

Table 2. Number of respondents to “Question 9. If I produce a low-technology product/service, I will still be capable of attracting the trust of my clients in me”

Country	Bulgaria, Ruse			Romania, Craiova		Serbia, Bor
	2021	2023	2025	2021	2023	2021
1 - NO						
2 - Rather No	1	13	9	22	27	4
3 - N/A	25	33	7	45	50	22
4 - Rather Yes	26	101	42	44	46	32
5 - YES	115	140	74	48	27	39
Total	289	582	222	200	201	104

Source: authors' survey

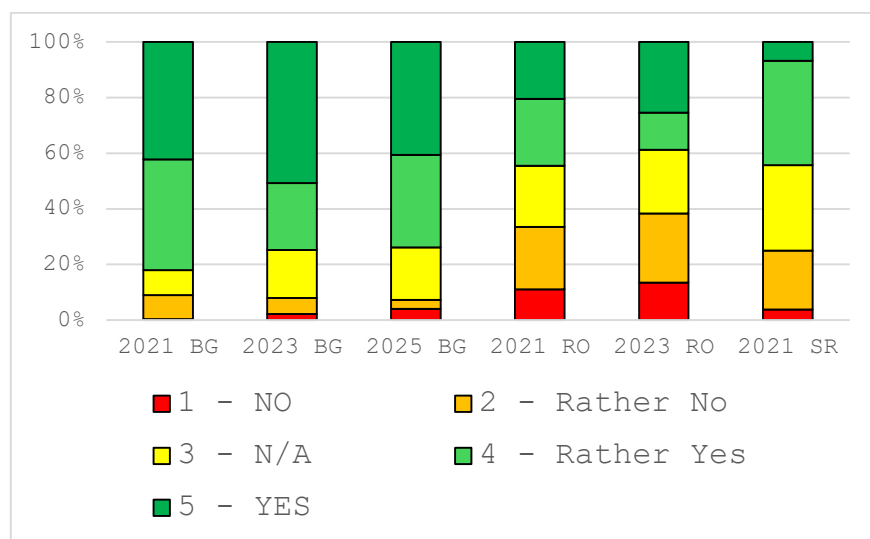


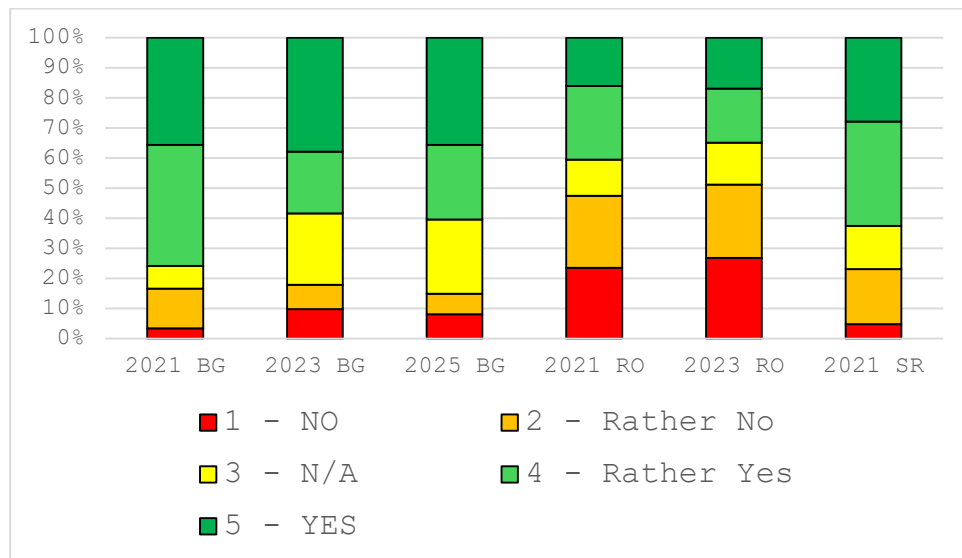
Figure 2. Share of respondents to “Question 9. If I produce a low-technology product/service, I will still be capable of attracting the trust of my clients in me”

About Question 10, the data in Table 3 and Figure 3 show that there are some differences between the Romanian students, compared to the Bulgarian and Serbian respondents.

*Table 3.* Number of respondents to “Question 10. To start something, I need the support from my relatives and best friends”.

Country	Bulgaria, Ruse			Romania, Craiova		Serbia, Bor
1 - NO	2021	2023	2025	2021	2023	2021
2 - Rather No	10	57	18	47	54	5
3 - N/A	38	47	15	48	49	19
4 - Rather Yes	22	138	55	24	28	15
5 - YES	116	120	55	49	36	36
Total	289	582	222	200	201	104

Source: authors' survey



*Figure 3.* Share of respondents to “Question 10. To start something, I need the support from my relatives and best friends”.

About Question 11, the data in Table 4 and Figure 4 show that there are no big differences between the respondents from the three countries.

*Table 4.* Number of respondents to “Question 11: I can convince my parents to give me some seed capital for my business”.

Country	Bulgaria, Ruse			Romania, Craiova		Serbia, Bor
1 - NO	2021	2023	2025	2021	2023	2021
2 - Rather No	28	99	43	25	34	9
3 - N/A	51	41	22	31	28	8
4 - Rather Yes	54	130	53	26	33	33
5 - YES	83	101	40	56	30	33
Total	289	582	222	200	201	104

Source: authors' survey

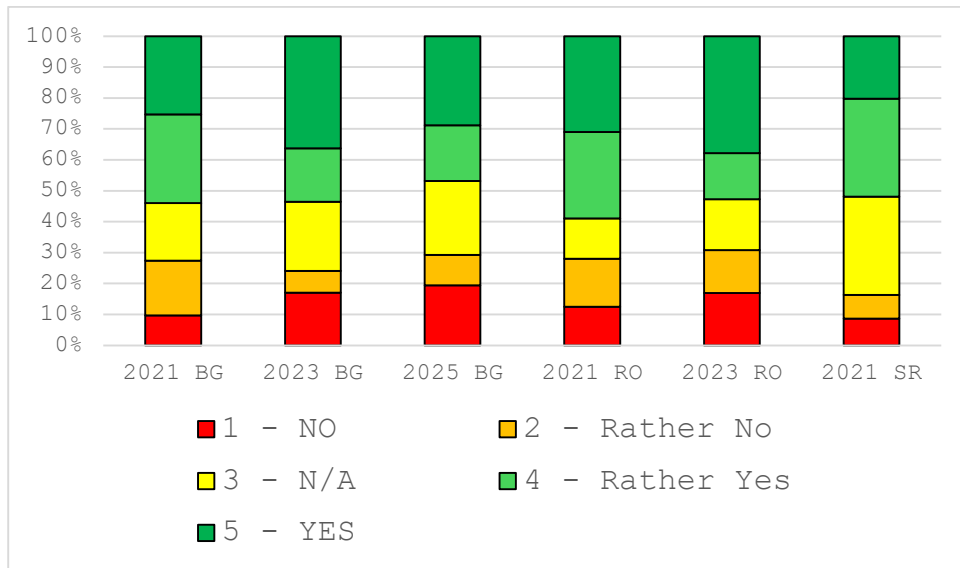


Figure 4. Share of respondents to “Question 11. I can convince my parents to give me some seed capital for my business”.

In the next section, we will discuss these findings.

## 5. DISCUSSION

The responses to Question 9 show some differences. The Bulgarian students show much more self-confidence that they are capable of attracting clients in case they produce a low-technology product/service, compared to the students from Romania and Serbia. A possible explanation could be their major education, as previously noted, the Bulgarian respondents are mostly from the Faculty of Business and Management, where they have studied many more business courses, compared to the educational program of the students from Romania and Serbia, whose educational background is not deeply focused on business processes.

The responses to Question 10 show some differences, too. The Bulgarian and Serbian respondents are quite open to asking their relatives and best friends for support when they start something new. In contrast, the Romanian students rely on themselves. The data for the Bulgarian respondents show that during the COVID-19 period (2020-2022), the Bulgarians (75,8%) were willing to look for the support of their best friends and close relatives. In the period after COVID-19, fewer Bulgarians need this type of support – 58,4% in 2023 and 60,4 % in 2025.

About Question 11, the positive answers “Rather Yes” and “YES” in Table 4 and Figure 4 show that there are no big differences between the respondents from the three countries – they can convince their parents to give them some seed capital for their businesses. The roots of this similarity could be traced back to the similar mentality of the countries from South-East Europe, where the family remains one of the main sources of support from the parents to their children.

## 6. CONCLUSION

Based on our findings, we consider that:

Hypothesis 1 is partly confirmed. Students with ideas to produce a low-technology product/service are capable to attract the trust of their clients in case they have more business courses during their education.

Hypothesis 2 is partly confirmed. Most of the answers are positive, but at the same time, some students rely mostly on themselves. A possible explanation could be found in the educational programs – if the students are stimulated to act in teams or individual activities.

Hypothesis 3 is confirmed. Most of the respondents think they can convince their parents to give them some seed capital to start the business. A possible explanation is the mentality in these three Balkan countries, which favours family ties and intergenerational support.

Based on the check of the three hypotheses, we may confirm our thesis with some small differences – *Yes, the students from South-East Europe have similar intentions when they think to attract the support from their friends, parents and other relatives in case they have an idea to produce a low-technology product/service and their capability.* Their success will be stronger if there are more group course assignments to stimulate teamwork and the family business intentions.

## ACKNOWLEDGMENT

This research was conducted within the framework of:

Project supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia, as part of the financing of scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-137/2025-03/ 200131.

Project 2025-BM-01 “Transformation of Socio-Economic Systems through Integration and Digitalization”, supported by the Scientific Research Fund of the University of Ruse “Angel Kanchev.”

International academic network INTERGEN “The intergenerational family businesses as a stress management instrument for entrepreneurs”.

## REFERENCE

- Bakracheva, M., Pavlov, D., Gudkov, A., Diaconescu, A., Kostov, A., Deneva, A., Kume, A., Wójcik-Karpacz, A., Zagorcheva, D., Zhelezova-Mindizova, D., Dedkova, E., Haska, E., Stanimirov, E., Strauti, G., Taucean, I., Jovanović, I., Karpacz, J., Ciurea, J., Rudawska, J., Ivascu, L., Milos, L., Venera, M., Sheresheva, M., Tamasila, M., Veličković, M., Damyanova, S., Demyen, S., Kume, V., Blazheva, V. (2020) THE INTERGENERATIONAL FAMILY BUSINESSES AS A STRESS MANAGEMENT INSTRUMENT FOR ENTREPRENEURS, p.9. <http://intergen-theory.eu/INTERGEN-BOOK-1.pdf>
- Calabrò, A., Frank, H., Minichilli, A., & Suess-Reyes, J. (2021). Business families in times of crises: The backbone of family firm resilience and continuity. *Journal of Family Business Strategy*, 12(2), 100442. <https://doi.org/10.1016/j.jfbs.2021.100442>
- Czakó, K., Polster, C., Setyaningsih, S., & Vasic, T. (2023). The role of the environment in the entrepreneurial propensity of youngsters’ business ideas. *Journal of innovation and entrepreneurship*, 12(1), 7. <https://doi.org/10.1186/s13731-023-00275-2>
- European Commission (n.d.). Family Business. Available at [https://single-market-economy.ec.europa.eu/smes/sme-fundamentals/family-business\\_en](https://single-market-economy.ec.europa.eu/smes/sme-fundamentals/family-business_en) (accessed on April 23, 2025)

- Galeone, G., Campobasso, F., & Dell'Atti, V. (2023). Innovation and digitalisation: what challenges and opportunities for family business?. *International Journal of Digital Culture and Electronic Tourism*, 4(2), 155-170. <https://doi.org/10.1504/IJDCET.2023.129028>
- Haynes, G., Marshall, M., Lee, Y., Zuiker, V., Jasper, C. R., Sydnor, S., ... & Wiatt, R. (2021). Family business research: Reviewing the past, contemplating the future. *Journal of Family and Economic Issues*, 42, 70-83. <https://doi.org/10.1007/s10834-020-09732-6>
- Miroshnychenko, I., Vocalelli, G., De Massis, A., Grassi, S., & Ravazzolo, F. (2024). The COVID-19 pandemic and family business performance. *Small Business Economics*, 62(1), 213-241. <https://doi.org/10.1007/s11187-023-00766-2>
- Pavlov, D., Sheresheva, M., & Perello, M. (2017). The Intergenerational Small Family Enterprises as Strategic Entities for the Future of the European Civilization - A Point of View // *Journal of Entrepreneurship & Innovation*, Issue 9, pp 121-133, [https://jei.uniruse.bg/Issue-2017/10.%20Pavlov\\_Sheresheva\\_Perello.pdf](https://jei.uniruse.bg/Issue-2017/10.%20Pavlov_Sheresheva_Perello.pdf)
- Pavlov, D., Puiu, S., Alieva, D. (2025). The Importance of the Family Businesses for Fundamental Sustainable Improvements: Cases from Bulgaria, Romania, and Uzbekistan. In: Idowu, S.O., Vertigans, S. (eds) *Sustainability in Global Companies. CSR, Sustainability, Ethics & Governance*. Springer, Cham. [https://doi.org/10.1007/978-3-031-77971-8\\_2](https://doi.org/10.1007/978-3-031-77971-8_2)
- Puiu, S. (2018). Entrepreneurial initiatives of immigrants in European Union. *Young Economists Journal*, (31), 75-85.
- Zapata-Cantu, L., Sanguino, R., Barroso, A., & Nicola-Gavrilă, L. (2023). Family business adapting a new digital-based economy: Opportunities and challenges for future research. *Journal of the Knowledge Economy*, 14(1), 408-425. <https://doi.org/10.1007/s13132-021-00871-1>





## A COMPARATIVE ANALYSIS OF MCDM METHODS BASED ON PAIRWISE COMPARISON: AHP, BWM AND FUCOM

Petra Grošelj\*, Gregor Dolinar

*University of Ljubljana, Biotechnical Faculty, Slovenia*

**Abstract:** MCDM methods based on pairwise comparisons are widely used to determine the weights of alternatives and criteria in complex problems. In this paper, we compare three of these methods: Analytic Hierarchy Process (AHP), Best-Worst method (BWM) and Full Consistency Method (FUCOM). We compared the number of pairwise comparisons required and the amount of information provided by the experts as well as the consistency of the judgments. The data came from a study on the ranking of driving parameters of business and production management in small and medium-sized enterprises. The results show that AHP with the higher requirement of pairwise comparisons also leads to very reliable weights, while a lower number of pairwise comparisons in BWM and FUCOM, as appealing as it is to the experts, could significantly reduce the input data and decisively influence the ranking of items. Our study also disproves the statement repeatedly found in the literature that BWM is more consistent than AHP due to the lower number of pairwise comparisons required. Rather, we have pointed out the problem of measuring inconsistency in BWM. For FUCOM, we have provided explicit formulas for calculating the weights.

**Keywords:** Multi-criteria decision making, Pairwise comparisons, Analytic Hierarchy Process, Best-Worst method, Full Consistency Method

### 1. INTRODUCTION

To analyze complex decision problems, multi-criteria decision-making (MCDM) provides a structured approach to evaluate and rank alternatives based on multiple, often conflicting criteria. MCDM encompasses a wide range of mathematical techniques to support decision-makers in various fields including engineering, environmental management, business, logistics, and healthcare (Sahoo & Goswami, 2023).

---

\* Corresponding author: [petra.groselj@bf.uni-lj.si](mailto:petra.groselj@bf.uni-lj.si)

Petra Grošelj, ORCID: 0000-0001-9363-9783  
Gregor Dolinar, ORCID: 0000-0001-9106-3995

In our study, we focused on pairwise comparison-based methods, in which judgments are obtained by comparing two items simultaneously. They are frequently used in practice because they are intuitively structured, place relatively low cognitive demands on the decision maker and can capture the relative importance of items. One of the well-known and most widely used methods is Analytic Hierarchy Process (AHP), which was introduced by Saaty (1980). It uses a complete set of pairwise comparisons between all items to derive their weights and includes a consistency check to assess the reliability of the judgments. While AHP provides a structured and robust framework, its reliance on numerous comparisons, especially in problems with a large number of elements to compare, can lead to increased decision maker fatigue and consequently inconsistency.

Several methods have been developed to overcome the limitations of the AHP. The Best-Worst Method (BWM) proposed by Rezaei (2015) reduces the cognitive load on decision makers by asking them to identify the best and worst elements, and then evaluate the other elements in comparison to these. This reduces the number of judgments required compared to AHP and, according to Rezaei (2015), provides more consistent comparisons.

Another more recent method based on pairwise comparison is the Full Consistency Method (FUCOM) developed by Pamučar et al. (2018), which further simplifies the comparison process by enforcing transitivity and ensuring consistency by focusing on only one set of pairwise comparisons, e.g. the best element with others or each element with the next most important element.

Beyond these methods several other methods also incorporate pairwise comparisons. For instance, PROMETHEE (Preference Ranking Organization METHod for Enrichment of Evaluations) is an outranking method that uses pairwise comparisons of alternatives regarding the criteria (Behzadian et al., 2010). Furthermore, DEMATEL (Decision-Making Trial and Evaluation Laboratory) uses pairwise comparisons to model interdependencies among criteria, often as a pre-processing step in hybrid MCDM approaches (Si et al., 2018).

The aim of this study is a comparative analysis of three MCDM methods based on pairwise comparisons: AHP, BWM and FUCOM. Despite the large number of studies using at least two of the selected methods (Akbari et al., 2021; AL-Juaidi, 2025; Ekin & Sarul, 2022; Fazeli & Peng, 2023; Srdjevic et al., 2022), comprehensive comparisons between them are still limited, especially in terms of their efficiency, consistency assessment and practical applicability. The present study aims to fill this gap by systematically comparing AHP, BWM and FUCOM using a decision problem involving the ranking of driving parameters of business and production management in small and medium-sized enterprises (Jelačić et al., 2021). By analyzing the results, we provide insights into their theoretical and computational aspects as well as the interpretability of the results. We also provide the formulas for calculating the explicit solution for the derivation of weights in FUCOM.

## **2. DATA AND METHODOLOGY**

### **2.1. Analytic hierarchy process**

In the AHP, all pairs of items are compared using Saaty's ratio 1-9 scale. The pairwise comparison matrix  $A$  summarizes all pairwise comparisons:

$$A = (a_{ij})_{n \times n} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix}. \quad (1)$$

The vector of weights  $w = (w_1, w_2, \dots, w_n)$  can be derived from  $A$  using the eigenvector method:

$$Aw = \lambda_{\max} w, \quad (2)$$

where  $\lambda_{\max}$  denotes the principal eigenvalue of the pairwise comparison matrix  $A$ . The consistency of the pairwise comparisons is measured by consistency ratio CR, the ratio between the consistency index (CI) and the random index (RI):

$$CR = \frac{CI}{RI}; \quad CI = \frac{\lambda_{\max} - n}{n - 1}. \quad (3)$$

In this study (Jelačić et al., 2021),  $CR < 0.15$  was considered acceptable.

## 2.2. Best-worst method

BWM consists of five steps. Step 1-2: Select the best (most important) (B) and the worst (least important) (W) element from the set of  $n$  evaluated elements. Step 3-4: Determine the preferences of the best element over all other elements using the 1-9 scale and collect the results in the best-to-others vector  $(a_{B1}, a_{B2}, \dots, a_{Bn})$ . Determine the preferences of all other elements over the worst element using the 1-9 scale and collect the results in the others-to-worst vector  $(a_{1W}, a_{2W}, \dots, a_{nW})$ . Step 5: Determine the weights of elements by solving the optimization model. We have chosen the linear model (Rezaei, 2016):

$$\begin{aligned} &\min \xi \\ &\text{s.t. } |w_B - a_{Bj} w_j| \leq \xi, \text{ for all } j \\ &\quad |w_j - a_{jW} w_W| \leq \xi, \text{ for all } j \\ &\quad \sum_j w_j = 1, w_j \geq 0, \text{ for all } j \end{aligned} \quad (4)$$

The consistency of judgments can be measured by the output-based consistency measure  $\xi$  or by the input-based CR, where the threshold for acceptable consistency depends on the value of the pairwise comparison  $a_{BW}$  (Liang et al., 2020).

$$CR = \max_j CR_j, \text{ where } CR_j = \begin{cases} \frac{|a_{Bj} a_{jW} - a_{BW}|}{a_{BW}^2 - a_{BW}}, & a_{BW} > 1 \\ 0, & a_{BW} = 1 \end{cases}. \quad (5)$$

### 2.3. Full consistency method

The first step in FUCOM method is ranking the elements according to their importance. The second step is comparison of the ranked elements. In our study we used the comparisons of the most important element to all others. On the basis of these pairwise comparisons the comparative priorities of sequentially ranked elements  $\varphi_{k/(k+1)}$ ,  $k = 1, \dots, n$  are calculated. In the third step the weights of elements are calculated by the following model:

$$\begin{aligned}
 &\min \chi \\
 &\text{s.t. } \left| \frac{w_k}{w_{k+1}} - \varphi_{k/(k+1)} \right| \leq \chi, \text{ for all } k \\
 &\quad \left| \frac{w_k}{w_{k+2}} - \varphi_{k/(k+1)} \varphi_{(k+1)/(k+2)} \right| \leq \chi, \text{ for all } k \\
 &\quad \sum_{k=1}^n w_k = 1, w_k \geq 0, \text{ for all } k
 \end{aligned} \tag{6}$$

### 2.4. Data

One of the objectives of the study Sustainable Production Management Model for Small and Medium Enterprises in Some South-Central EU Countries (Jelačić et al., 2021) was to rank seven driving parameters of the business and production management system in small and medium enterprises of wood processing and furniture manufacturing in a time of disrupted market situation due to the global COVID-19 pandemic. The selected driving parameters were:

- LPOSC–Leadership, Policy, and Organizational Structure of the Company
- PCMPD–Process Culture, Management Processes, and Production Deadlines
- RPQP–Range of Products and Quality of Products
- MMAC–Marketing and Market Activities of the Company
- HR–Human Resources
- ITMPT–Information Technology and Modern Production Technology
- EFP–Environmentally friendly production.

Twenty experts in wood processing and furniture manufacturing from Slovenia and Croatia from the fields of management, production and marketing evaluate them using AHP method.

For the derivation of weights by BWM, the parameter with the highest weight in AHP was chosen as the best and the parameter with the lowest weight in AHP as the worst. Then pairwise comparisons from AHP of these two parameters with the others were used to calculate their weights. For the derivation of weights by FUCOM, the judgments of best to others parameters already used in BWM were used.

## 3. RESULTS

### 3.1. The solution of the model in FUCOM

When real numbers are used for pairwise comparisons in FUCOM, the solution of the model (6) is  $\chi = 0$  and the weights of the elements can be calculated explicitly, without having

to solve a nonlinear model. The weights  $w_1, w_2, \dots, w_n$  of the elements  $E_1 \pm E_2 \pm E_3 \pm \dots \pm E_n$ , where  $\pm$  indicates “is equally important or more important” can be calculated as follows:

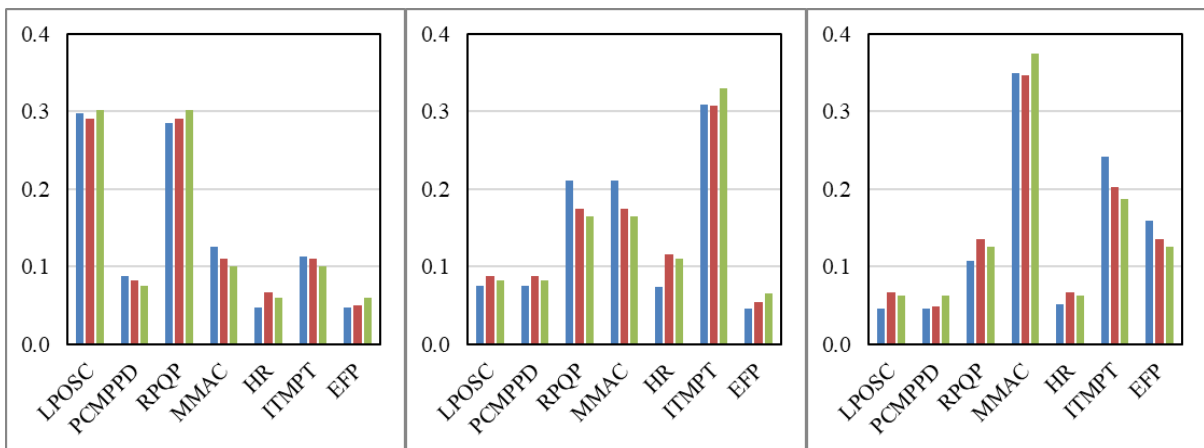
$$w_k = \frac{\varphi_{k/(k+1)} \varphi_{(k+1)/(k+2)} \cdot \dots \cdot \varphi_{(n-1)/n}}{1 + \varphi_{(n-1)/n} + \varphi_{(n-2)/(n-1)} \varphi_{(n-1)/n} + \varphi_{(n-3)/(n-2)} \varphi_{(n-2)/(n-1)} + \dots + \varphi_{1/2} \varphi_{2/3} \varphi_{3/4} \cdot \dots \cdot \varphi_{(n-1)/n}}, \quad k = 1, \dots, n-1 \quad (7)$$

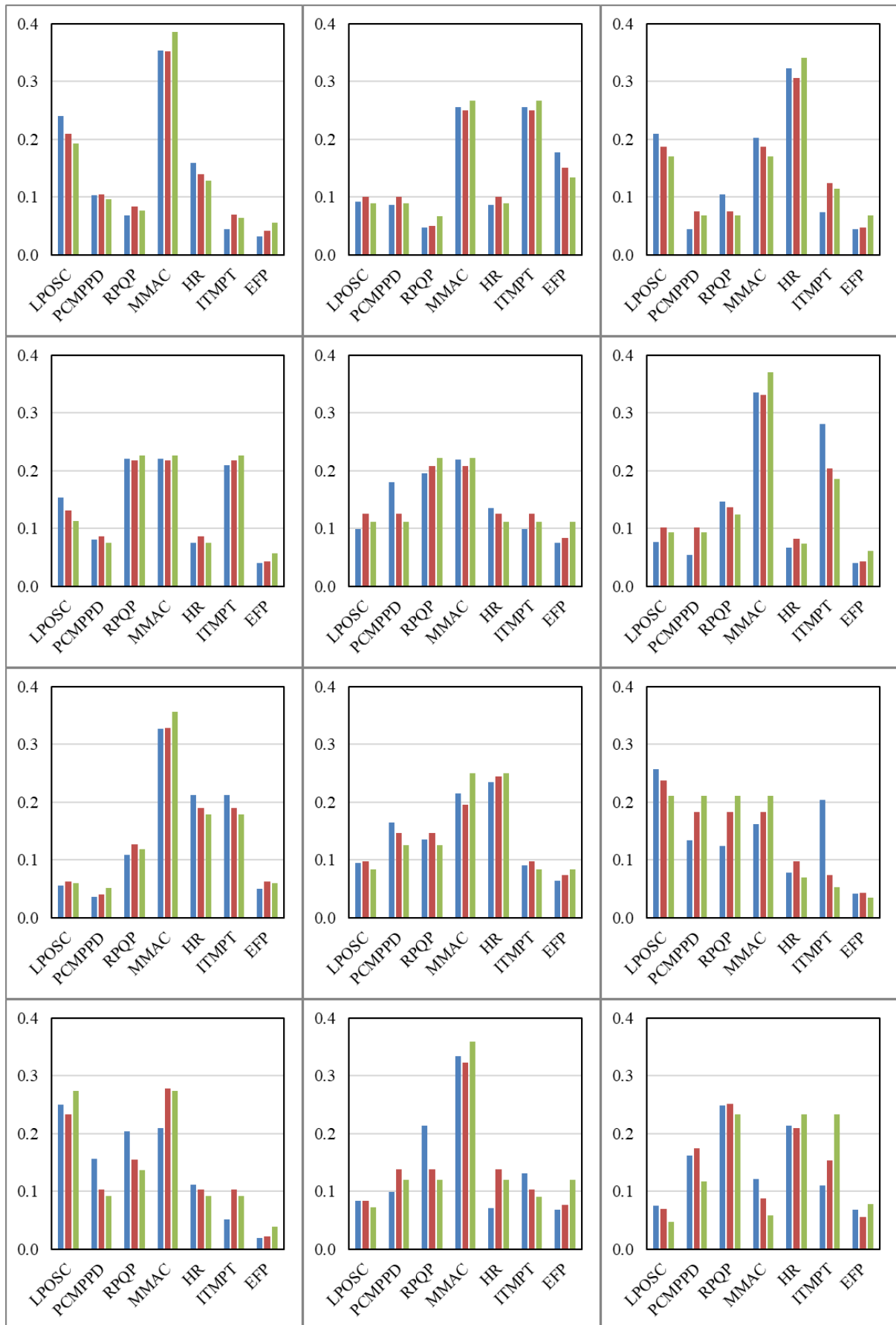
$$w_n = \frac{1}{1 + \varphi_{(n-1)/n} + \varphi_{(n-2)/(n-1)} \varphi_{(n-1)/n} + \varphi_{(n-3)/(n-2)} \varphi_{(n-2)/(n-1)} + \dots + \varphi_{1/2} \varphi_{2/3} \varphi_{3/4} \cdot \dots \cdot \varphi_{(n-1)/n}}$$

It is obvious that these weights fulfil the constraints  $\frac{w_k}{w_{k+1}} = \varphi_{k/(k+1)}$  and  $\frac{w_k}{w_{k+2}} = \varphi_{k/(k+1)} \varphi_{(k+1)/(k+2)}$  for all  $k$ , so that all conditions of the FUCOM method are satisfied and complete consistency is guaranteed.

### 3.2. The weights of the driving parameters

The weights of seven driving parameters were calculated by AHP, BWM and FUCOM for 20 experts (Figure 1). The consistency of the judgments was assessed by CR in AHP and by the output-based consistency measure  $\xi$  as well as by the input-based CR in BWM, while the judgments in FUCOM are completely consistent. The twenty small graphs in Figure 1 are sorted by ascending CR in AHP. The results show that the ranking and the weights of parameters are more similar in the first few graphs where the consistency of judgments in AHP is high. If the weights of the parameters are similar, their ranking may vary depending on the method. The highest weight determined by FUCOM is often slightly higher than the highest weight determined by AHP or BWM. With higher but still acceptable inconsistency of judgement AHP, the ranking and weights differ significantly between the methods.





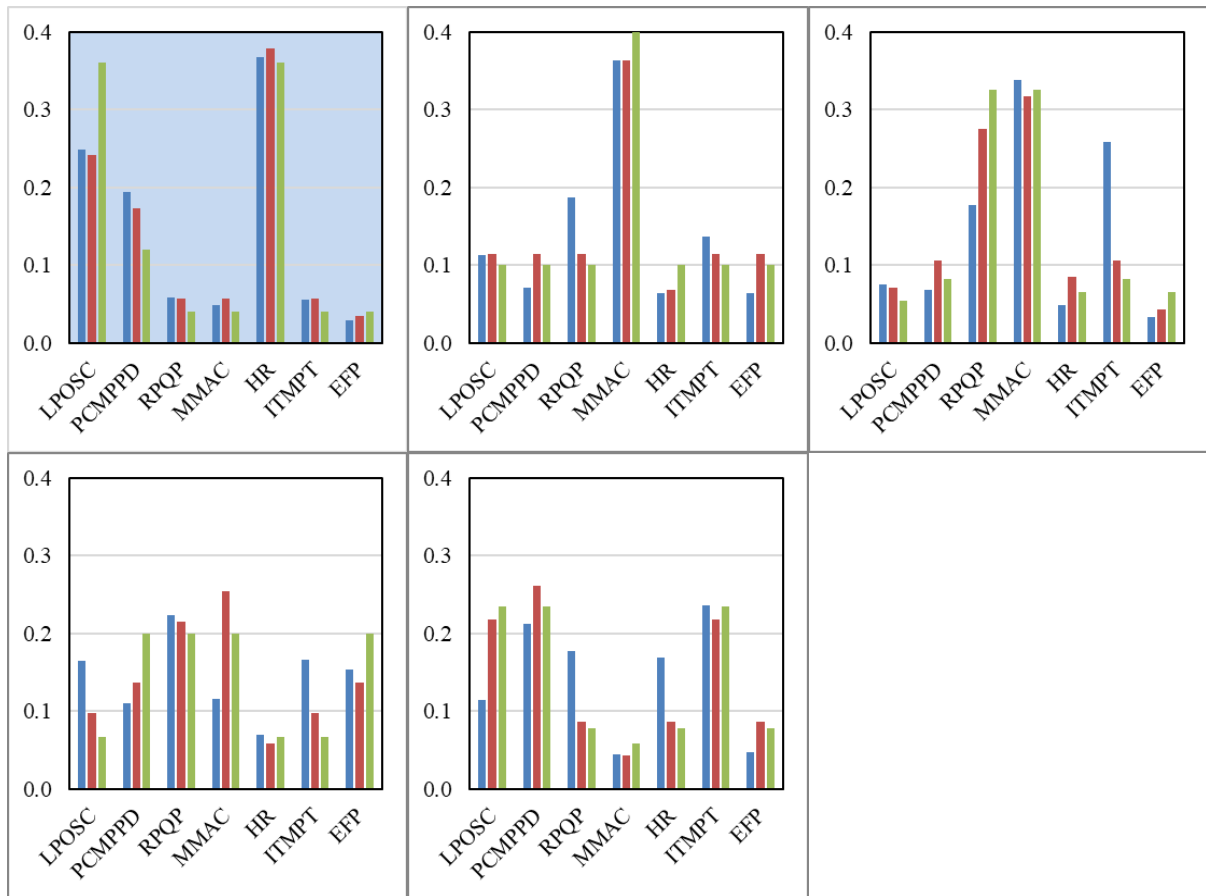


Figure 1. The weights of seven driving parameters, calculated by AHP (blue columns), BWM (red columns) and FUCOM (green columns) for 20 experts, sorted by ascending CR in AHP

In such cases, the additional pairwise comparisons in AHP provide further information to obtain more reliable weights. For example, in the graph with the blue background, the  $CR_{AHP} = 0.113$  was slightly above the threshold 0.1, the  $CR_{BWM}^{input-based} = 0.250 < 0.352$  was below the threshold, while the output-based BWM consistency measure  $\xi = 0.138$  was the highest among all 20 experts. The expert rated the HR parameter as the most important, with comparisons to the other parameters presented in Table 1. The FUCOM method results show only three different values for the weights, with the weights of HR and LPOSC being the highest and equal, while the weights of RPQP, MMAC, ITMPT and EFP are also equal and smallest. The BWM weights differ between HR with the highest value and LPOSC with the second highest value. However, the weights of RPQP, MMAC and ITMPT are still the same. The AHP weights of HR and LPOSC are similar to the BWM weights, while additional AHP pairwise comparisons help to assign unique weights and rankings to the other parameters.

Table 1. Pairwise comparisons of parameter HR with other parameters

Best to Others	LPOSC	PCMPPD	RPQP	MMAC	HR	ITMPT	EFP
HR	1	3	9	9	1	9	9

### 3.3. The consistency of the results

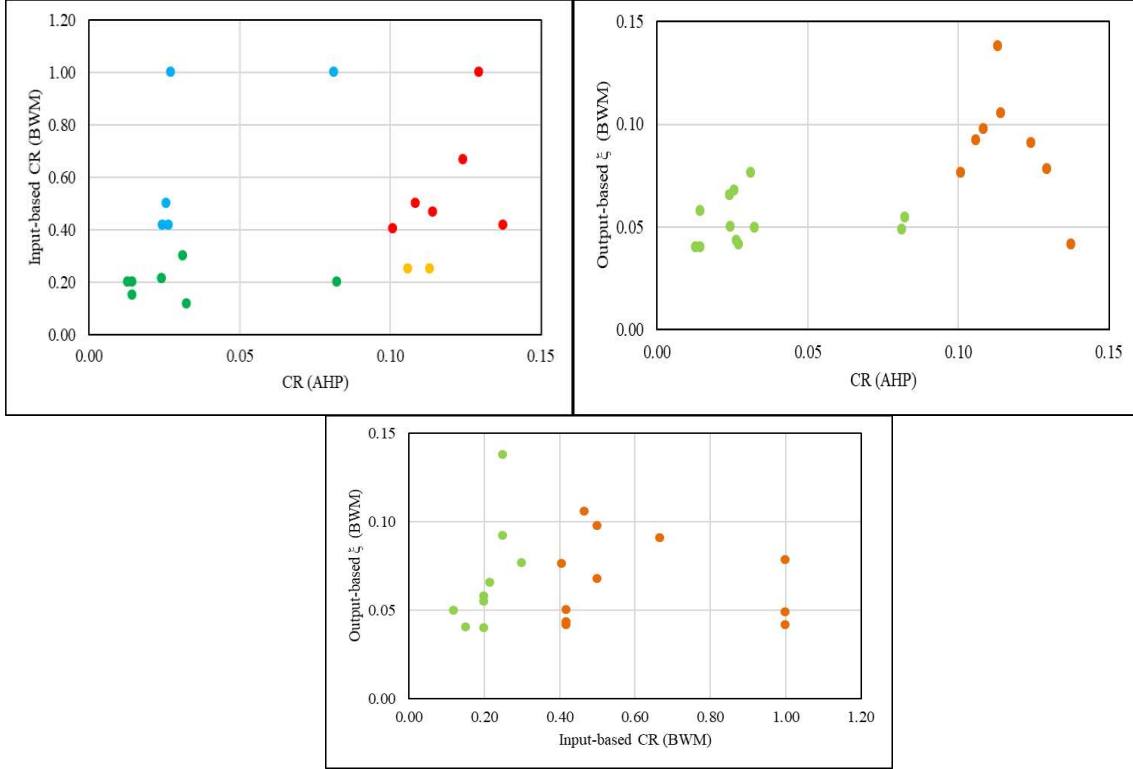


Figure 2. Correlation between consistency measures

Figure 2 shows the correlation between all three pairs of consistency measures. When comparing the consistency of pairwise comparisons in AHP and BWM, Pearson correlation coefficient indicates a higher correlation between CR (AHP) and output-based  $\xi$  (BWM) ( $r_p = 0.59$ ) than between CR (AHP) and input-based CR (BWM) ( $r_p = 0.33$ ). The most surprising result is the non-existent correlation between input-based CR (BWM) and output-based  $\xi$  (BWM) ( $r_p = -0.02$ ). In Figure 1, in the upper left graph green dots represent experts with  $CR_{AHP} < 0.1$  and  $CR_{BWM}^{input-based} < t$ , where  $t$  is the threshold for acceptable consistency, depending on  $a_{BW}$ . Blue dots represent experts with  $CR_{AHP} < 0.1$  and  $CR_{BWM}^{input-based} > t$  and yellow dots represent experts with  $CR_{AHP} > 0.1$  and  $CR_{BWM}^{input-based} < t$ . Red dots represent experts with  $CR_{AHP} > 0.1$  and  $CR_{BWM}^{input-based} > t$ . We see that all four combinations occur and that  $CR_{AHP} < 0.1$  does not indicate acceptable consistency in BWM. In Figure 1, in the upper right graph green dots represent experts with  $CR_{AHP} < 0.1$ , while orange dots represent experts with  $CR_{AHP} > 0.1$ . The threshold for the acceptable output-based  $\xi$  (BWM) does not exist. The results in Figure 1, in the lower graph green dots represent experts with  $CR_{BWM}^{input-based} < t$ , while orange dots represent experts with  $CR_{BWM}^{input-based} > t$ , indicating that the measurement method of consistency of pairwise comparisons in BWM is unclear. The two measures presented provide very contradictory results and should be studied in more detail in the future.



#### 4. DISCUSSION

In the literature, many authors (Fazeli & Peng, 2023; Omrani et al., 2020) cite the reasons given by Rezaei (2015) when the BWM was first introduced as the reason for choosing the BWM instead of the AHP: fewer pairwise comparisons and greater consistency.

*Table 2.* Number of pairwise comparisons regarding the number of compared elements in AHP, BWM and FUCOM

Number of elements	3	4	5	6	7	8	9	$n$
AHP	3	6	10	15	21	28	36	$n(n-1)/2$
BWM	3	5	7	9	11	13	15	$2n-3$
FUCOM	2	3	4	5	6	7	8	$n-1$

Table 2 clearly shows that the number of pairwise comparison is lower for BWM and even lower for FUCOM. However, the results of our study clearly show that a lower number of pairwise comparisons is not always an advantage. While fewer pairwise comparisons can shorten the time for evaluation they provide less information that influences the calculation of weights and can therefore lead to less reliable weights. Especially in cases with low but still acceptable consistency, additional pairwise comparisons in AHP can provide crucial information that can influence the ranking of parameters. Furthermore, the cognitive load on the experts does not only depend on the number of pairwise comparisons required. In BWM, the experts have to determine the best and the worst parameter, while in FUCOM the entire ranking of the parameters has to be determined before pairwise comparisons can be performed. If the parameters are similarly important, this might not be an easy task for the experts. The authors in literature claim that the main advantage of a smaller number of pairwise comparisons is greater consistency, which is not confirmed in our study. A similar result was also presented in (Grošelj et al., 2021). Our study shows a low to medium correlation of AHP and BWM consistency. It also shows that the measurement of consistency in BWM is still an open question.

#### 5. CONCLUSION

In the study, we have compared three MCDM methods, based on pairwise comparisons, namely AHP, BWM and FUCOM. While BWM and FUCOM are more often used in recent studies, with the main reason being fewer pairwise comparisons and greater consistency, those reasons are often not justified. Our study shows the problems in measuring consistency in BWM and does not confirm the claim of greater consistency compared to AHP. For FUCOM, we presented formulas to calculate consistent weights without solving a nonlinear model. The consistency of the weights combined with a very low number of pairwise comparisons makes FUCOM an attractive method. However, the amount of information in FUCOM is also very small compared to AHP. We therefore conclude that AHP is indeed a very sound method, and that while the higher number of pairwise comparisons required may be a disadvantage for AHP, it is also its advantage in terms of providing more information that yields very reliable weights. More in-depth analysis is needed in the future to better substantiate our claims.

#### ACKNOWLEDGMENT

**Funding:** This study was supported by the Slovenian Research Agency, Research Programs P4-0059.

## REFERENCES

- Akbari, M., Meshram, S. G., Krishna, R., Pradhan, B., Shadeed, S., Khedher, K. M., Sepehri, M., Ildoromi, A. R., Alimerzaei, F., & Darabi, F. (2021). Identification of the groundwater potential recharge zones using MCDM models: full consistency method (FUCOM), best worst method (BWM) and analytic hierarchy process (AHP). *Water Resources Management*, 35, 4727-4745. <https://doi.org/https://doi.org/10.1007/s11269-021-02924-1>
- AL-Juaidi, A. E. (2025). Enhancing flood vulnerability assessment in eastern Jeddah watersheds using advanced multicriteria decision analysis and sensitivity evaluation. *Environment, Development and Sustainability*, 1-28. <https://doi.org/https://doi.org/10.1007/s10668-025-06098-3>
- Behzadian, M., Kazemzadeh, R. B., Albadvi, A., & Aghdasi, M. (2010). PROMETHEE: A comprehensive literature review on methodologies and applications. *European journal of Operational research*, 200(1), 198-215. <https://doi.org/https://doi.org/10.1016/j.ejor.2009.01.021>
- Ekin, E., & Sarul, L. S. (2022). Investigation of smart city components by AHP-BWM-FUCOM and DEMATEL methods. *Alphanumeric Journal*, 10(2), 197-222. <https://doi.org/https://doi.org/10.17093/alphanumeric.1210018>
- Fazeli, H. R., & Peng, Q. (2023). Integrated approaches of BWM-QFD and FUCOM-QFD for improving weighting solution of design matrix. *Journal of Intelligent Manufacturing*, 34(3), 1003-1020. <https://doi.org/https://doi.org/10.1007/s10845-021-01832-w>
- Grošelj, P., Dolinar, G., & Šmidovnik, T. (2021). *Comparison of Best-Worst Method and Analytic Hierarchy Process* Proceedings of the 16th International Symposium on Operational Research in Slovenia, SOR'21, Ljubljana.
- Jelačić, D., Pirc Barčič, A., Oblak, L., Motik, D., Grošelj, P., & Jošt, M. (2021). Sustainable production management model for small and medium enterprises in some south-central EU countries. *Sustainability*, 13(11), 6220. <https://doi.org/https://doi.org/10.3390/su13116220>
- Liang, F., Brunelli, M., & Rezaei, J. (2020). Consistency issues in the best worst method: Measurements and thresholds. *Omega*, 96, 102175. <https://doi.org/https://doi.org/10.1016/j.omega.2019.102175>
- Omran, H., Alizadeh, A., & Naghizadeh, F. (2020). Incorporating decision makers' preferences into DEA and common weight DEA models based on the best-worst method (BWM). *Soft Computing*, 24, 3989-4002. <https://doi.org/https://doi.org/10.1007/s00500-019-04168-z>
- Pamučar, D., Stević, Ž., & Sremac, S. (2018). A new model for determining weight coefficients of criteria in mcdm models: Full consistency method (fucom). *symmetry*, 10(9), 393. <https://doi.org/https://doi.org/10.3390/sym10090393>
- Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, 53, 49-57.
- Rezaei, J. (2016). Best-worst multi-criteria decision-making method: Some properties and a linear model. *Omega*, 64, 126-130. <https://doi.org/https://doi.org/10.1016/j.omega.2015.12.001>
- Saaty, T. L. (1980). *The analytic hierarchy process*. McGraw-Hill.
- Sahoo, S. K., & Goswami, S. S. (2023). A comprehensive review of multiple criteria decision-making (MCDM) Methods: advancements, applications, and future directions. *Decision Making Advances*, 1(1), 25-48. <https://doi.org/https://doi.org/10.31181/dma1120237>

- Si, S.-L., You, X.-Y., Liu, H.-C., & Zhang, P. (2018). DEMATEL Technique: A Systematic Review of the State-of-the-Art Literature on Methodologies and Applications. *Mathematical Problems in Engineering*, 2018, 3696457. <https://doi.org/10.1155/2018/3696457>
- Srdjevic, B., Srdjevic, Z., Reynolds, K. M., Lakicevic, M., & Zdero, S. (2022). Using analytic hierarchy process and best–worst method in group evaluation of urban park quality. *Forests*, 13(2), 290. <https://doi.org/https://doi.org/10.3390/f13020290>



## THE ROLE OF MANAGERS IN OPTIMIZING BUSINESS PROCESSES IN THE IT INDUSTRY

Zorana Janković<sup>1</sup>\*, Snežana Urošević<sup>2</sup>

<sup>1</sup>PhD student, University of Belgrade, Technical faculty in Bor, Serbia

<sup>2</sup>University of Belgrade, Technical faculty in Bor, Serbia

**Abstract:** In the modern business environment, business process optimization has an important role in achieving competitive advantage, especially in the dynamic IT industry. Managers in this industry must be skilled at identifying inefficiencies within business processes and guiding teams to implement innovative solutions that improve overall performance. Optimization involves the systematic improvement of operational activities through the identification of inefficiencies, elimination of redundant steps, automation of tasks, and implementation of innovative technological solutions. This paper aims to explore the role of managers in business process optimization. A quantitative study was conducted using an online survey. The research results indicate that business processes are optimized at a high level, although many respondents recognize opportunities for further improvement. Managers frequently initiate process improvement initiatives, with Agile and Lean management being the most commonly used approaches in IT companies. ANOVA analysis showed that, in most cases, there are no significant differences in the perception of business process optimization concerning managerial position.

**Keywords:** Business processes, optimization, managers, IT industry.

### 1. INTRODUCTION

The IT industry is a dynamic sector where innovation and rapid technological development dictate business conditions. Organizations face challenges arising from the need to quickly adapt to new technologies, market trends, and user demands. In order to remain competitive, organizations must frequently optimize their business processes. Managers play a crucial role in this process, as their decisions, skills, and approach directly impact performance. Quality management is essential for the functioning of business systems.

This paper explores the role of managers in the optimization of business processes in the IT sector, focusing on their ability to identify the need for process improvement, use modern

---

\* Corresponding author: zoranajankovic2001@gmail.com

Zorana Janković, ORCID: 0009-0008-6265-1454

Snežana Urošević, ORCID: 0000-0002-6647-0449

tools and techniques, and measure success. Daines (2011, p. 128) defines a business process as "a series of interconnected activities that cross functional boundaries." Business process optimization involves the continuous improvement of existing procedures. Current business trends and constant market changes demand that managers increasingly focus on business processes and their efficiency (Zahar Đorđević, 2019).

The first part of the paper presents the theoretical framework of the research, which includes defining business processes and business process optimization, as well as the main optimization methods and the role of managers in this process. The main optimization methods presented in the paper are Agile Management, the Lean approach, Six Sigma, Business Process Reengineering, and Total Quality Management. The next part of the paper presents the research methodology, along with the presentation and interpretation of the research results. Finally, the paper concludes with a summary and a list of references.

## **2. BUSINESS PROCESSES AND BUSINESS PROCESS OPTIMIZATION**

Rentzhog (2000) states that a process represents a chain of activities that, through feedback loops, creates value for consumers. Vukšić et al. (2008, p. 17) define a business process as "a structured and analytical cross-functional set of activities that requires continuous improvement. It consists of activities with clearly established beginnings and endings, during which value is created for consumers at more or less regular intervals." Dobrosavljević and Urošević (2019b) define business processes as a complex network of interconnected activities, whose role in organizational operations is reflected in the creation of value for consumers. A business process encompasses a series of activities, steps, or tasks, with each activity defined by its inputs and outputs (Daines, 2011). Dobrosavljević and Urošević (2020) emphasize that an appropriate approach to managing these processes enables an organization to achieve flexibility and agility.

Zahar Đorđević (2019) points out that the inputs and outputs of a process can be tangible, such as documents, records, or (semi)finished products, but also intangible, such as services, data, requests, or decisions. The most common inputs into a process include customer information, materials, service execution requests, work plans, events, changes, and proposals. Common outputs include processed materials, completed services, invoices, reports, analyses, improvement proposals, projects, and technological procedures.

Rentzhog (2000) argues that processes can be improved through supporting activities and preventive measures. Supporting activities involve identifying and analyzing problems to determine root causes and develop appropriate solutions. Preventive improvement efforts focus on actively seeking improvement opportunities before problems occur. Vukšić et al. (2008) note that when improving business processes, it is important to focus on key processes that generate value, as this helps avoid unnecessary costs associated with improving "wrong" processes. Process optimization is particularly oriented towards increasing value for both the customer and the company (Bojanić, 2021).

Buble (2010) emphasizes that one of the main characteristics of process orientation is the striving for constant improvements. Since every attempt to enhance organizational efficiency constitutes a whole, such improvements are usually implemented through a series of projects aimed at improving business processes. Whether through radical redesign of business processes to dramatically improve performance or through the introduction of continuous and less drastic improvements leading to increased competitiveness, efficiency, and flexibility of the organization, both approaches are essential.

According to Dobrosavljević and Urošević (2020), improving business processes leads to greater efficiency, enhanced customer service, improved information and data flow, more

effective use of information technology, and the reduction of repetitive tasks within processes. Business process improvement initiatives range from marginal continuous improvements to business process reengineering. Business processes vary from one organization to another, depending on industry needs, so the process improvement methodology must be tailored to individual organizations. Business process management focuses on achieving efficiency and effectiveness, regardless of whether the processes are creative or labor-intensive.

The most important business process optimization methods, according to Dobrosavljević and Urošević (2019a) are Agile Management, Lean Management, Six Sigma, Business Process Reengineering (BPR), and Total Quality Management (TQM). Sweeney and Cifuentes (2010) highlight that the Agile approach is a set of management principles that can be applied to almost any process driven by the development of functionalities. The goal of the Agile approach is to deliver functional, potentially shippable product units within a limited time frame. Meanwhile, Lean production is defined as “a systematic approach to identifying and eliminating waste (activities that do not add value) through continuous improvement by changing products and services according to customer demand in the pursuit of perfection” (Adams et al., 1999, p. 1092). According to El-Sayed (2013), one of the main drivers of Lean thinking is the simplification of processes, requiring processes to have a minimal number of steps.

Stojanović (2016) defines Six Sigma as an approach that enables organizations to drastically improve their core operations by designing and monitoring daily business activities in a way that minimizes resource waste while simultaneously increasing customer satisfaction. Business Process Reengineering can be defined as “the radical redesign of business processes to achieve dramatic improvements in business performance” (Riposo et al., 2013, p. 19). Kapor and Lizdek (2023) state that Business Process Reengineering fundamentally changes business practices to achieve better overall effects in terms of cost, service quality, speed, and expertise; it is applied in cases where dramatic solutions to specific inefficiencies are required. Ireh (1994, p. 9) defines Total Quality Management as “a comprehensive philosophy of life and work within organizations that emphasizes a continuous striving for constant improvement.”

### **3. THE ROLE OF MANAGERS IN BUSINESS PROCESS OPTIMIZATION**

Caples (1965) emphasizes that when we talk about managers, we usually refer to a group of individuals employed by a company, paid by that company, and expected to manage operations for the benefit of another group of people—the owners. The work of management is often defined as planning, organizing, and controlling a business enterprise, or as the allocation of resources to achieve the desired goal of producing goods or services at the lowest possible cost. Management can also be defined as the art or science of leading people and managing organizations to achieve goals set by others (Caples, 1965). As Srivastava (2020) states, managers have always strived to improve working conditions, business practices, job satisfaction, and worker productivity.

Human resources represent one of the key variables that determine the success of an enterprise, and they are also a crucial factor in the success of implementing organizational improvement programs. Considering the central role of people in programming measures to enhance organizational processes highlights the importance of motivating the actors involved in business process improvement projects (Buble, 2010). Ankli and Sommer (1996) point out that it is the task of management to anticipate the future and to shape and align the short-term and long-term goals of the organization. Long-term planning should prevent managers from uncritically projecting current trends into the future and assuming that today’s products, services, markets, and technologies will remain unchanged.

Mohanty (2016) states that an organization's success depends equally on the skills and motivation of its members as it does on other key factors. The modern pace of change emphasizes the importance of human resource development activities in preparing members of the organization to successfully overcome challenges. The difference between success and failure in a corporation often lies in how effectively the organization utilizes the energy and talents of its employees (Ralston, 1985).

Human resource management includes the planning, recruitment, training, and retention of a qualified workforce, representing a key aspect of managerial activities. It focuses on continuous development, achievement of business goals, as well as on the motivation, fulfillment of needs, and retention of competent employees. The role of people has been identified as one of the key factors in the success or failure of business process improvement initiatives (Dobrosavljević & Urošević, 2020).

## **4. RESULTS OF THE CONDUCTED RESEARCH**

### **4.1. Research methodology**

The research focuses on the role of managers in the process of business process optimization within the IT industry. The study explores how managers in the IT sector contribute to the improvement of business processes through the application of various optimization methodologies. It examines the current level of business process optimization in companies, areas for improvement, the extent to which managers initiate optimization initiatives, as well as the effectiveness of the tools and technologies they use. Furthermore, the research investigates how managers monitor and measure the success of optimization efforts.

The study involved 79 managers working in the IT sector. The research was conducted from December 2024 to February 2025. Data were collected through an online survey created specifically for this research, using multiple-choice questions and a Likert-type scale. The questionnaire consists of 15 questions, three of which relate to the demographic structure of the respondents. Data were processed using the SPSS software. To examine differences between groups of managers, an ANOVA test was applied.

### **4.2. Presentation of research results**

#### **4.2.1. Demographic data**

In the research, 79 respondents participated, of which 38% are first-line managers, 57% are middle managers, and 5.1% belong to top management. As shown in Table 1, the majority of respondents (92.4%) are employed in companies with more than 100 employees, while 5.1% work in companies with 10 to 49 employees. A smaller number of managers (2.5%) work in companies with 50 to 100 employees. The largest portion of the sample (44.3%) consists of managers with 10 to 20 years of work experience, while 36.7% of respondents have between 5 and 10 years of experience. Managers with less than 5 years of experience make up 12.7% of the sample, while 6.3% of respondents have over 20 years of work experience.

Table 1. Demographic data

		Frequency	Percent
Position in company	First-line menager	30	38.0
	Middle menager	45	57.0
	Top menager	4	5.1
	Total	79	100.0
Numbers of employees in company	10 to 49	4	5.1
	50 to 100	2	2.5
	More than 100	73	92.4
	Total	79	100.0
Years of work experience	Up to 5 years	10	12.7
	5 to 10 years	29	36.7
	10 to 20 years	35	44.3
	Over 20 years	5	6.3
	Total	79	100.0

#### 4.2.2. Descriptive statistics results

Based on the results of the conducted research, we can conclude that the majority of managers in the IT industry believe that business processes are optimized at a high level (54.5%). However, there is a certain number of individuals who have a neutral stance or believe that optimization is not at a satisfactory level. Although a higher percentage of respondents believe that business processes are optimized, a significant number of managers (38%) still believe that there is room for improvement. Managers often initiate process improvements, with 35.4% of respondents answering "true," while 26.6% selected the answer "completely true" (Table 2).

Table 2. Methodologies used in the optimization process in IT companies

		Responses	
		N	Percent
Methodologies used	Agile Management (Scrum, Kanban)	72	60.5%
	Lean Management	27	22.7%
	SIX Stigma	4	3.4%
	Business Process Reengineering (BPR)	11	9.2%
	Total Quality Management (TQM)	5	4.2%
Total		119	100.0%

The results also show that Agile Management (Scrum, Kanban) is the most commonly used methodology in companies, applied by 60.5% of the respondents. Lean Management ranks second with 35.5%, while other methodologies are used to a lesser extent: Business Process Reengineering (BPR) at 14.5%, Total Quality Management (TQM) at 6.6%, and Six Sigma at only 5.3%.

#### 4.2.3. Results of the ANOVA test by managerial position in the company and discussion

As shown in Table 3, the results of the ANOVA analysis indicate that there are no significant differences between the groups of respondents regarding the perception of business process optimization, the space for improvement, and the frequency of managerial initiatives.



*Table 3. ANOVA – The impact of managerial position on responses regarding business process optimization*

Question	Between Groups	
	F	Sig.
Business processes in the company are optimized at a high level.	.226	.798
There is significant room for improvement of business processes in the company.	.084	.920
Managers in the company often initiate initiatives to improve business processes.	.479	.621

The results suggest that there are no statistically significant differences between the groups regarding the above-mentioned questions (Table 4).

*Table 4. ANOVA – The impact of managerial position on responses regarding tools and techniques for optimization*

Question	Between Groups	
	F	Sig.
The tools used by managers significantly contribute to the efficiency of business processes.	.250	.779
Managers regularly update and improve tools and technologies for business process optimization.	3.019	.055
Managers use automated tools for business process optimization.	2.175	.121

The results of the ANOVA test, presented in Table 5, indicate that for most questions, there are no significant differences in the responses based on the managerial position. The only significant difference in responses is related to the use of clearly defined metrics for monitoring the success of business process optimization. Top managers use these metrics less frequently compared to middle-level managers. No significant difference was observed for other questions among managers working at different levels.

*Table 5. ANOVA – The impact of managerial position on responses regarding the efficiency and measurement of optimization*

Question	Between Groups	
	F	Sig.
The parameters monitored by managers reliably indicate the success of business process optimization.	.367	.694
Managers use clearly defined metrics to monitor the success of business process optimization.	3.843	.026
Managers regularly evaluate the effectiveness of the tools they use for business process optimization.	2.175	.121

## 5. CONCLUSION

Based on the conducted research, we can conclude that business processes in the IT industry are optimized at a high level, but there is still room for further improvements. Managers frequently initiate business process improvement efforts and use various tools and methodologies. Agile management is the most prevalent approach in the industry, with Lean management coming in second. The ANOVA analysis showed that, in most cases, there are no significant differences in the perception of business process optimization based on the position of the manager. The result indicates that, regardless of their position, managers assess how business process optimization works in their organization in a similar way. A significant difference in responses exists only regarding the use of clearly defined metrics to monitor the

success of business process optimization. This difference in perception regarding metrics may point to a communication gap between different levels of management, as well as a need for better defining, communicating, and using performance indicators across all organizational levels. Future research can analyze the impact of specific methodologies such as Lean management, Six Sigma, TQM, or BPR on the efficiency of business processes in the IT industry. Additionally, optimization processes in companies of different sizes, as well as in other related sectors, can be explored.

## REFERENCES

- Adams, M., Compton, P., Czarnecki, H., & Schroer, B. (1999). Lean Manufacturing: How to Start, Support and Sustain. *SAE Transactions*, 108, 1092–1097. <http://www.jstor.org/stable/44650723>
- Ankli, R. E., & Sommer, E. (1996). The Role of Management in the Decline of the American Steel Industry. *Business and Economic History*, 25(1), 217–231. <http://www.jstor.org/stable/23703117>
- Bojanić, T. (2021). Integrated risk management model in business processes within industrial systems (Integrirani model menadžmenta rizika u poslovnim procesima u industrijskim sistemima). (Doktorska disertacija, Univerzitet u Novom Sadu). (in Serbian)
- Bosilj Vukšić, V., HERNANUS, T. & KOVAČIĆ, A. (2008). Business process management – organizational and information approach (*Upravljanje poslovnim procesima - organizacijski i informacijski pristup*). Školska knjiga. Zagreb. (in Croatian)
- Buble, M. (2010). The Impact of Organizational Variables on the Success of Business Process Improvement Programs (*Uticaj organizacijskih varijabli na uspeh programa unapređenja poslovnih procesa*). Sveučilišna knjižnica u Splitu (in Croatian)
- Caples, W. G. (1965). The Traditional Role of Management. *Current History*, 49(287), 9–52. <http://www.jstor.org/stable/45311332>
- Daines, J. G. (2011). Re-engineering Archives: Business Process Management (BPM) and the Quest for Archival Efficiency. *The American Archivist*, 74(1), 123–157. <http://www.jstor.org/stable/23079004>
- Dobrosavljević, A. & Urošević, S. (2020). The impact of human resource management on business process improvement: an analysis within the MSMEs of the textile and clothing industry. *BizInfo*, 11(2), 19-32. <https://doi.org/10.5937/bizinfo2002019D>
- Dobrosavljević, A. (2019). Managing the creative and labor-intensive business processes of the apparel industry. *Tekstilna industrija*, 67(4), 58-66. <https://doi.org/10.5937/tekstind1904058D>
- Dobrosavljević, A. U. & Urošević, S. M. (2019a). Evaluation of performance orientation and process improvement in manufacturing organizations (Evaluacija usmerenosti na performanse i poboljšanja procesa u proizvodnim organizacijama). *Tehnika – Menadžment*, 69. <https://doi.org/10.5937/tehnika1902287D> (in Serbian)
- Dobrosavljević, A. U. & Urošević, S. M. (2019b). Factors influencing the adoption of business process management practices in labor-intensive industries (Faktori usvojenosti prakse upravljanja poslovnim procesima u radnointenzivnim delatnostima). *Tehnika – Menadžment*, 69. <https://doi.org/10.5937/tehnika1906861D> (in Serbian)
- Dobrosavljević, A., & Urošević, S. (2020). Prioritization of key activities on establishment of BPM practice in apparel organizations. *Textile and Apparel*, 30(3), 190-199. <https://doi.org/10.32710/tekstilvekonfeksiyon.672312>

- El-Sayed, M. (2013). Lean Implementation in Integrated Design and Manufacturing. *SAE International Journal of Materials and Manufacturing*, 6(3), 487–493. <http://www.jstor.org/stable/26268545>
- Ireh, M. (1994). Applying the Deming TQM Philosophy to the School Setting. *American Secondary Education*, 22(3), 8–15. <http://www.jstor.org/stable/41064071>
- Kapor, N. & Lizdek, N. (2023). Business Process Reengineering through the Application of ICT in Modern Business (Reinženjering poslovnih procesa kroz primjenu IKT u savremenom poslovanju). *Turizam u funkciji razvoja domaćeg poljoprivredno-prehrambenog sektora*. (in Serbian)
- Mohanty, S. K. (2016). Human Resource Development Practices in IT Industry. *Indian Journal of Industrial Relations*, 52(2), 321–335. <http://www.jstor.org/stable/44840817>
- Ralston, D. A. (1985). Employee Ingratiation: The Role of Management. *The Academy of Management Review*, 10(3), 477–487. <https://doi.org/10.2307/258129>
- Rentzhog, O. (2000). Foundations of the enterprise of tomorrow – a process-oriented business philosophy (Temelji preduzeća sutrašnjice – procesima usmerena poslovna filozofija). Prometej. Novi Sad. (in Serbian)
- Riposo, J., Weichenberg, G., Duran, C. K., Fox, B., Shelton, W., & Thorsen, A. (2013). Business Process Reengineering. In *Improving Air Force Enterprise Resource Planning-Enabled Business Transformation* (pp. 19–22). RAND Corporation. <http://www.jstor.org/stable/10.7249/j.ctt5hhvgh.12>
- Srivastava, K. B. L. (2000). Rethinking HR: Role of HR Professionals in a Changing Business Environment. *Indian Journal of Industrial Relations*, 35(4), 532–544. <http://www.jstor.org/stable/27767684>
- Stojanović, D. D. (2016). A model for business process selection and a methodology for their improvement (Model za selekciju poslovnih procesa i metodologija njihovog poboljšanja). (Doktorska disertacija, Univerzitet u Beogradu). (in Serbian)
- Sweeney, D. S., & Cifuentes, L. (2010). Using Agile Project Management to Enhance the Performance of Instructional Design Teams. *Educational Technology*, 50(4), 34–41. <http://www.jstor.org/stable/44429839>
- Zahar Đorđević, M. S. (2019). Business process performance management in small and medium-sized manufacturing enterprises (Upravljanje performansama poslovnih procesa u malim i srednjim proizvodnim preduzećima). (Doktorska disertacija, Univerzitet u Kragujevcu). (in Serbian)



## TRENDS AND DETERMINANTS OF STUDENTS' ENTREPRENEURSHIP INTEREST AND CAREER ASPIRATIONS ABROAD: A COMPARATIVE STUDY OF ALBANIA AND BULGARIA

Fatma Jaupi<sup>1 \*</sup>, Anisa Kume<sup>1</sup>, Daniel Pavlov<sup>2</sup>

<sup>1</sup> University of Tirana, Faculty of Economy, Albania

<sup>2</sup> University of Ruse "Angel Kunchev", Bulgaria

**Abstract:** This research paper presents some findings on the evolution of entrepreneurial intention among Albanian and Bulgarian students and their career aspirations. Additionally, this research analyzes their life satisfaction and reasons to continue their careers in their home country from 2020-2023. The dataset is composed of 600 responses from students in each country, 1200 students interviewed in total, evenly distributed in both countries. The findings illustrate differences in entrepreneurial intentions towards future career opportunities overseas, with major contrasts between the two countries. Notably, the results indicate that students who prefer to work abroad are likely to be entrepreneurs. Gender-based analysis revealed that male students have better entrepreneurial aspirations, while female students will likely consider seeking career opportunities abroad. Furthermore, the study provides empirical evidence to inform educational institutions and governments too, with a focus on the significance of quality entrepreneurial education and cross-border employment opportunities.

This study contributes to the existing literature by integrating theoretical frameworks such as the Theory of Planned Behavior and Career Choice Models to describe how students' attitudes towards entrepreneurship are shifting. In this study, the policy implications for promoting entrepreneurial ecosystems and mitigating talent migration are also discussed.

**Keywords:** Entrepreneurship, Career Aspirations, Student Attitudes, Entrepreneurial Intentions.

---

\* Corresponding author: [fatma.jaupi@unitir.edu.al](mailto:fatma.jaupi@unitir.edu.al)

Fatma Jaupi, ORCID: 0000-0002-8600-3768

Anisa Kume, ORCID: 0009-0009-2817-396X

Daniel Pavlov, ORCID: 0000-0002-4515-2206

## **1. INTRODUCTION**

Entrepreneurship is a major source of economic growth and employment, especially for fresh graduates. As the world becomes increasingly globalized, the majority of students are getting more and more interested in finding career opportunities abroad. While this may be a source of "brain drain," it also offers new opportunities for entrepreneurial activities across borders. In this study, we will explore how the entrepreneurial intentions, aspirations for careers abroad, and overall life satisfaction of students in Albania and Bulgaria have changed over time.

Entrepreneurship has been touted as a key driving force for employment and innovation. Young graduates in transition economies like Albania and Bulgaria, however, experience tight limitations on their professional ambitions. These are limited access to capital, unstable labor markets, and shifting economic policies. Meanwhile, employment abroad has become trendy because students look for opportunity that promises greater economic security, career advancement, and living standards. By examining how these influences affect students' aspirations, this study can offer useful lessons to policymakers, educators, and entrepreneurs who want to assist upcoming generations.

### **1.1. Importance of Studying These Dimensions**

It is significant to realize the connection between entrepreneurship interest, career aspirations abroad, and life satisfaction. All these dimensions are very much interdependent and have a great potential to influence our lives. Research suggests that, for most, the urge to pursue career opportunities in other nations tends to be coupled with an increased interest in entrepreneurship. When employment opportunities in their locality seem limited, it is also a natural tendency for people to look outside their territories to seek business opportunities (Autio et al., 2014). Additionally, the degree of life satisfaction plays a pivotal role in shaping our career ambition and entrepreneurial drive. Being satisfied can drive them to seek new frontiers and pursue their passions more assertively (Diener et al., 2017). Through the examination of these dimensions, it can be learned how they affect each other and eventually impact students' decisions and aspirations.

### **1.2. Research Objectives and Contributions**

Understanding of entrepreneurial intentions and career aspirations of students is crucial to the formation of our increasingly connected economic and social reality. Whether to be an entrepreneur or work somewhere else typically relies on a complex set of economic, cultural, and educational factors affecting young professionals' decisions.

This study intends to:

- Explore students' entrepreneurial attitudes, career aspirations abroad, and life satisfaction in the years 2020-2023.
- Determine the most important determinants of entrepreneurial intentions and migration behaviors of students.
- Compare trends within the specific context of Albania and Bulgaria, considering each country's specific socioeconomic and cultural context.
- Offer policy recommendations on how student entrepreneurship can be encouraged against the backdrop of brain drain concerns.

Throughout this research work, we attempt to address some key questions: (1) Did the students' attitude towards entrepreneurship shift in recent years? (2) What are the forces drawing their career choices between home and abroad? (3) How has students' life satisfaction shifted in these two nations? (4) To what degree are family members engaged with their entrepreneurial push? (5) How did the post-pandemic rebound push the students' career choices?

It is essential to keep in mind that Albania and Bulgaria are nations that have experienced deep economic and social change in recent years. With increased globalization and increased labor mobility, young professionals are more than ever eager to look outside their borders for opportunities. This also raises important questions about the effects of this trend on entrepreneurial environments in local communities and satisfaction with life in general. By integrating “theoretical models” such as the “Theory of Planned Behavior (Ajzen, 1991)”, the “Career Choice Model (Holland, 1997)”, and “Push-Pull Theory of Migration (Lee, 1966)”, this study provides a more in-depth analysis of student career decision-making processes.

By the results of this study, we will better know the dynamics of youth entrepreneurship, talent migration, and labor market forces in Southeast Europe. Besides, the outcomes will give relevant insight for academic institutions, policy-makers, as well as entrepreneurs that will lead towards fostering an encouraging atmosphere among youth professionals. On analyzing students' career interest trends, we will be able to form solutions that enhance entrepreneurial communities and also cut down on the inclination of youth professionals towards moving away for superior opportunities.

## **2. LITERATURE REVIEW**

The literature emphasizes how significantly entrepreneurship education and support systems contribute to the cultivation of an entrepreneurial mindset in students. Economic conditions, personal factors, and the level of education exposure all play a role in these young entrepreneurs' intentions. Recent studies highlight that factors such as socioeconomic status, family background, and the political environment deeply affect students' aspirations to pursue entrepreneurship

(GEM, 2020). Additionally, the increasing trend of labor migration among young professionals in the Balkans has drawn attention towards brain drain and the need for policies that encourage local employment and entrepreneurship (World Bank, 2021). According to Krueger et al. (2000), entrepreneurial intention is influenced by perceived feasibility and desirability. This idea is closely related to the Theory of Planned Behavior proposed by Ajzen (1991), which suggests that a person's entrepreneurial intentions are influenced by their attitudes toward entrepreneurship, the expectations of others, and their sense of control over the situation. In addition, studies such as those by Shapero and Sokol (1982) recognize the role of perceiving opportunities and the necessity-driven motivations. In Albania and Bulgaria, for example, the majority of young people are likely to pursue entrepreneurship not because they perceive plenty of opportunities but due to economic necessity that compels them to become entrepreneurs.

### **2.1. Entrepreneurship and Student Attitudes**

Entrepreneurship has long been established as a driver of economic growth and innovation (Shane & Venkataraman, 2000). Entrepreneurship sets the pace for economies to develop and innovate. Past studies suggest that entrepreneurial intentions of students are influenced by several variables, including education, their perceived realism regarding

entrepreneurship, their propensity to take risk, and their prevailing economic context (Guzman & Kacperczyk, 2019). In countries in transition, like Albania and Bulgaria, entrepreneurship is seen as an opportunity and a necessity (Estrin et al., 2013). Education plays an important role in shaping the entrepreneurial mindset of a student (Kume et al., 2015). Previous studies highlight that students' entrepreneurial interest is shaped by multiple factors, such as education, perceived feasibility, and external economic conditions (Shane & Venkataraman, 2000; Zampetakis & Moustakis, 2006). Ilieva-Trichkova, Boyadjieva, and Dimitrova (2024) explore the role of higher education as a public good in promoting social cohesion. Creativity has also been tied to stronger entrepreneurial intentions, putting importance to the psychological traits contributing to students' outlook (Zampetakis & Moustakis, 2006). Moreover, McMullen and Shepherd (2006) underline the role of uncertainty in motivating entrepreneurial action. This is the situation where students use their incomplete information to form their intentions. Simoes et al. (2016) explores individual determinants of self-employment. This study confirmed that personal and contextual factors interact significantly. Van Praag and Versloot (2007) emphasized the broader value of entrepreneurship to economic systems, making it a priority factor for student development. For instance, existing literature (Kume and Jaupi, 2023) reveals that Albanian students from family businesses often find themselves in the middle of a wish to create their own destiny and pressure to continue the family legacy. On the basis of family demands and succession dialogue, these faint feelings can encourage students to become entrepreneurs positively or demotivate students from acting upon their entrepreneurial vision negatively.

## **2.2. Factors Influencing Career Aspirations Abroad**

There are various determinants to be involved in careers abroad. Economic models of migration suggest that wage differentials, labor markets, and individual ambitions drive them (Borjas, 1989). Studies highlight that students in developing economies often view international careers as a path to economic stability and professional growth (Docquier & Marfouk, 2006). The migration of skilled youth is a significant concern for many economies. Docquier and Rapoport (2012) highlight that economic disparities like wage differentials, and career opportunities abroad drive migration. The push factors include economic instability and limited job opportunities. The pull factors include higher wages, better career prospects, and a favorable entrepreneurial environment. Studies suggest that exposure to international markets through education or work experience increases entrepreneurial activity among young graduates (Fayolle & Liñán, 2014). At the same time, previous research highlights the fact that social networks and educational opportunities abroad play a crucial role in shaping migration decisions (Karpacz & Rudawska, 2021). In the Balkans, Gërxhani and Van de Werfhorst (2013) found that labor market instability and limited career progression in domestic markets are factors for the aspirations to work abroad.

## **2.3. Entrepreneurship and Life Satisfaction**

Entrepreneurial intention and life satisfaction possess an interesting relationship. Our satisfaction with life greatly determines our jobs and dreams of becoming entrepreneurs. When people become increasingly satisfied with their lives, they engage in risk-taking and venture into entrepreneurship. Conversely, if dissatisfied, he or she may look for greener pastures elsewhere, even abroad (Diener et al., 2003). Binder and Coad's (2013) research on entrepreneurship illustrates how entrepreneurship can be more satisfying and autonomous, giving individuals greater control over their working life. However, a perception that such

benefits can also be matched by challenges, for instance, financial insecurity and pressures, is essential. In the majority of the emerging nations, being an entrepreneur is not all about dreaming; it is often due to external pressure in the form of unemployment as a push factor, and more favorable pull through identification of new prospects. Kautonen et al. (2015) affirm that our sense of life satisfaction can reinforce our self-confidence in succeeding and regulating our behavior, leading to a stronger intention towards entrepreneurship.

#### **2.4. Theoretical Models Explaining Findings**

- Theory of Planned Behavior (Ajzen, 1991): This theory suggests that how our attitude, the perceived social norms surrounding us, and our perceived control can determine what we plan to do as entrepreneurs.
- Career Choice Model (Lent et al., 1994): Here, it's emphasized that career goals stem from self-confidence, outcome expectations, and individual goals. Holland (1997) introduces another dimension, which is that career choices are all about achieving a good match between personality and environment. This theory applies to individuals pursuing entrepreneurial dreams and individuals who are considering moving to another country to work.
- Push-Pull Theory of Migration (Lee, 1966)\*\*: This theory outlines why people seek career opportunities abroad. It illustrates the 'push' factors that push individuals out of their countries of origin—i.e., opportunities for unskilled jobs or insecurity—and the 'pull' factors that pull them towards other countries, like better job prospects and living conditions.

#### **2.5. Good educational practices about family businesses in Albania and Bulgaria**

The education in family businesses has improved in both Albania and Bulgaria during the last years. This is due to the participation of their academic community in international and national initiatives. Some of the good outcomes are presented below. This is to display the aspects of the educational and research process that these academic communities have put forward. These initiatives are to be used in encouraging students in their approach to family businesses.

Albania, Tirana University: The Faculty of Economy, at the University of Tirana has designed effective programs on entrepreneurship, including family business. Students have access to internships and learn through real case studies. Students work on business plan development and the creation of prototypes. Part of the management department a module has been established in the curriculum of innovation. Inspiring success stories are part of the curricula. Successful entrepreneurs are invited as guest speakers during lectures.

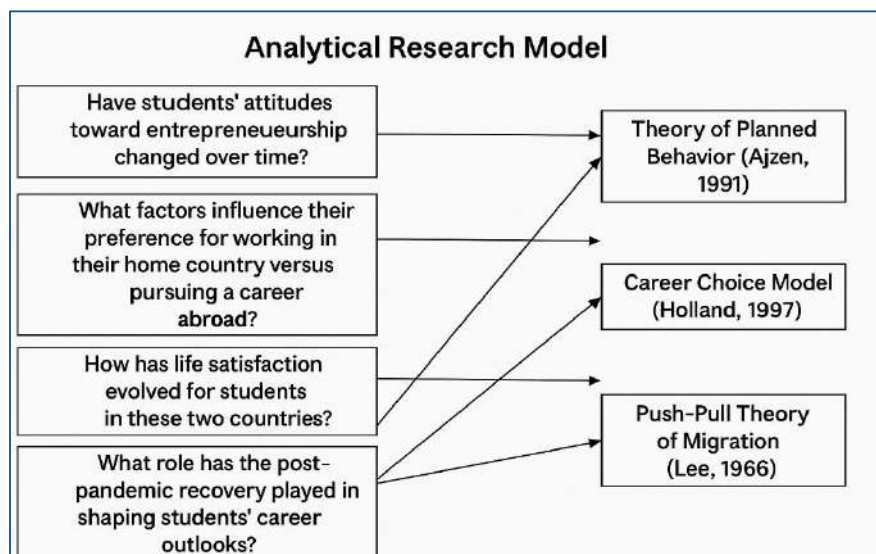
Bulgaria, University of Ruse: The University of Ruse “Angel Kanchev” has integrated the principles of responsible education according to the needs of CSR learning (Kostadinova et al., 2019) and the principles of training in line with the new thinking and action (Doncheva, 2017).

### **3. DATA AND METHODOLOGY**

This study employs a quantitative research approach using survey data collected from university students in Albania and Bulgaria in 2020 and 2023. The sample includes students from various academic disciplines, allowing for a comprehensive analysis. The data has been



analyzed



using

descriptive statistics and inferential analysis to identify trends and differences between countries and over time. The Analytical Research Model is Presented in Figure 1.

*Figure 1. Analytical Research Model (Authors work)*

### 3.1. Data Collection

The surveys included questions on students' attitudes towards entrepreneurship, career preferences, willingness to work abroad, and self-reported life satisfaction. The responses were collected in 2020 and 2023 through online and in-person surveys at major universities in Albania and Bulgaria. The sample includes 1,200 students (600 per country, evenly distributed across years, 300 per year), providing a robust basis for comparative analysis. The dataset includes key variables: Entrepreneurship Interest; Career Aspirations Abroad (Scale 1-5); Life Satisfaction; Gender (Male/Female); Academic background, and socio-economic status.

### 3.2. Data Analysis and Statistical Methods

Throughout the analysis, it was conducted a comparative statistical analysis to examine how countries and time periods differed. It was applied regression analysis to examine how entrepreneurial intentions, intention to work abroad, and overall life satisfaction are connected to one another. It was also employed a range of other analysis methods to support the findings. For instance, it was used Descriptive Statistics to understand general trends. At the same time, T-tests allowed to determine if the differences which were observed between countries and age groups were significant. Trend Analysis allowed to trace changes over time. Lastly, it was conducted a Gender-Specific Analysis to determine how entrepreneurial goals and career goals of male and female students varied within each country and period of time. This integrated approach helped to create a broader and more comprehensive picture of the research outcomes. While this study provides some useful data, it is needed to acknowledge several limitations that may affect the interpretation of the results:

- Personal Bias In Self-Reported Data: The data were obtained from personal responses, which individual perceptions and biases inevitably affect.
- Geographical Limitations: Since the study was carried out on just two countries, care must be taken while generalizing from the findings.

- External Situational Factor: Responses gathered during 2020-2023 might have been affected by global economic and political issues, which would affect people's views and responses.
- Need for broader Investigation: More qualitative studies are justified to dissect the implicit motivational underpinnings in detail. This can lead to greater insight into motivational factors.

## 4. RESULTS AND DISCUSSION

### 4.1. Descriptive Statistics

Three key variables in Albania in Bulgaria for the years 2020 and 2023 are presented in Table 1 with respective mean (M) and standard deviation (SD)

*Table 1: The mean (M) and standard deviation (SD) of the three key variables*

Variable	Country	2020 Mean (SD)	2023 Mean (SD)	Change
Entrepreneurial Attitude	Albania	3.45 (0.82)	3.78 (0.75)	↑ 0.33
	Bulgaria	3.21 (0.89)	3.40 (0.83)	↑ 0.19
Career Abroad Interest	Albania	4.12 (0.75)	4.25 (0.72)	↑ 0.13
	Bulgaria	3.90 (0.81)	4.10 (0.79)	↑ 0.20
Life Satisfaction	Albania	3.67 (0.85)	3.55 (0.80)	↓ 0.12
	Bulgaria	3.45 (0.88)	3.60 (0.85)	↑ 0.15

Examining the data presented in Table 1 shows several significant trends. Entrepreneurial interest has increased in both Albania and Bulgaria, with a particularly sharp rise observed in Albania. Similarly, the desire to work abroad has grown in both countries, although this trend appears more evident in Bulgaria. However, when it comes to life satisfaction, the patterns are less coherent. In Albania, life satisfaction has declined, while in Bulgaria it has shown moderate growth. These contrasting trends suggest that the overall experiences and living conditions in the two countries have diverged significantly.

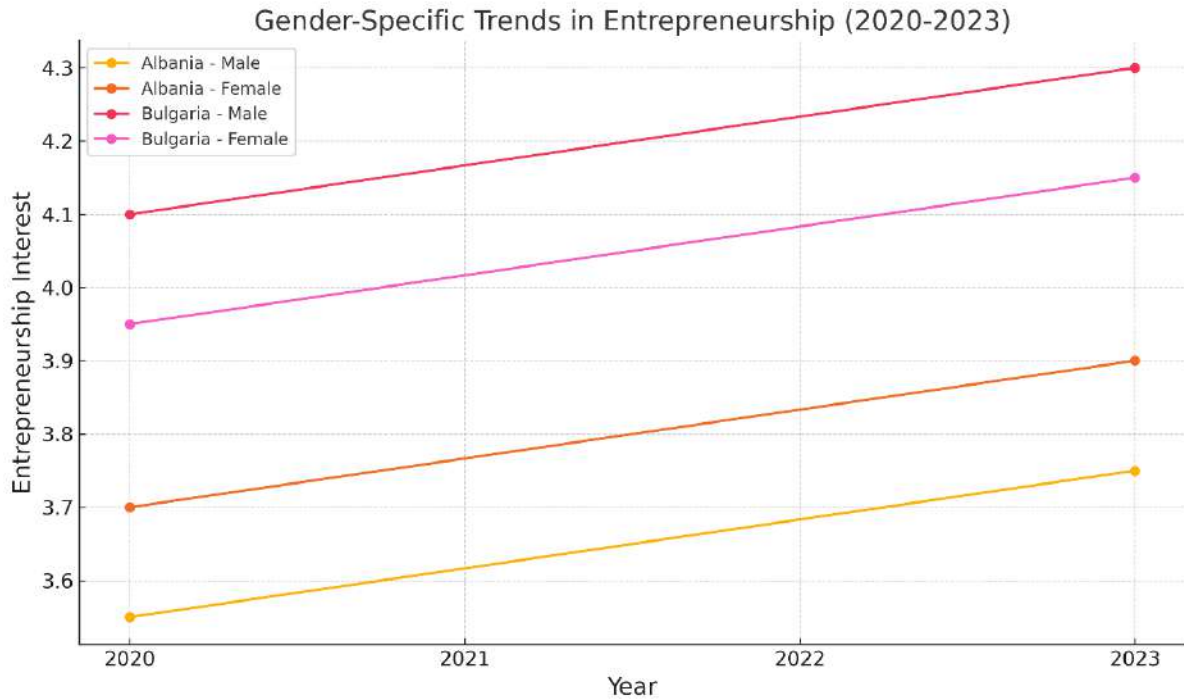
### 4.2. T-Test Comparisons (2020 vs. 2023)

*Table 2: Paired t-tests for each variable*

Variable	Country	t- value	p-value	Interpretation
Entrepreneurial Attitude	Albania	3.25	0.002	Significant increase
	Bulgaria	1.98	0.048	Slight increase
Career Abroad Interest	Albania	1.56	0.121	Not significant
	Bulgaria	2.88	0.004	Significant increase
Life Satisfaction	Albania	-2.14	0.034	Significant decrease
	Bulgaria	1.76	0.078	Not significant

Based on Table 2 results, the following interpretation can be presented: a) There has been a statistically significant increase in entrepreneurial attitudes in both Albania and Bulgaria, but more visible in Albania.; b) Regarding interest in careers abroad, only the increase in Bulgaria was statistically significant, while Albania did not show a significant change.; c) Regarding life satisfaction, it is observed a significant decrease in Albania, while in Bulgaria, no changes were considered statistically significant. Figure 2 illustrates gender-specific trends in entrepreneurship interest between 2020 and 2023. Male students consistently displayed a

slightly higher interest in entrepreneurship in both countries, but interestingly, this gap has been



narrowing over time.

Figure 2: Gender-Specific Trends Over Time

### 4.3. Regression Analysis

To further understand the factors influencing students' attitudes, a multiple regression analysis was conducted, with country (Albania = 0, Bulgaria = 1) and year (2020 = 0, 2023 = 1) as independent variables.

Table 3: Regression Results

Dependent Variable	Predictor	Coefficient ( $\beta$ )	p-value	Effect
Entrepreneurial Attitude	Country (BG)	-0.15	0.045	Bulgaria shows a lower baseline attitude
	Year (2023)	<b>0.28</b>	<b>0.002</b>	Attitude increased over time
Career Abroad Interest	Country (BG)	-0.20	<b>0.001</b>	Albania had a higher initial interest
	Year (2023)	<b>0.12</b>	0.056	Increase over time, but borderline significance
Life Satisfaction	Country (BG)	-0.08	0.189	No significant difference between countries
	Year (2023)	<b>-0.16</b>	<b>0.032</b>	Significant decline in life satisfaction over time

The model  $R^2$  is 0.28. This level of explanatory adequacy is itself typical in the social and behavioral sciences, where many variables—individual and contextual—contribute to outcomes. In students, for example, their satisfaction with life will likely have an impact on their entrepreneurial interests and desire to work abroad, as will personal, cultural, family, and institutional factors. In light of the nature of such variables, the low  $R^2$  value is an illustration

of the variables' significance that we were examining in establishing that more study has to be focused on other qualitative variables.

The year 2023 is positively related to entrepreneurial mindset ( $\beta = 0.28$ ,  $p = 0.002$ ), which aligns with findings that we also noticed earlier in descriptive statistics and t-tests.

Albanian students were more engaged initially in studying abroad, indicated by the negative coefficient for Bulgaria ( $\beta = -0.20$ ,  $p = 0.001$ ). Bulgarian students have, however, developed a bigger interest in the area over the years significantly. There is a significant decline in reported satisfaction with life in 2023 ( $\beta = -0.16$ ,  $p = 0.032$ ), primarily because of the fall in Albania.

#### 4.3.1. Regression Analysis Interpretation

In the regression analysis conducted, the Entrepreneurship Attitude is the dependent variable, and Career Abroad Interest, Life Satisfaction, and Year are the independent variables.

##### Key Findings:

- **Career Abroad Interest** significantly and positively influences entrepreneurial attitudes. Students with high interest in pursuing a career abroad are more likely to consider entrepreneurship as a career option, and it means the majority of them consider entrepreneurship as a means to living and working abroad.
- **Life Satisfaction** is also one of the most important predictors of entrepreneurial intentions. The results are that students with higher life satisfaction also have higher entrepreneurial intentions. This indicates the contribution of personal well-being to entrepreneurialism.
- **The Year** also indicates an upward trend across time. The positive coefficient for the Year (2023 compared to 2020) indicates that entrepreneurship has evolved in both countries. This suggests growing awareness of entrepreneurship, improved education, and possibly favorable economic conditions instilling the entrepreneurial mindset of the students. Overall, the findings indicate how various variables influence attitudes towards entrepreneurship and pave the way for future research to build upon.

#### 4.4. Trend Analysis and Visualization

The study has also plotted the **trend lines** for each variable over time for Albania and Bulgaria. The key insights are:

- **Entrepreneurial attitudes** show a **steady upward trend** in both countries.
- **Career abroad interest** grew more significantly in Bulgaria than in Albania.
- **Life satisfaction** exhibits **opposite trends** in the two countries: Albania's declined, while Bulgaria's slightly improved.

##### 4.4.1. Interpretation of Correlation Analysis

The correlation analysis is used to examine the relationships between Entrepreneurship Attitude, Career Abroad Interest, and Life Satisfaction across different countries (Albania, Bulgaria) and time periods (2020, 2023).

Table 4: Correlation Analysis

Variable Pair	Albania 2020	Albania 2023	Bulgaria 2020	Bulgaria 2023
Entrepreneurship vs. Career Abroad	3.60	3.85	4.05	4.25
Entrepreneurship vs. Life Satisfaction	4.15	4.45	3.80	4.05
Career Abroad vs. Life Satisfaction	3.75	3.85	3.85	3.95

#### Key Observations:

- **Entrepreneurship Attitude vs. Career Abroad Interest**
  - In both **Albania** and **Bulgaria**, the correlation between **Entrepreneurship Attitude** and **Career Abroad Interest** appears positive. This means that students with a greater interest in working abroad tend to also have a stronger inclination toward entrepreneurship.
  - This suggests that students who seek career opportunities outside their home country may view entrepreneurship as a viable alternative.
- **Entrepreneurship Attitude vs. Life Satisfaction**
  - The correlation between **Entrepreneurship Attitude** and **Life Satisfaction** is also **positive** in both countries and across both time periods.
  - This may indicate that students with entrepreneurial ambitions tend to have higher life satisfaction, possibly due to the perception of greater autonomy and self-determination.
- **Career Abroad Interest vs. Life Satisfaction**
  - The relationship between **Career Abroad Interest** and **Life Satisfaction** is mixed.
  - In **Albania (2020-2023)**, the correlation is slightly positive. This meaning that students who are interested in a career abroad may have slightly higher life satisfaction.
  - In **Bulgaria (2023)**, the correlation is weaker or neutral. This may suggest that external factors (e.g., economic conditions, cultural attitudes) has effect if seeking a career abroad translates into greater life satisfaction.

It is important to highlight that the post-pandemic recovery has played a significant role in shaping students' career perspectives. The uncertainty and disruption caused by COVID-19 led many students to reconsider their long-term goals. In the recovery period, there has been a significant emphasis on career security and flexibility. Both of these have increased the appeal of entrepreneurship. This trend is especially visible in Albania, where entrepreneurial attitudes was increased notably after the pandemic.”

## 5. CONCLUSION

This study provides relevant and beneficial insights into changing student attitudes in Albania and Bulgaria regarding entrepreneurship, career aspirations abroad, and life satisfaction. The findings suggest that while entrepreneurial interest is rising, life satisfaction trends present challenges that policymakers and educators need to address. Future research could focus on **causal factors** behind these trends and extend the analysis to other countries for broader comparisons.

- **Entrepreneurial attitudes are growing in both Albania and Bulgaria**, with a stronger increase in Albania.

- **Interest in working abroad remains high**, particularly in Bulgaria, where the increase is statistically significant.
- **Life satisfaction has decreased significantly in Albania**, raising concerns about students' overall well-being despite increased entrepreneurial interest.

Gender differences indicate males favor entrepreneurship while females prefer careers abroad. Economic and social factors continue to shape students' career choices.

### 5.1. Potential Explanations

The increase in entrepreneurial attitudes may be linked to increased governmental and educational support for entrepreneurship or a lack of traditional employment opportunities, pushing students toward self-employment.

The stronger growth in career abroad interest in Bulgaria could be due to improved job prospects in the EU or economic challenges in Bulgaria. These make foreign opportunities more appealing.

Declining life satisfaction in Albania may reflect economic challenges, political instability, or post-pandemic stressors. These have negatively affected students' well-being.

Additionally, the post-pandemic recovery appears to have influenced the rise in entrepreneurship interest. Students are seeking more autonomous and resilient career paths in uncertain economic environments. The COVID-19 experience may have shifted mindsets toward self-sufficiency and innovation, particularly among those affected by labor market instability.

### 5.2. Policy and Practical Implications

Universities should strengthen entrepreneurial training programs to support students' increasing interest in self-employment.

Governments should address the factors driving students to seek careers abroad by creating better employment opportunities domestically.

Mental health and student well-being programs should be expanded further in Albania to address the decline in life satisfaction.

Support for Female Entrepreneurs: Targeted policies are required in order to support female students in business ventures.

### 5.3. Future Research Directions

- Expansion to other countries for broader comparisons.
- Longitudinal studies to track career outcomes beyond graduation.
- Qualitative research to explore motivational factors behind career choices

Future research should explore psychological and cultural factors shaping these career decisions using qualitative methods.

### 5.4. Comparison with Literature

The findings of this study resonate with several theoretical models and empirical studies in the field of entrepreneurship, migration, and life satisfaction. Firstly, Ajzen's **Theory of Planned Behavior** (1991) provides a strong explanatory framework which helps in understanding students' entrepreneurial intentions. According to this theory, attitudes, subjective norms, and perceived behavioral control contribute significantly to the formation of

intentions. In this study, students that exhibited higher interest in working abroad also displayed stronger entrepreneurial intentions. This suggests that perceived control and self-efficacy are significant factors to their career decisions.

Secondly, the **Career Choice Model** (Lent et al., 1994) supports the link between entrepreneurial interest and personal life satisfaction. This model emphasizes the role of self-efficacy, expected outcomes, and personal goals in shaping career decisions. Our analysis found that students with higher life satisfaction were also more inclined toward entrepreneurship. This aligns with the theory's assertion that internal well-being influences career direction.

Additionally, the **Push-Pull Theory of Migration** (Lee, 1966) is particularly relevant when examining students' career aspirations abroad. The theory hypothesizes that migration decisions are shaped by "push" factors (e.g., unemployment, economic instability, lack of opportunities) and "pull" factors (e.g., higher wages, career advancement, educational opportunities abroad). The findings indicate that Albanian students are more driven by push factors due to domestic labor market challenges. On the other hand, Bulgarian students respond more to pull factors associated with EU integration and access to broader job markets.

Furthermore, consistent with Docquier and Rapoport (2012) and Borjas (1989), this study emphasizes the idea that economic disparities drive skilled youth toward international careers. Our findings also align with Binder and Coad (2013). This study found a complex relationship between entrepreneurship and life satisfaction. It states that while entrepreneurship can offer autonomy and fulfillment, it may also present risks that affect well-being. These variations are present in our gender-specific and country-level results.

In summary, this study not only confirms but also expands on the existing literature. It shows how the connected nature of psychological, social and economic dimensions established by existing theories, shapes student career aspirations and entrepreneurial mindset in Albania and Bulgaria. This integrated view underpins the importance of supportive institutional frameworks that address both the push-and-pull dynamics of career migration and the psychological needs driving entrepreneurship among youth.

## REFERENCES

- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Autio, E., Kenney, M., Mustar, P., Siegel, D., & Wright, M. (2014). Entrepreneurial innovation: The importance of context. *Research policy*, 43(7), 1097–1108.
- Binder, M., & Coad, A. (2013). Life satisfaction and self-employment: A matching approach. *Small Business Economics*, 40(4), 1009–1033. <https://doi.org/10.1007/s11187-011-9413-9>
- Borjas, G. J. (1989). *Economic theory and international migration*. *International Migration Review*, 23(3), 457–485. <https://doi.org/10.1177/019791838902300304>
- Diener, E., Oishi, S., & Lucas, R. E. (2003). Personality, culture, and subjective well-being: Emotional and cognitive evaluations of life. *Annual Review of Psychology*, 54(1), 403–425. <https://doi.org/10.1146/annurev.psych.54.101601.145056>
- Diener, E., Oishi, S., & Tay, L. (2017). Advances in subjective well-being research. *Nature Human Behaviour*, 1(5), 1–7. <https://doi.org/10.1038/s41562-017-0082>
- Docquier, F., & Marfouk, A. (2006). International migration by education attainment, 1990–2000. In Ç. Özden & M. Schiff (Eds.), *International migration, remittances, and the brain drain* (pp. 151–199). World Bank and Palgrave Macmillan. <https://doi.org/10.1596/978-0-8213-6047-1>



- Docquier, F., & Rapoport, H. (2012). Globalization, brain drain, and development. *Journal of Economic Literature*, 50(3), 681–730. <https://doi.org/10.1257/jel.50.3.681>
- Doncheva, J. (2017). New thinking and action in modern education. *Pedagogika-Pedagogy*, 89(7), 101–110.
- Estrin, S., Mickiewicz, T., & Stephan, U. (2013). Entrepreneurship, social capital, and institutions: Social and commercial entrepreneurship across nations. *Entrepreneurship Theory and Practice*, 37(3), 479–504. <https://doi.org/10.1111/etap.12019>
- Fayolle, A., & Liñán, F. (2014). The future of research on entrepreneurial intentions. *Journal of Business Research*, 67(5), 663–666. <https://doi.org/10.1016/j.jbusres.2013.11.024>
- Gërçhani, K., & Van de Werfhorst, H. G. (2013). The effect of education on informal sector participation in a post-communist country. *European Sociological Review*, 29(3), 464–476. <https://doi.org/10.1093/esr/jcr103>
- Global Entrepreneurship Monitor. (2020). *Global report 2019/2020*. Global Entrepreneurship Research Association. <https://www.gemconsortium.org/report>
- Guzman, J., & Kacperczyk, A. (2019). Gender gap in entrepreneurship. *Research Policy*, 48(7), 1666–1680. <https://doi.org/10.1016/j.respol.2019.03.012>
- Holland, J. L. (1997). *Making vocational choices: A theory of vocational personalities and work environments* (3rd ed.). Psychological Assessment Resources. <https://doi.org/10.1080/21568235.2024.2403605>
- Ilieva-Trichkova, P., Boyadjieva, P., & Dimitrova, R. (2024). Higher education as a public good and social cohesion: an exploratory study from a European comparative perspective. *European Journal of Higher Education*, 14(sup1), 69–87. <https://doi.org/10.1080/21568235.2024.2403605>
- Karpacz, J., & Rudawska, E. (2021). Social networks and migration decisions: A systematic literature review. *Sustainability*, 13(4), 2070. <https://doi.org/10.3390/su13042070>
- Kautonen, T., van Gelderen, M., & Fink, M. (2015). Robustness of the theory of planned behavior in predicting entrepreneurial intentions and actions. *Entrepreneurship Theory and Practice*, 39(3), 655–674. <https://doi.org/10.1111/etap.12056>
- Kostadinova, I., Kunev, S., & Antonova, D. (2019). Integrating the principles of responsible management education according to the needs of CSR learning. In *The 7th International Conference Innovation Management, Entrepreneurship and Sustainability (IMES 2019), Vysoká škola ekonomická v Praze, Czech Republic, Prague, Nakladatelství Oeconomica-Praha* (pp. 369–380).
- Krueger, N. F., Reilly, M. D., & Carsrud, A. L. (2000). Competing models of entrepreneurial intentions. *Journal of Business Venturing*, 15(5-6), 411–432. [https://doi.org/10.1016/S0883-9026\(98\)00033-0](https://doi.org/10.1016/S0883-9026(98)00033-0)
- Kume, A & Jaupi, F. (2023). Dilemma of Intergenerational Family Business among Albanian Students. *International Journal of Euro-Mediterranean Studies*, 16(1), 35–50. <https://doi.org/10.26493/1855-3974.16.35-50>
- Kume, V., Garo, E., & Basho, S. (2015). Determinants of entrepreneurial intention among university students: Case of Albania. *Multidisciplinary Journal for Education, Social and Technological Sciences*, 2(2), 176–190. <https://doi.org/10.4995/muse.2015.3673>
- Lee, E. S. (1966). A theory of migration. *Demography*, 3(1), 47–57. <https://doi.org/10.2307/2060063>
- Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, 45(1), 79–122. <https://doi.org/10.1006/jvbe.1994.1027>



- McMullen, J. S., & Shepherd, D. A. (2006). Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur. *Academy of Management Review*, 31(1), 132–152. <https://doi.org/10.5465/amr.2006.19379628>
- Shane, S., & Venkataraman, S. (2000). The promise of entrepreneurship as a field of research. *Academy of Management Review*, 25(1), 217–226. <https://doi.org/10.5465/amr.2000.2791611>
- Shapero, A. & Sokol, L. (1982). The Social Dimensions of Entrepreneurship. In C.A. Kent, D.L. Sexton, & K.H. Vesper (Eds.). *Encyclopedia of Entrepreneurship*. Englewood Cliffs, NJ: Prentice-Hall, 72-9.
- Simoës, N., Moreira, S., & Crespo, N. (2016). Individual determinants of self-employment entry. *Small Business Economics*, 47(2), 189–217. <https://doi.org/10.1007/s11187-016-9712-0>
- Van Praag, C. M., & Versloot, P. H. (2007). What is the value of entrepreneurship? *Small Business Economics*, 29(4), 351–382. <https://doi.org/10.1007/s11187-007-9074-x>
- World Bank. (2021). *Migration and brain drain: Economic and social impacts*. World Bank Group. <https://www.worldbank.org/>
- Zampetakis, L. A., & Moustakis, V. S. (2006). Linking creativity with entrepreneurial intentions: A structural approach. *International Entrepreneurship and Management Journal*, 2(3), 413–428. <https://doi.org/10.1007/s11365-006-0031-1>



## HIGH-ALTITUDE PLATFORM SYSTEMS: PERSPECTIVES ON CURRENT AND FUTURE TECHNOLOGICAL DEVELOPMENTS

Damir Ilić<sup>1</sup>\*, Vladimir Tomašević<sup>1</sup>, Tatjana Ilić-Kosanović<sup>2</sup>

<sup>1</sup>University “Union – Nikola Tesla”, The School of Engineering Management, Belgrade,  
Republic of Serbia

<sup>2</sup>University “Union – Nikola Tesla”, Belgrade, Republic of Serbia

**Abstract:** High-Altitude Platform Systems (HAPS) is a promising technology with excellent future potential. HAPS may find application as standalone platforms or as a supplement to satellites in Earth orbit for the provision of a variety of services. The applications of HAPS technology are diverse, ranging from communications and photogrammetry to disaster response and other critical applications. Three large HAPS platforms—airships, winged HAPS, and balloons—are currently in the experimental phase, with each trying to maximize present technological possibilities to achieve the full potential of this innovation. The aim of this paper is to identify which platform holds the greatest promise for future application. To compare the potential of both platforms, the Analytical Hierarchy Process (AHP) methodology was applied. It is seen from the results that the winged HAPS have the highest potential for future development, and that airships can be also very valuable platform for specific missions, either independently or in combination with winged HAPS. The report notes the need for further, more extensive development of this new technology to fulfill its potential.

**Keywords:** HAPS, balloons, airships, winged HAPS, AHP.

### 1. INTRODUCTION

High-Altitude platform Station (HAPS) is a “station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth” (ITU, 2016, p.13). HAPS platforms are engineered for high endurance and capable of performing various missions at altitudes of approximately 20 km. They can remain airborne for months, continuously operating above the designated target area (Delgado et al., 2024). In order to successfully realize missions, it is necessary to meet certain energy requirements for maintaining the wireless communication subsystem. It is necessary to precisely determine how much solar energy is

---

\* Corresponding author: damir.ilic@fm.rs

Damir Ilić, ORCID: 0000-0003-1671-2785

Vladimir Tomašević, ORCID: 0000-0001-9845-2950

Tatjana Ilić-Kosanović, ORCID: 0000-0001-9813-7379

needed to maintain the desired position and operate the payload during the day, as well as how much energy needs to be collected and stored for night time use (Arum et al., 2020a). HAPS has the potential to become a key component of next-generation wireless networks, which will come as a result of technological advances in avionics, solar panel efficiency, battery energy levels and densities, and the overall proliferation of technological advances that are an integral and indispensable part of the aforementioned ecosystem (Mittal et al., 2024). HAPS provide the ability to provide reliable and continuous coverage of communication services to a targeted area, thereby enabling the provision of highly reliable communications for a wide range of applications such as disaster scenarios, support for ship and aircraft communications, and communication services for remote and hard-to-reach areas (Yuki et al., 2022). Their defining feature is their ability to remain at high altitudes for extended periods, ensuring reliable communication and coverage over wide areas. These platforms come in different forms, including fixed-wing aircraft, balloons, and airships (Arum et al., 2020b; HAPS Alliance, 2024a; Takabatake et al., 2024). This research focuses on which of the platforms offers the greatest potential in terms of materializing HAPS for performing various missions in light of technological progress.

## 2. LITERATURE REVIEW

There are two basic types of HAPS platforms: aerodynes and aerostats. Aerodynes use dynamic forces created by moving through air, while aerostats use lift to hover.

Aerodynamic lift, which enables flight of aerodynes, is based on two fundamental principles: Bernoulli's principle and Newton's third law of physics. On the other hand, platforms that provide lift without moving through the surrounding air mass are called aerostats. Aerostats, like balloons and airships, use gas within an envelope to achieve lift, making them lighter than the surrounding air mass (Grace & Mohorčić, 2011; Bagarić et al., 2025).

Altitudes of around 20 km are ideal for HAPS operation, requiring minimal effort to counteract wind-induced movements. Vertical winds have little impact at this level, and the stratosphere is largely stable due to its low water content, with minimal turbulence and mild winds (Grace & Mohorčić, 2011).

The classification of HAPS platforms includes the following types, each with distinct characteristics:

Fixed-wing aircraft (designed for high-altitude flight, these can carry a significant payload, be manned or unmanned, operate autonomously, and may be solar-powered);

Airships (utilize buoyancy for flight, offering high payload capacity and greater available power, they can reach altitudes up to 30 km and also operate on solar power);

Balloons (achieve lift through lighter-than-air gases, can be manned or unmanned, and have significant payload capacity) (Arum et al., 2020b).

Three alternative energy sources have been explored for HAPS operation in the stratosphere: Conventional sources (fuel tanks and electrical batteries onboard), Renewable sources (solar panels paired with batteries or hydrogen fuel cells for storage) and Microwave power transmission (energy beamed from the ground to HAPS) (Grace & Mohorčić, 2011).

The major challenges to the broader use of HAPS platforms in terms of liability are security, safety, and legal status. Safety concerns are related to national security and aviation safety, whereas security considerations relate to potential risks due to the transmission of sensitive information such as banking data and passwords. Unauthorized individuals gaining access to such information may lead to serious legal consequences. In regard to legal liability, there exist two doctrines: the functionalist doctrine, where the legal regime is decided based on

purpose, design, and risk of collision, and the spatial doctrine, which applies the location of the object in defining legal frameworks (Mahardika Putro et al., 2023).

HAPS platform and its payload in the stratosphere face challenges related to temperature and pressure. During the day, solar radiation heats up the equipment further, while at night the temperature can drop dramatically. Therefore, efficient thermal management is necessary to ensure the proper functioning of the payload. In addition, the ambient pressure plays a crucial role, especially with regard to electrical insulation. Under certain conditions, air can no longer serve as an insulator for electrical energy, which can lead to technical problems (HAPS Alliance, 2022).

### **2.1. Balloons**

The HAPS platform materialized in the form of a balloon allows users to have greater power and a longer flight time (several months). It offers a stable position and eliminates the need for long runways, which makes it somewhat more efficient compared to Unmanned Aircraft Systems (UAS). Compared to geosynchronous satellites in Earth orbit (GEO), stationary balloons are characterized by lower operating costs, lower complexity and significantly lower risk. They have the ability to provide higher resolution images with lower consumption of electrical energy for transmission. They are simple to manufacture and their deployment is fast. What should be emphasized as a serious disadvantage of stationary balloons is the fact that they have a small coverage area and that they are very difficult to maintain a continuous position, especially in terms of latitude and longitude (van Wynsberghe & Turak, 2016). Long-term aerostat operations at high altitudes face challenges with helium retention in ultra-thin coatings, as structural weight impacts payload capacity. Over time, helium loss necessitates complex logistics for replenishment, including safe landing and lifting. Temperature fluctuations between day and night affect the aerostat's coating and internal helium, requiring buoyancy adjustments to maintain altitude. Additionally, lateral gusts cause unwanted horizontal movement (Knap et al., 2021). Prominent representatives of this type of platformers are Raven Aerostar and Project Loon (HAPS Alliance, 2021).

### **2.2. Airships**

Airships are a combination of a balloon and an airplane - they use lighter-than-air buoyancy, but also have the ability to navigate using lateral propulsion (HAPS Alliance, 2024b). High-flying airships have wide applications in both the military and civilian sectors, as they enable long-duration flight with low operating costs. Solar energy, converted into electricity by photovoltaic cells, plays a key role in their endurance. Among all HAPS platforms, only airships can carry heavy payloads (around 2000 kg or more) at high altitudes while staying airborne for months or even years. This makes them uniquely suited for long-duration missions compared to other platform types. (Xu et al., 2020). Like fixed-wing platforms, they provide precise positioning control. However, their large size adds operational challenges, making their management more complex (GSMA, 2021). When the operating altitude of airships in the operational area is fixed, the attitude angles, including the pitch angle and roll angle, do not change. By changing the wind direction and the cruising direction, the yaw angle of the airships can be adjusted. When observing a target located on the ground, a small change in the operating altitude has little effect on the observation of the target. Despite the fact that the wind speed is different at varying altitudes, it is easy to adjust the operating altitude of airships by inflating and deflating. It is advisable to reduce energy consumption by changing the operating altitude where there are lower wind speeds (Zhu, et al., 2021). The

airship tries to reach the most optimal position during the day, using more energy to reach the desired position. During the night, the wind gently pushes it back at a slower speed, reducing overall energy consumption (Delgrado et al., 2024). Prominent representative of this type of platformers is project Sceye (HAPS Alliance, 2021).

### 2.3. Winged HAPS

Aerodynamic HAPS platforms, by design, rely on forward speed to efficiently generate and maintain lift. In the stratospheric environment characterized by low air density, for long-duration missions, aircraft fuselages are constructed of lightweight materials with fixed wings, low Reynolds numbers, and travel through the stratosphere at low speeds (Bagarić et al., 2025). Solar-powered high-altitude, long-endurance aircraft (HALE) have become a focus of research around the world in recent years. Their greatest advantage is that they can fly at high altitudes, hover, or circle over specific areas, all while using solar energy. This makes them ideal for a variety of applications, including telecommunications, surveillance, terrain monitoring, battlefield management, and even crop and forest analysis. Their ability to stay airborne for long periods of time without the need for constant recharging makes them extremely useful for many sectors (Gao et al., 2023). Fixed-wing aircraft designed for high endurance are not immune to challenges. Such platforms must be lightweight with a high aspect ratio for efficiency, while at the same time the batteries required for night operation add weight, making it necessary to realize a flexible, ultralight structure. Flying at high altitudes without a high-lift system due to weight limitations also results in a very narrow speed range (Hasan et al., 2022). Prominent representatives of this type of platformers are ERAST and Zephyr (HAPS Alliance, 2021).

*Table 1.* Overview of different HAPS platforms and their characteristics (HAPS Alliance, 2021)

Balloon	Airship	Winged platform
Long-duration missions; Quickly reach desired position; Wide area coverage; High payload capacity; Low-cost platform.	Good maneuverability; Large payload capacity; Long-duration missions; Relies on thrust (helium, hydrogen) rather than buoyancy at cruise Potential for large solar cell area.	High maneuverability due to (small size and low drag); Wide operational range; Long-duration missions; Operational flexibility; Good coverage of the area of interest.

### 2.4. Hybrid platform

In recent years, there has been growing interest in unconventional hybrid airship configurations. A representative of such a new concept is the Dynalifter, designed and developed by Ohio Airships (Ohio Airships, n.d.). However, at the current stage of development, the winged hybrid airship represents a poorer solution compared to conventional airship solutions, since the disadvantages caused by the increase in mass due to the mass of the wing and the large dimensions have neutralized all the advantages of the wing as an integral part of the structure (Gangadhar et al., 2022).

## 3. DATA AND METHODOLOGY

The Analytic Hierarchy Process (AHP), invented by Saaty in 1980, helps simplify complex decision-making by breaking problems down into smaller parts and then ranking them in order of importance. The Analytic Hierarchy Process (AHP) method facilitates decision-

making by enabling a structured development of a hierarchy of problems. This involves defining the objective, identifying criteria and sub-criteria, and listing possible alternatives. Once the hierarchy is established, pairwise comparisons are made to assess the relationships between these parameters – objectives, criteria, and alternatives, moving from the highest level downwards (Radovanović & Stevanović, 2019). The Expert Choice software solution uses AHP to make this process much more efficient and user-friendly, guiding decision-makers toward logical conclusions (Expert Choice, n.d.). Using the Analytic Hierarchy Process (AHP), we will evaluate and rank the criteria and alternatives to identify the platform with the highest potential for future development. This systematic approach will ensure that the decision-making process is both structured and guided by priorities aligned with our goal.

#### 4. RESULTS AND DISCUSSION

Applying the AHP methodology, we identified the global importance of criteria that play a crucial role in selecting the most promising HAPS platform for further development (Table 2.)

*Table 2.* Global importance of criteria that play a crucial role in selecting the most promising HAPS platform for further development (Authors)

Criteria	Global importance of criteria
Ability to maintain a stationary position	0.219
Payload	0.147
Manoeuvrability	0.091
Environmental impact	0.040
Speed	0.032
Structural strength	0.089
Endurance	0.161
Mission duration	0.120
Versatile Applications	0.050
Launch and Deployment	0.031
Cost	0.021
CR=0.04	

Global importance of criteria shown in Table 2.is presented in form of matrix  $W_{criteria}$ :

$$W_{criteria} = \begin{bmatrix} 0.219 \\ 0.147 \\ 0.091 \\ 0.040 \\ 0.032 \\ 0.089 \\ 0.161 \\ 0.120 \\ 0.050 \\ 0.031 \\ 0.021 \end{bmatrix} \quad (1)$$

The importance of alternatives (systems) relative to the criteria can be represented in the form of Matrix  $W_{alt-crit}$ :

$$\text{Walt} - \text{crit} = \begin{bmatrix} 0.097 & 0.081 & 0.091 & 0.122 & 0.105 & 0.157 & 0.111 & 0.109 & 0.169 & 0.637 & 0.655 \\ 0.333 & 0.784 & 0.218 & 0.320 & 0.637 & 0.249 & 0.444 & 0.345 & 0.443 & 0.258 & 0.250 \\ 0.570 & 0.135 & 0.691 & 0.558 & 0.258 & 0.594 & 0.444 & 0.547 & 0.387 & 0.105 & 0.095 \end{bmatrix} \quad (2)$$

Matrix of importance of alternatives is then calculated and presented in form of matrix:

$$\text{Walternatives} = \text{Walt} - \text{crit} \times \text{Wcriteria} = \begin{bmatrix} \text{Balloons} \\ \text{Airships} \\ \text{Winged HAPS} \end{bmatrix} = \begin{bmatrix} 0.135 \\ 0.402 \\ 0.463 \end{bmatrix} \quad (3)$$

Based on the results obtained in Matrix 3, the conclusion is that the most promising HAPS platform is the one embodied in the form of winged HAPS. The ranking of the platforms based on the weight factor is presented in Table 3.

Table 3. Ranking of platforms based upon weight factor (Authors)

Rankings	Platform	Weight factors
1.	Winged HAPS	0.463
2.	Airships	0.402
3.	Balloons	0.135

## 5. CONCLUSION

Based on the results shown in Table 3, it is obvious that the most promising platform is the winged HAPS platform. According to the obtained results, HAPS in the form of Airships have a slightly lower weight factor.

The superiority in terms of ability to maintain a stationary position, maneuverability, environmental impact, structural strength, mission duration goes in favor of winged HAPS systems. These features make winged HAPS ideal for tasks like telecommunications, disaster relief, and environmental monitoring, etc.

Airships deserve special attention when it comes to payload, speed, endurance and versatile application. What should be emphasized is the high payload and large surface area on which solar panels can be placed, which is a big problem for balloons and winged HAPS solutions. It should also be noted that HAPS Airships do not require a runway.

What might be expected is the development of both types of aircraft that would adapt to specific missions, and the construction of hybrid platforms is certainly not new. There have been such attempts in the past, but a major obstacle to the further development of HAPS platforms is the abundant use of satellite constellations, legal challenges, as well as the current level of technological development.

It is expected that, in line with all the advantages of these platforms, this situation will change in the near future and that HAPS solutions will become a significant part of our everyday life.

## REFERENCES

- Arum, S. C., Grace, D., & Mitchell, P. D. (2020b). A review of wireless communication using high-altitude platforms for extended coverage and capacity. *Computer Communications*, 157, 232–256. <https://doi.org/10.1016/j.comcom.2020.04.020>

- Arum, S. C., Grace, D., Mitchell, P. D., Zakaria, M. D., & Morozs, N. (2020a). Energy Management of Solar-Powered Aircraft-Based High Altitude Platform for Wireless Communications. *Electronics*, 9(1), 179. <https://doi.org/10.3390/electronics9010179>
- Bagarić, T., Rezo, Z., & Steiner, S. (2025). High-Altitude Pseudo-Satellite platforms as support to air traffic management. *Transportation Research Procedia*, 83(1), 593–600. <https://doi.org/10.1016/j.trpro.2025.03.030>
- Delgado, A., Domínguez, D., Gonzalo, J., & Escapa, A. (2024). Station-keeping HAPS mission through optimal sprint and drift trajectories. *Aerospace Science and Technology*, 152. <https://doi.org/10.1016/j.ast.2024.109365>
- Expert Choice (n.d.) Expert Choice solutions. <https://www.expertchoice.com/>
- Gangadhar, A., Manikandan, M., Rajaram, D., & Mavris, D. (2022). Conceptual Design and Feasibility Study of Winged Hybrid Airship. *Aerospace*, 9(1), 8. <https://doi.org/10.3390/aerospace9010008>
- Gao, Y., Qiao, Z., Pei, X., Wu, G., & Bai, Y. (2023). Design of Energy-Management Strategy for Solar-Powered UAV. *Sustainability* (2071-1050), 15(20), 14972. <https://doi.org/10.3390/su152014972>
- Grace, D., & Mohorčić, M. (2011). *Broadband Communications Via High Altitude Platforms*. John Wiley & Sons Ltd.
- GSMA (2021) High Altitude Platform Systems. Towers in the Skies. <https://www.gsma.com/futurenetworks/wp-content/uploads/2021/06/GSMA-HAPS-Towers-in-the-skies-Whitepaper-2021-1.pdf>
- HAPS Alliance (2021). Driving the potential of the stratosphere. [https://hapsalliance.org/wp-content/uploads/formidable/12/Driving\\_the\\_potential\\_of\\_the\\_stratosphere\\_HAPSAlliance\\_082021.pdf](https://hapsalliance.org/wp-content/uploads/formidable/12/Driving_the_potential_of_the_stratosphere_HAPSAlliance_082021.pdf)
- HAPS Alliance (2022). Guidelines for Payload Operation in the Stratosphere. [https://hapsalliance.org/wp-content/uploads/formidable/12/Guidelines\\_for\\_Payload\\_Operation\\_in\\_the\\_Stratosphere\\_WhitePaper\\_2022.pdf](https://hapsalliance.org/wp-content/uploads/formidable/12/Guidelines_for_Payload_Operation_in_the_Stratosphere_WhitePaper_2022.pdf)
- HAPS Alliance. (2024a). Creating an Enabling Regulatory Environment for HAPS Deployment. [https://hapsalliance.org/wp-content/uploads/formidable/12/HAPS\\_Alliance\\_TWG\\_Regulatory\\_Positions\\_Paper\\_2024.pdf](https://hapsalliance.org/wp-content/uploads/formidable/12/HAPS_Alliance_TWG_Regulatory_Positions_Paper_2024.pdf)
- HAPS Alliance. (2024b). HAPS Reference Architecture Series. Cell Towers in the Sky. [https://hapsalliance.org/wp-content/uploads/formidable/12/2024\\_HAPS\\_Reference\\_Architecture\\_Series\\_Cell\\_Towers\\_In\\_The\\_Sky\\_White\\_Paper.pdf](https://hapsalliance.org/wp-content/uploads/formidable/12/2024_HAPS_Reference_Architecture_Series_Cell_Towers_In_The_Sky_White_Paper.pdf)
- Hasan, Y. J., Roeser, M. S., Hepperle, M., Niemann, S., Voß, A., Handojo, V., & Weiser, C. (2023). Flight mechanical analysis of a solar-powered high-altitude platform. *CEAS Aeronautical Journal*, 14(1), 201–223. <https://doi.org/10.1007/s13272-022-00621-2>
- ITU (2016). Radio Regulations. Articles. Edition of 2016. [https://www.itu.int/pub/R-REG-RR-2016\\_p.13](https://www.itu.int/pub/R-REG-RR-2016_p.13)
- Knap, L., Świercz, A., Graczykowski, C., & Holnicki-Szulc, J. (2021). Self-deployable tensegrity structures for adaptive morphing of helium-filled aerostats. *Archives of Civil & Mechanical Engineering* (Elsevier Science), 21(4), 1–18. <https://doi.org/10.1007/s43452-021-00292-6>
- Yuki, H., Yoshihisa, K., & Takahiro, A. (2022). Studies toward Practical Application of HAPS in the Space RAN. *NTT Technical Review*, 20(12), 28-35. <https://doi.org/10.53829/ntr202212fa3>



- Mahardika Putro, Y., Aditya Nugraha, R., Rachmat Nugraha, T., Christiawan, R., Bodhihanna, A., Pratama Ong, J., & Testarosa, M. R. (2023). Legal Issues Pertaining to High Altitude Platform Station Implementation in Indonesia as an Archipelagic State. *Udayana Journal of Law and Culture*, 7(2), 144–164. <https://doi.org/10.24843/UJLC.2023.v07.i02.p06>
- Mittal, N., Ivanova, N., Jain, V., & Vishnevsky, V. (2024). Reliability and availability analysis of high-altitude platform stations through semi-Markov modeling. *Reliability Engineering & System Safety*, 252, 110419. <https://doi.org/10.1016/j.ress.2024.110419>
- Ohio Ships. (n.d.) Dynalifter-drone-runner. <http://www.ohioairships.com/dynalifter-faq-s.html>.
- Radovanović, M., & Stevanović M. (2019). Analysis of the construction characteristics of automatic domestic production rifles for the purpose of equipping units of the Serbian Army. *Serbian Journal of Engineering Management*, 5(1), 40–49. <https://doi.org/10.5937/SJEM2001040R>
- Saaty, T. L. (1980). *The Analytic Hierarchy Process*. McGraw-Hill, New York.
- Takabatake, W., Shibata, Y., Hoshino, K., & Ohtsuki, T. (2024). Time-Efficient Neural-Network-Based Dynamic Area Optimization Algorithm for High-Altitude Platform Station Mobile Communications. *Future Internet*, 16(9), 332. <https://doi.org/10.3390/fi16090332>
- van Wynsberghe, E., & Turak, A. (2016). Station-keeping of a high-altitude balloon with electric propulsion and wireless power transmission: A concept study. *Acta Astronautica*, 128, 616–627. <https://doi.org/10.1016/j.actaastro.2016.08.017>
- Xu, Y., Zhu, W., Li, J., & Zhang, L. (2020). Improvement of endurance performance for high-altitude solar-powered airships: A review. *Acta Astronautica*, 167, 245–259. <https://doi.org/10.1016/j.actaastro.2019.11.021>
- Zhu, W., Zhang, B., Zhang, L., Xu, Y., & Yang, K. (2021). Spatial path analysis for high-altitude solar-powered airship with maximum net energy. *Aerospace Science and Technology*, 117. <https://doi.org/10.1016/j.ast.2021.106922>



## THE USE OF SMART CONTRACTS TO PRESERVE THE INTEGRITY OF COLD SUPPLY CHAINS

Dimitrije Soleša<sup>1</sup>, Radovan Vladislavljević<sup>1\*</sup>, Svetlana Marković<sup>2</sup>

<sup>1</sup> University Business Academy in Novi Sad, Faculty of Economics and Engineering  
Management in Novi Sad, Serbia

<sup>2</sup> University Business Academy in Novi Sad, Faculty of Law for Commerce and Judiciary in  
Novi Sad, Serbia

**Abstract:** The aim of the paper is to present a series of organizational and technical solutions that ensure the preservation of the integrity of cold supply chains. The implications of these technologies on the economic and health aspects of society are more than visible. With the help of the Internet of Things and new sensor technologies, it is possible to automate the monitoring of cold supply chains using smart contract technologies and thus preserve the quality of the goods that are the subject of this type of logistics.

**Keywords:** microcontrollers, sensor technologies, cold supply chains, blockchain, smart contracts, quality of goods.

### 1. INTRODUCTION

Transporting and handling sensitive goods, from the point of view of temperature differences, has always been a special challenge. From a technical point of view, with the appearance of refrigerated transport vehicles and cold storage, it was possible to offer perishable or sensitive goods to the market. However, poor handling of goods in various aspects of logistics leads to a decrease in the quality of the same or even to spoilage. Economically, this leads to additional costs as well as supply chain disruption. On the other hand, the impact on the safety and health of consumers may be threatened, and some consequences may appear after a long period of time.

Among the sensitive and perishable goods that must be treated separately are agricultural products, primarily food, medicines and other biotechnological products. In the case of large temperature fluctuations when handling such goods, it can lead to the development

---

\* Corresponding author: [radovan.vladislavljevic@fimek.edu.rs](mailto:radovan.vladislavljevic@fimek.edu.rs)

Dimitrije Soleša, ORCID: 0009-0001-8254-927X

Radovan Vladislavljević, ORCID: 0000-0002-8502-8584

Svetlana Marković, ORCID: 0000-0003-2776-6519

of pathogenic microorganisms or the appearance of unwanted chemical reactions that reduce the effectiveness of medicines or biotechnological products.

## **2. LOGISTICS OF SENSITIVE GOODS**

Logistics by its very definition is the skill of managing material flows, however, the importance of information and cooperation of various elements of the supply chain is becoming increasingly apparent. Supply chain is a much broader concept than logistics, however, due to the limitation of the scope of work, we will mainly deal with logistics problems. Supply chains go beyond the logistics of an iodine company and focus on the inter-organizational connection of logistics systems in the chain of suppliers, manufacturers and end users, i.e. consumers.

However, for the purposes of this paper, the distinction between logistics and supply chain is not important, what is important is the information shared between the various participants in the logistics process. By logistics processes we mean five key activities such as procurement, transportation, storage, inventory and working with users. By integrating these pillars of logistics, it is possible to manage voluminous material flows very efficiently and safely. However, not all goods are the same, so treating them appropriately is crucial. Sensitive goods include various food products, highly reactive chemical products, medicines and the like. Sensitive products can lose quality and/or quantity amid a poorly managed logistics system. For example, direct exposure to direct sunlight can cause certain products to start certain chemical or biological processes that usually lead to a drastic shortening of the product's shelf life. It follows from this that inadequate handling of sensitive products leads to placing on the market products that are no longer for human or animal use.

In the best case, the disputed products will be withdrawn before being presented to potential consumers. This will create negative economic effects, because the goods will not be sold and instead of creating a profit, additional costs will be created to remove inadequate products. However, there is a worse scenario that involves the absence of consumer protection against goods that are inadequately handled in the logistics process. Consumers can consume such products and put their well-being at risk.

In extreme situations, the health of consumers will be so damaged that their very survival can be questioned. In such situations, large fines, court costs, etc. will additionally burden a company. Of course, it is not necessary to emphasize the appearance of negative publicity that will further reduce confidence in the company's ability to present a safe product. However, with some products, such as medicines, it is possible that the effect of the same can be significantly reduced by mishandling.

## **3. COLD SUPPLY CHAINS**

The focus of the work is on preserving the integrity of cold supply chains. In order to place sensitive products on the market in a usable condition, some form of preservation must be applied. Most often, a low or lower temperature can, if not stop, then at least slow down biological or chemical processes in sensitive goods and thereby gain time to present these goods to consumers. "Regarding the numerous causes of food waste, it becomes obvious that a significant amount is lost not only because of natural and unavoidable decay, but due to errors occurring along the supply chain" (Brenner, 2015).

From the place of production to the place of sale or even consumption, a low temperature must be ensured, often below freezing temperatures. For decades, there have been technologies that can maintain a low temperature during logistics processes. In particular, there

are refrigerated containers, refrigerated trucks and cold warehouses that store goods during transport and storage. This technology is relatively complex and requires certain expenditures in energy and additional organizational activities.

However, failures often occur due to technical or organizational problems. It is not uncommon for sensitive goods to be mistakenly transported or stored in inadequate conditions. Also, errors may occur during loading and unloading that lead to spoilage of the transported goods.

Goods that have been thawed once can be refrozen, unfortunately in the meantime the goods may lose their quality. In some cases, it is not possible to see by visual inspection that the goods have not been adequately handled. So consumers are the first to notice irregularities, often after consumption.

#### 4. BLOCKCHAIN TECHNOLOGY

Blockchain technologies are most often mentioned in the context of cryptocurrencies, but it is a separate technology. The purpose of this technology is to record data in a non-destructive way. Classic databases take some data from the user or program and feed it into their structure, each change of this data means the loss of previous values and the writing of new values. With this, speed is gained, but visibility is lost in the sense of a historical overview of the data, i.e. how the data has changed over time.

The concept itself is not new, namely land registers as well as accounting records follow the logic of non-destructive data. Each change in the ownership of the land opens a new record and is linked to the previous one, so it is possible to see who was the owner of the land. Financial transactions, especially in banks, have a similar way of recording. Each payment or withdrawal is recorded separately and in this way it is easier to track changes in the account.

The advantage of blockchain technology lies primarily in the transparency and security of data. Data is written in blocks, and the blocks are connected to each other in a unique chain. Blockchain technology itself relies heavily on cryptographic technologies, primarily hash functions. A hash function is able to take inputs of different sizes and create a unique fixed string of letters and numbers as a result.

Each block in the chain goes through a hash function and becomes an integral part of the next block. In this way, the accuracy of the data is ensured, every change in the previous blocks results in a drastic change in the hash. If the hash of one block does not agree with the hash of the previous block then the whole chain is questioned.

*Table 1.* Example of using the "hash" function

Originalni podatak: <b>Moj podatak je 123</b>
„Hash“ kod: b273870401a04d9f64f2c470c79f465db8709637578136faa509547a2b0ba104
Izmenjeni podatak: <b>Moj podatak je 223</b>
„Hash“ kod: f6486049e4f527bdb5a15da508c990b4e419e0d428802e010703203f40cf6e0a

Blockchains are not only held in one place, i.e. one server, they are held on multiple servers. There is no exact data on the minimum number of copies of the blockchain, but it is estimated that the copies must be fed to dozens of servers. Inserting new blocks requires a special mechanism for accepting new blocks. This mechanism is called a consensus mechanism where it is requested that all or the vast majority of copies of the blockchain accept new blocks.

It follows from this that the blocks themselves are protected from changes to previous records, and the insertion of new ones depends on the mechanism for accepting new blocks. So maliciously injecting new blocks would require gaining control over all or the vast majority of servers holding copies of the blockchain, which is unlikely. Especially considering that different servers run under different operating environments. "Traditional systems, which often use centralized architectures, face several vulnerabilities and limitations that make them susceptible to various cyber threats and cyber attacks" (Nour, 2024). Which is certainly not the case with blockchain technologies.

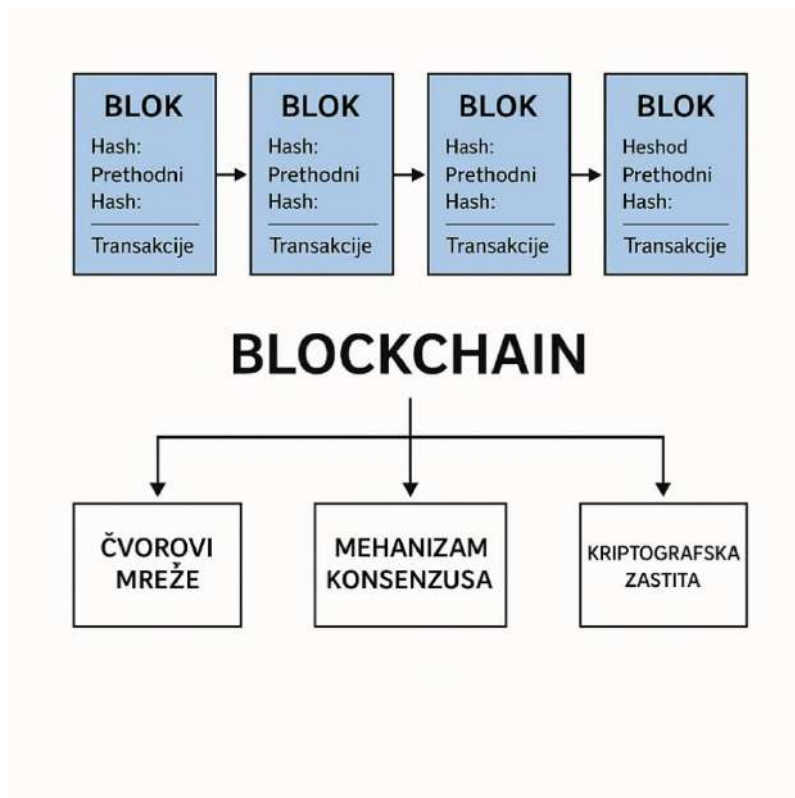


Figure 1. Scheme of "blockchain" (Vladislavljević et al., 2025).

For the needs of logistics and supply chains, it is extremely important to have up-to-date and real data. Any ambiguity, lack of timeliness and lack of transparency leads to supply problems, sending goods to the wrong address, not giving instructions for proper handling of goods, etc. lead to errors that can affect the quality of the goods. "Logistics also represents the management of the flow of goods, for example raw materials, to the producer, and then finished products to the user, and they are applied for military purposes, as well as for business purposes, both for use in the economy and outside it" (Marković, 2010). "Firms also use the Internet to develop close relationships with their logistics partners" (Laudon & Traver, 2023).

This is one of the reasons for the early adoption of blockchain technologies because the transactions that occur in the logistics supply chain are clear and unambiguous. This is the basis for creating a quality system based on the blockchain where each transaction can be treated separately with a link to previous transactions. Sending and receiving goods are separate transactions that are usually handled by separate organizational units or even separate organizations. The transfer of "ownership" from one sector or organization to another can easily be demonstrated through the blockchain.

## 5. SMART CONTRACTS

Basically, these are pieces of code that are automatically executed if pre-defined conditions occur. Smart contracts are part of a block and any transaction recorded in subsequent blocks can be subject to the execution of a smart contract. It follows that smart contracts do not have many points of contact with legal contracts.

Legal contracts are relatively broadly defined and depend on the context in which they are created as well as the intentions of the contracting parties. Legal contracts have a relatively free system of interpretation, and any ambiguity can lead to litigation. On the other hand, smart contracts are clearly designed and unambiguous with clearly defined parameters. For example, it is possible to create a smart contract and tie payment to the delivery of goods. When ordering, the customer's funds can be reserved, which will be paid to the seller the moment the customer receives the requested goods.

From this it follows that it is possible to automate various actions based on various inputs, of course related to transactions in blocks. Based on various sensors, assessments and predictions, it is possible to direct goods to different paths or prevent compromised goods from reaching the final consumers.

## 6. INTERNET OF THINGS IN LOGISTICS

A new chapter in the world of the Internet is precisely the term Internet of Things, this term denotes the intertwining of different technologies that can be connected via the World Wide Web. The traditional understanding of the Internet involves connecting networks of computers into a worldwide network. The next step is the emergence of mobile technologies such as laptops and smartphones. However, these technologies deviate very little from the established concept. "The Internet of Things (IoT) connects networks of smart devices. Smart devices can be embedded in vehicles, buildings or other electronic objects with software, sensors, actuators and network connectivity"(Singh et al., 2023).

The appearance of new products that are able to connect to the Internet opens completely new possibilities. "The fourth industrial revolution, also known as Industry 4.0, was initiated by the development of information and communication technology, which enabled more competitive production systems by connecting smart objects and equipment" (Selamoğlu, 2023). Professional machines used in industry, small household appliances or even pieces of clothing can be connected and share information. Management and management of machines, tools, etc. is possible via the Internet. However, the real power of the Internet of Things lies in quickly obtaining accurate data related to a specific object.

This is important because a machine can signal the occurrence of excess heat through its sensors or the gas sensor can signal the occurrence of harmful gas emissions. So a quick intervention can avoid major damage. At home, the Internet of Things is the basis for smart homes. "Smart homes are another example; they measure temperatures or detect the presence of beverages in the refrigerator to adjust the thermostat in the first case, or to prepare a report for us to pick up some milk or beer on the way home in the second case" (Ziemann, 2023). All this leads to a higher quality of life and work.

Wearables is a relatively new term that refers to the emergence of clothing and footwear that can connect to the Internet. Today there are sneakers that count the number of steps taken, jackets and vests that monitor the breathing and heart rate of the wearer. With the application

of artificial intelligence, health problems can be detected even before they become serious. Also, the quality of life can be significantly increased by using these technologies.

In the world of logistics, professional vehicles have had built-in location tracking modules for decades. GPS technologies help in navigation but also in creating better routes during transportation. Even transshipment vehicles can have different GSP modules or RFID chips through which the efficiency of loading and transshipment operations can be monitored.

Pallets and containers, as the basic load carriers, can be equipped with various modules and sensors with which it is possible to monitor not only the movement but also the way the goods are handled. Any data collected through internal sensors from the palace or container can be sent in real time over the Internet. This data becomes the basis for quick and automatic decision-making that saves time and money.

## **7. MICROCONTROLLERS AND SENSOR TECHNOLOGIES**

Nowadays, it is relatively easy to find quality solutions related to sensor technologies and microcontroller technologies. Microcontrollers are compact electronic devices that integrate a processor, memory, and input-output (I/O) units on a single chip. They are intended for managing specific tasks within larger systems. Due to their low power consumption, high reliability and ability to precisely control devices and sensors, microcontrollers are a key component in various industrial applications, including cold chain monitoring systems.

In the context of using smart contracts to preserve the integrity of cold chains, microcontrollers enable real-time data collection and processing — for example, measuring the temperature, humidity or location of products during transport and storage. By integrating with blockchain networks and smart contracts, that data can be automatically written into distributed ledgers, ensuring its immutability and trustworthiness. Thus, microcontrollers play a key role in creating a transparent and secure system for tracking sensitive products.

Raspberry Pi, Arduino and dedicated microcontrollers represent different approaches in the development of electronic systems for real-time data acquisition and device management. "The Raspberry Pi is a single-board computer that is about the size of a credit card. Despite its small size, it is a very capable device" (Cicolani, 2018). Its application is common in more complex applications that require more resources and multi-level data management.

The Arduino platform is simpler and focused on direct interaction with sensors and actuators. "Arduino is another small processing device that is readily available and easy to use. Unlike a Raspberry Pi, however, it does not have the capacity for a full operating system. Rather than running a microprocessor like the ARM, it uses a different type of chip called a microcontroller" (Cicolani, 2018). It is suitable for applications that require a quick reaction to physical events, such as changes in temperature, humidity or movement. Thanks to its large community and wide support, Arduino is often used for prototyping and systems where reliability and low power consumption are key.

Dedicated microcontrollers are designed for specific tasks and optimized to work in conditions where high reliability, efficiency and long-term autonomy are required. In cold chain integrity applications, these microcontrollers enable constant monitoring of parameters and local decision-making without the need for constant communication with central servers.

Programming languages such as Python, C and C++ are most often used to manage Raspberry Pi devices. Arduino devices are generally programmed using the Arduino IDE, using a simplified version of the C/C++ language. Dedicated microcontrollers are programmed depending on the chip architecture, with the most commonly used languages being C, C++ and,



in specialized cases, assembler, when maximum performance optimization is required. "The common IoT sensors available on the market work with both the Raspberry Pi and Arduino because they use GPIO pins to communicate" (Mathur, 2020).

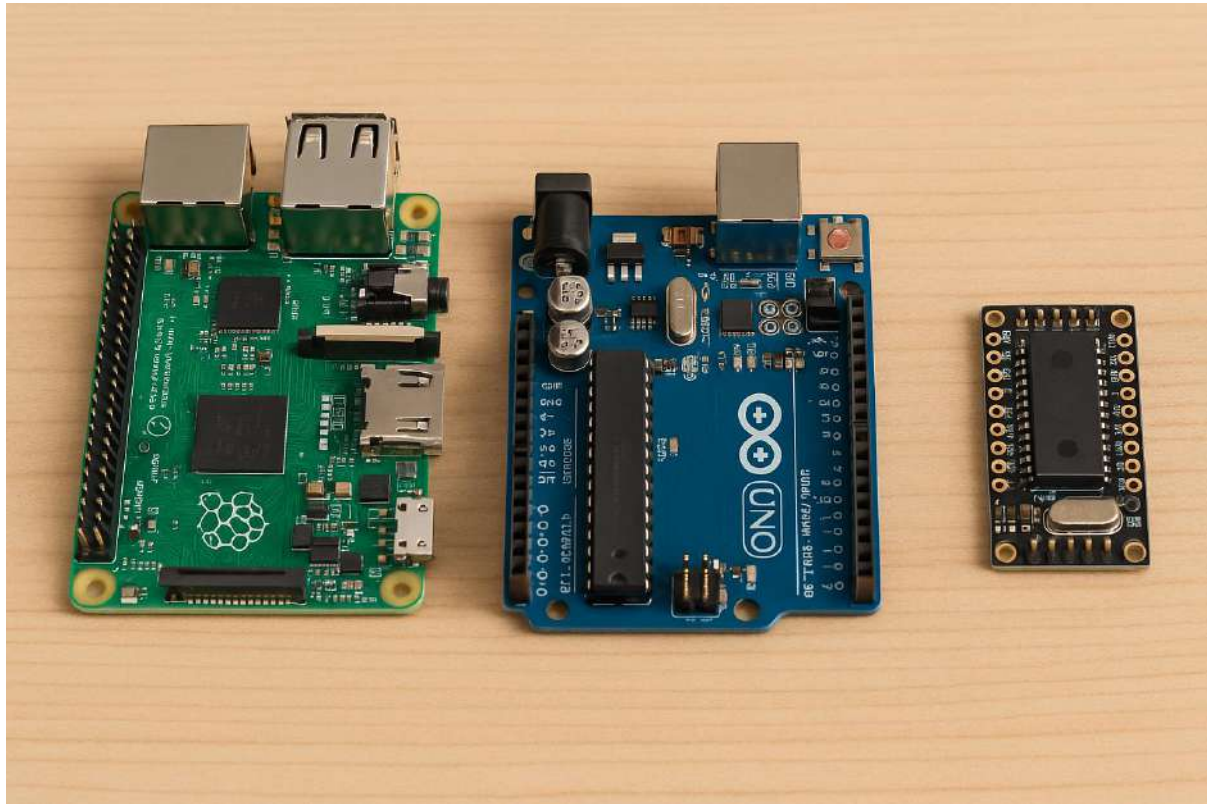


Figure 2. Raspberry Pi, Arduino and dedicated microcontroller (own source)

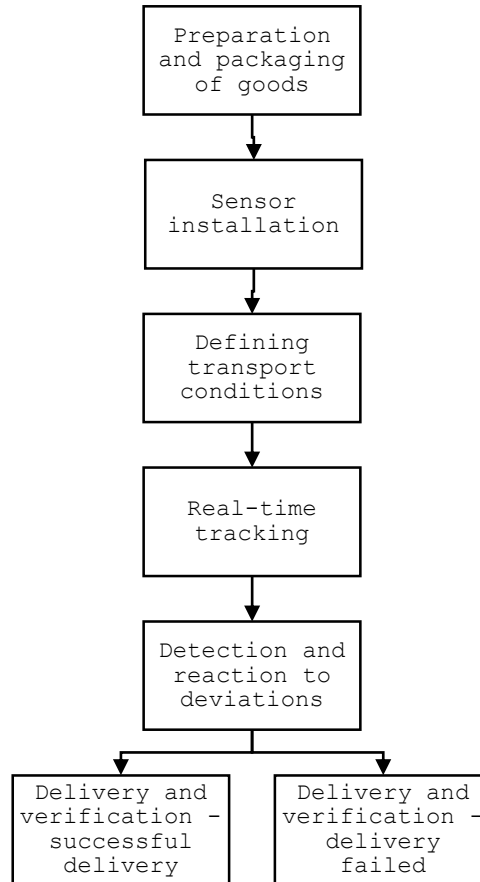
Sensors are key components in microcontroller-based systems because they enable the collection of real-world information. By connecting different types of sensors such as temperature, humidity, gas, light, vibration or GPS modules, microcontrollers gain the ability to perceive, analyze and react to changes in the environment. In this way, the basic functionality of the microcontroller, which is reduced to the processing of predefined instructions, is significantly expanded in the direction of adaptive and autonomous decision-making. "Digital circuits in electronics operate with two states of digital signals: the low signal ("0") and the high signal ("1")" (Rippel, 2024).

Sensor integration allows microcontrollers to not only monitor physical parameters but also automatically trigger actions based on defined thresholds, logic, or rules set in programming code. For example, temperature sensor readings can automatically trigger an alarm or change the system's operating mode if safety limits are exceeded. In more advanced applications, the combination of data from multiple sensors can be used to create complex models of system behavior, which further increases the autonomy and intelligence of the device.

Such extended microcontroller systems are particularly useful in critical industries, such as monitoring cold supply chains, where continuous and reliable monitoring of the condition of goods becomes the key to preserving product quality and safety. Connected sensors, together with the ability to record data on the blockchain through smart contracts, enable the creation of transparent, secure and immutable records of all critical parameters during storage and transportation



## 8. MODEL



*Figure 3.* A rough model of the use of sensors to preserve the integrity of the cold supply chain.

The model of the process of packing and sending goods through cold supply chains is based on automated data management, optimization of transport conditions and preservation of the integrity of goods through all stages of distribution. The algorithm works through the following key steps:

**Preparation and packing of the goods:** Before the beginning of the transport, the goods are packed in specialized packaging that allows maintaining the required temperature and humidity. Each shipment receives a unique identifier (eg QR code or RFID tag), which enables monitoring of its status in real time.

**Sensor installation:** Sensors are integrated inside the package that measure key parameters such as temperature, humidity, pressure and the possible presence of gases (to control spoilage). The sensors are connected to microcontrollers that continuously record the readings.

**Defining transport conditions:** Before shipping, all reference conditions (e.g. permitted temperature range) are digitally written into a smart contract on the blockchain network. The smart contract automatically checks whether the conditions are met at each stage of the transport.

**Real-time tracking:** During transportation, microcontrollers continuously collect data from sensors and send it at periodic intervals to a distributed tracking system. Each reading can be automatically written to the blockchain, thus guaranteeing data immutability.

Detection and reaction to deviations: If any parameter exceeds the permissible threshold, the system automatically generates an alarm, notifies the responsible persons and records the incident in the blockchain. Based on the rules defined in the smart contract, actions can be taken automatically, such as redirecting the shipment to the nearest warehouse or activating additional cooling systems.

Delivery and verification: When delivering goods, all data from the smart contract and sensor readings are verified. If all conditions during transport are met, the goods are automatically marked as safe for use. If there is a deviation, the complaint or additional quality control process is automatically initiated.

## 9. CONCLUSION

The application of smart contracts, microcontrollers and sensors in cold supply chain systems represents one of the most important achievements in modern logistics. The combination of these technologies enables continuous monitoring of the transport and storage conditions of sensitive goods, with every relevant piece of data automatically recorded and stored on a distributed, secure platform such as blockchain. This eliminates the risks of manipulation, errors in records and delays in responding to irregularities.

Microcontrollers, as control centers of connected sensor systems, enable real-time data processing and initiation of actions based on predefined criteria. Sensors, as an extended arm of the microcontroller, give the product the ability to "communicate" with the environment, enabling accurate and timely detection of all changes that could affect its quality. Smart contracts, on the other hand, automate the verification of fulfillment of conditions and the execution of contractual obligations without the need for human intervention, which further reduces costs and increases operational efficiency.

The introduction of such intelligent systems not only raises the standards of safety and transparency in cold supply chains, but also significantly contributes to building trust among all participants — from manufacturers, distributors, to end users. It also enables better resource management, waste reduction, reduced risk of spoilage and supports regulatory requirements for product quality control, particularly in industries such as pharmaceuticals, food and vaccine transport.

Through the further development and wider application of these technologies, the gradual transformation of cold supply chains into fully digitized, independent and adaptive systems, capable of responding to increasing market demands in terms of speed, security and accountability, is expected.

As technologies such as the Internet of Things (IoT), artificial intelligence and blockchain continue to develop and integrate with each other, cold supply chains will evolve into intelligent, self-learning networks that will not only preserve the quality of goods, but actively contribute to the sustainability and resilience of global logistics systems.

## REFERENCES

- Brenner, V. (2015). *Causes of Supply Chain Disruptions An Empirical Analysis in Cold Chains for Food and Pharmaceuticals*. Springer Fachmedien Wiesbaden : Imprint: Springer Gabler.

- Cicolani, J. (2018). Beginning robotics with Raspberry Pi and Arduino: using Python and OpenCV. Apress.
- Laudon, C., K., Traver, G., C. (2023). E-commerce: business. technology. society., Pearson.
- Marković N., (2010), Poslovna logistika, CEKOM-books, Novi Sad.
- Mathur, P. (2020). IoT Machine Learning Applications in Telecom, Energy, and Agriculture. Apress.
- Nour El Madhoun. (2024). Building Cybersecurity Applications with Blockchain and Smart Contracts. Springer Nature.
- Rippel, J. (2024). Logic Analyzers in Practice PC USB Logic Analyzers with Arduino, Raspberry Pi, and Co., Elector.
- Selamoğlu, I., B. (2023). MRP and ERP, CRC Press.
- Singh, R., Gehlot, A., Singh, B., Choudhury, S. (2023). Internet of Things (IoT) Enabled Automation in Agricultural, CRC Press.
- Vladislavljević, R., Stojković, & P., Živkucin, S. (2025). Uloga pametnih ugovora u logistici poljoprivrednih proizvoda, Fifth International Scientific Conference: Challenges of Modern Economy and Society Through the Prism of Green Economy and Sustainable Development – Cesged 2025, Novi Sad.
- Ziemann, V. (2023). A Hands-On Course in Sensors Using the Arduino and Raspberry Pi: Second Edition, CRC Press.



## COSMETIC BRANDS PERCEPTION BY GENERATION Z THROUGH THE PRISM OF CONSCIOUS CONSUMPTION

Marina Sheresheva<sup>1</sup>, Daria Golub<sup>1</sup>, Daniel Pavlov<sup>2</sup> \*

<sup>1</sup> Lomonosov Moscow State University, Russia

<sup>2</sup> University of Ruse “Angel Kanchev”, Bulgaria

**Abstract:** This paper examines the role of conscious consumption concept as a way to can help to build confidence and attract sustainability-driven young consumers of cosmetic brands. We first discuss theoretical approaches to understanding the phenomenon of conscious consumption, a specific trend in consumer behavior in which the consumer is guided by a conscious need, ethical and environmental considerations. Based on the academic literature, we conclude that conscious consumption should not be considered as an isolated phenomenon, but is an integral part of a wider system where politics, economics and social expectations interact to form sustainable practices. The empirical results presented in the literature confirm that there are specific features characterizing Gen Z consumers as more conscious than older generations. In our research, we used these particular features as basic to put forward hypotheses concerning conscious consumption impact on Russian Zoomers’ behaviour. Then we present and discuss the empirical data obtained through online survey conducted in March-April 2025. The analysis of survey results leads to the conclusion that there is a segment of young Russian conscious consumers focused on sustainable development, but not all Zoomers are ready to give preference to skin care cosmetic brands due to their eco-friendly characteristics.

**Keywords:** conscious consumption, Generation Z, cosmetic brands, Russia.

### 1. INTRODUCTION

Currently, academics and practitioners pay growing attention to issues of sustainable development (Cherenkov et al., 2020; Biyase et al., 2024). More and more people are on the path of rethinking the process of consumption and its consequences for the environment and human health. As a result, the trend of conscious consumption has developed (Carr et al., 2012; Garg et al., 2024).

---

\* Corresponding author: [dpavlov@uni-ruse.bg](mailto:dpavlov@uni-ruse.bg)

Marina Sheresheva, ORCID: 0000-0002-8153-7111

Daria Golub, ORCID: 0009-0007-0800-8890

Daniel Pavlov, ORCID: 0000-0002-4515-2206

In existing studies, it is widely believed that young educated consumers belonging to Generation Z are most concerned about the importance of conscious consumption, compliance with ethical standards by brands, as well as the social and environmental consequences associated with traditional, non-ecological consumption (Michel et al., 2023).

In particular, the concept of conscious consumption has had a major impact on the cosmetics industry (Rocca et al., 2022, 2023; Venciute et al., 2023). Cosmetics manufacturers now care about cosmetic products made from natural raw materials and incorporate principles of sustainable development at all stages of production (Acerbi et al., 2023).

The Russian cosmetics market is currently undergoing a significant transformation. The cosmetics industry, like many other segments of the consumer market, proved to be sensitive to changes in aggregate demand and the level of disposable income of the population during periods of turbulence. Some multinational companies have exited the market in 2022, leaving empty niches. In this situation, buying habits and preferences of Russian consumers are changing, and the opportunities for Russian producers and newcomers to fill the niches became obvious. After a temporary decline in 2022-2023, there was a noticeable resumption of positive dynamics in 2024. Such a significant increase indicates a recovery in domestic demand and a strengthening of domestic producers, who have managed to adapt to the new conditions by diversifying their product range, introducing innovative developments and revising their marketing strategies. The growth in production volumes was the result of an integrated approach, including increased investment in research and development, the use of modern equipment and a flexible response to market demands in the context of rapidly changing trends.

In this paper, we present the results of the study conducted in 2024-2025. The main research goal was to identify how Russian young consumers perceive the responsible marketing efforts of cosmetic firms, with the focus on the prospects of conscious consumption approach in development and promotion of skin care cosmetics.

## **2. LITERATURE REVIEW**

### **2.1. Conscious consumption**

Research on the concept of conscious consumption, as well as the conscious consumers behaviour and consumer perception of conscious brands, is becoming more and more numerous (Wang et al., 2014; Mingazova et al., 2025; Zhuang et al., 2021; Vuong & Bui, 2025). This trend has become widespread due to the popularization of the principles of sustainable development: more and more people began to think not only about the impact of human activities on the environment, but also about social aspects (Haider et al., 2022).

Many authors focus on the actual purchase, or on the purchase intention, or on these two aspects in terms of measuring the gap between them (Carrigan & Attalla, 2001; Lebel & Lorek, 2008; Wijekoon & Sabri, 2021).

Research in the field of responsible marketing emphasizes the importance of understanding individual behavior in order to influence consumer choices between competing products or brands (Sharma, 2021). The conscious consumer behavior implies evaluating a wider range of alternatives, including conscious choices to reduce consumption (Amoako et al., 2022; Kaur et al., 2022) or finding other ways to satisfy their desires that do not involve purchasing a product. The level of trust or skepticism with which consumers assess product claims of companies, as well as their environmental claims, has a significant impact (Farooq & Wicaksono, 2021; Sun et al., 2021; Szabo & Webster, 2021; Tee et al., 2022).

The process of making a purchase itself can be considered a significant act in terms of conscious consumption (Zhang & Dong, 2020), since the actions performed by an individual

will have different impact on the environment. In addition, the concept of conscious consumption aims to maximize the use of a product, and to arrange its subsequent disposal with minimal negative impact (Peattie, 2010; Jeswani et al., 2021).

In general, the results obtained by many researchers show that conscious consumption is a multifactorial phenomenon. Along with personal characteristics, social pressure, awareness and the availability of incentives from state and business play an important role. One should not consider conscious consumption as an isolated phenomenon. It is an integral part of a wider system where politics, economics and social expectations interact to form sustainable practices.

## **2.2. Generation Z (Zoomers) key features**

In the contemporary world, the new “rules of green marketing” increasingly characterize the purchasing preferences of new generations (Ottman, 2011, p.xiii). In particular, Gen Z consumers tend to be more inclined towards responsible shopping and conscious consumption.

An important feature of Gen Z is the emphasis on individuality and self-expression. Zoomers strive for uniqueness in their lifestyle and consumption. They choose brands not only for the quality of their products or services, but also for their ability to reflect personal values and beliefs. Concepts such as inclusiveness, transparency, sustainability, fair value products resonate with this consumer segment (Sheresheva et al., 2023). This creates a significant challenge for companies: it is necessary not only to sell a product, but also to create a whole story around it that will resonate with the target audience (Channa et al., 2025).

Social activity also plays an important role in the lives of representatives of Generation Z. They are inclined to support social movements and participate in the discussion of current issues through social media platforms (Literat & Kligler-Vilenchik, 2023).

Generation Z is characterized by a desire for immediacy and convenience when making purchases (Sisodiya & Vaidya, 2023). They have high expectations regarding the speed of service - they prefer online shopping with fast delivery or the ability to pick up goods without queues in stores. This requires businesses to implement new technologies to optimize the purchasing process.

Zoomers' trust in peer reviews is significantly higher compared to previous generations (Herrando et al., 2021; Thangavel et al., 2022), meaning that companies must actively work on their brand reputation online. A negative review can significantly influence a potential customer's purchase decision (Ahn & Lee, 2024). One should also mention that bloggers and their recommendations have a more significant impact on purchasing decisions than traditional advertising, as well as reviews from other consumers (Belanche et al., 2021).

Awareness of global environmental and social issues motivates Gen Z to choose environmentally friendly products or services from socially responsible companies (Khalil et al., 2021; Halicka et al., 2025). They prefer to shop with companies that are actively involved in local communities and support social initiatives. In addition, they tend to support local and small businesses that offer environmentally friendly and ethically produced goods. Brands must actively demonstrate their efforts to reduce negative environmental impacts and their commitment to social issues to attract the attention of this audience.

Generation Z shows interest in “zero waste” and “slow fashion” concepts which reflects their desire to reduce the number of unnecessary purchases and choose high-quality, durable products (Zhang et al., 2022; Gurova, 2024). This leads to the growing popularity of secondary markets, renting and exchanging goods, which reduce resource consumption and waste.

An important element of Gen Z conscious consumption is also ethical consumption. Zoomers prefer to support brands that adhere to fair trade principles and provide decent working conditions (Djafarova & Fouts, 2022). This means that companies that do not pay attention to the ethical aspects of their activities risk losing the loyalty of this audience.

Another important trend in conscious consumption is the use of technology to increase transparency and awareness. Generation Z actively uses applications and platforms that allow you to track the origin of products, their composition and environmental characteristics. This creates additional opportunities for interaction between brands and consumers.

Based on the academic literature, one can conclude that there are specific features characterizing Gen Z consumers as more conscious than older generations. In our research, we used these particular features as basic to put forward hypotheses concerning conscious consumption impact on Russian Zoomers' behaviour.

### 3. MATERIALS AND METHODS

In the study, we put forward five hypotheses concerning Russian Zoomers' behaviour depending on their awareness of the conscious consumption concept (H1), level of education (H2), cosmetic brand social responsibility importance (H3), commitment to a healthy lifestyle (H4), commitment to the principles of conscious consumption (H5).

To obtain empirical data, we developed a questionnaire for an online survey, most questions using Likert Scale. Respondents were Zoomers using skin care cosmetics from different Russian regions. The online platform Google Forms was chosen to conduct the survey. Questionnaires were distributed in social networks. The information was collected anonymously and did not imply the processing of the respondent's personal data. Respondents were informed that the results of the survey would only be used in an anonymous form as part of the study.

390 completed questionnaires were received. In addition, the survey included two open questions; after excluding answers that were not relevant in meaning, we received 228 responses to the first open question and 127 responses to the second open question.

In the sample, 78% of the respondents were women, 22% were men. The largest share of respondents are residents of the megacities and big cities. 5% of respondents assessed their income as high, 29% - above average, 13% - below average, the largest number (42%) answered that their income is at an average level, and 11% do not have their own income.

### 4. RESULTS

The obtained results were as follows:

Russian Zoomers' *awareness of the conscious consumption concept* has a positive effect on the perceived quality of cosmetics produced by eco-friendly brands, and on the willingness to use eco-cosmetic products.

Russian Zoomers' *level of education* has a significant positive effect on the perceived quality of cosmetics produced by eco-friendly brands.

The degree *cosmetic brand social responsibility importance* for Russian Zoomers has a significant positive effect on the willingness to use eco-cosmetic products, and on the recognition of cosmetic brands that use eco-friendly methods and components in skin care products.

Russian Zoomers' *commitment to a healthy lifestyle* has a significant positive impact on the willingness to use eco-friendly cosmetic products, and on the recognition of cosmetic brands that use eco-friendly methods and components in skin care products.

Russian Zoomers' *commitment to the principles of conscious consumption* has a significant positive impact on the perceived quality of cosmetics produced by eco-friendly brands, and on the perception a cosmetic brand image if this brand adheres to the conscious consumption principles.

At the same time, there were respondents who were indifferent to the issues of conscious consumption, having price as the main criterion to choose skin care cosmetics. Thus, there is a segment of young Russian conscious consumers focused on sustainable development, but not all Zoomers are ready to give preference to skin care cosmetic brands due to their eco-friendly characteristics.

## 5. CONCLUSIONS

After conducting a survey, we can conclude that Zoomers represent a new generation of conscious consumers who actively seek to minimize the negative impact of their purchases on the environment and society. In this regard, the trend to conscious consumption is a quite promising way to differentiate cosmetic products and increase young consumers' loyalty to cosmetic brands in a changing social and cultural paradigm. It makes sense to develop cosmetic products taking into account that responsible shopping and conscious consumption grow in importance. Green characteristics of cosmetic brands can help to build confidence and attract sustainability-driven young consumers. At the same time, the lack of knowledge about conscious consumption principles may prevent Zoomers from evaluating the attractive points of green cosmetic products.

The research results offer some practical implications for providers of cosmetic products for young Russian consumers.

Firstly, cosmetic firms should institutionalize the environmental and social agenda, making it part of the corporate mission and officially declared values.

Secondly, it is necessary to develop a community-oriented marketing model that takes into account the high importance of the Gen Z reference group.

Thirdly, cosmetic brand communication strategy should integrate an educational component that reveals the essence of the conscious consumption concept and demonstrates how this particular brand implements the concept in practice.

To sum up, cosmetic firms have to adapt their marketing strategy to the growing interest of young generations to the conscious consumption.

## REFERENCES

- Acerbi, F., Rocca, R., Fumagalli, L., & Taisch, M. (2023). Enhancing the cosmetics industry sustainability through a renewed sustainable supplier selection model. *Production & Manufacturing Research*, 11(1), 2161021. <https://doi.org/10.1080/21693277.2022.2161021>
- Ahn, Y., & Lee, J. (2024). The Impact of Online Reviews on Consumers' Purchase Intentions: Examining the Social Influence of Online Reviews, Group Similarity, and Self-Construct. *Journal of Theoretical and Applied Electronic Commerce Research*, 19(2), 1060–1078. <https://doi.org/10.3390/jtaer19020055>
- Amoako, G. K., Dzugbenuku, R. K., Doe, J., & Adjaisson, G. K. (2022). Green marketing and the SDGs: emerging market perspective. *Marketing Intelligence & Planning*, 40(3), 310-327.
- Belanche, D., Casaló, L. V., Flavián, M., & Ibáñez-Sánchez, S. (2021). Understanding influencer marketing: The role of congruence between influencers, products and



- consumers. *Journal of Business Research*, 132, 186-195. <https://doi.org/10.1016/j.jbusres.2021.03.067>
- Biyase, M., Kirsten, F., Zwane, T., & Bila, S. (2024). Tracing environmental Kuznets curves: unveiling the interplay of inequality, urbanization, GDP and emissions in BRICS nations. *BRICS Journal of Economics*, 5(1), 83-104. <https://doi.org/10.3897/brics-econ.5.e117948>
- Carr, D. J., Gotlieb, M. R., Lee, N. J., & Shah, D. V. (2012). Examining overconsumption, competitive consumption, and conscious consumption from 1994 to 2004: disentangling cohort and period effects. *The annals of the American academy of political and social science*, 644(1), 220-233. <https://doi.org/10.1177/0002716212449452>
- Carrigan, M., & Attalla, A. (2001). The myth of the ethical consumer—do ethics matter in purchase behaviour? *Journal of consumer marketing*, 18(7), 560-578. <https://doi.org/10.1108/07363760110410263>
- Channa, A., Sharma, A., Jain, A., Malhotra, P., & Khumar, S. (2025). Sustainable Storytelling Engaging Audiences With Eco-Narratives in the Digital Age. In *Driving Business Success Through Eco-Friendly Strategies* (pp. 441-464). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-9750-3.ch023>
- Cherenkov, V., Sheresheva, M., Starov, S., Gladkikh, I., Tanichev, A., Berezka, S., ... & Yussuf, A. (2020). Sustainability trends and consumer perceived risks towards private labels. *Entrepreneurship and Sustainability Issues*, 8(1), 347. [http://doi.org/10.9770/jesi.2020.8.1\(24\)](http://doi.org/10.9770/jesi.2020.8.1(24))
- Djafarova, E., & Foots, S. (2022). Exploring ethical consumption of generation Z: Theory of planned behaviour. *Young Consumers*, 23(3), 413-431. <https://doi.org/10.1108/YC-10-2021-1405>
- Farooq, Y., & Wicaksono, H. (2021). Advancing on the analysis of causes and consequences of green skepticism. *Journal of Cleaner Production*, 320, 128927.
- Garg, R., Bansal, S., Rathi, R., & Bhowmick, S. (2024). Mindful consumption—A systematic review and research agenda. *Journal of Cleaner Production*, 459, 142373. <https://doi.org/10.1016/j.jclepro.2024.142373>
- Gurova, O. (2024). Practice theory approach to Gen Z's sustainable clothing consumption in Finland. *Young Consumers*, 25(3), 289-307. <https://doi.org/10.1108/YC-06-2023-1765>
- Haider, M., Shannon, R., & Moschis, G. P. (2022). Sustainable consumption research and the role of marketing: A review of the literature (1976–2021). *Sustainability*, 14(7), 3999. <https://doi.org/10.3390/su14073999>
- Halicka, E., Kaczorowska, J., Rejman, K., & Plichta, M. (2025). Investigating the Consumer Choices of Gen Z: A Sustainable Food System Perspective. *Nutrients*, 17(3), 591. <https://doi.org/10.3390/nu17030591>
- Herrando, C., Jiménez-Martínez, J., & Martín-De Hoyos, M. J. (2021). The mediated effect of social presence on social commerce WOM behavior. *Information*, 12(12), 498. <https://doi.org/10.3390/info12120498>
- Jeswani, H. K., Figueroa-Torres, G., & Azapagic, A. (2021). The extent of food waste generation in the UK and its environmental impacts. *Sustainable Production and Consumption*, 26, 532-547. <https://doi.org/10.1016/j.spc.2020.12.021>
- Kaur, B., Gangwar, V. P., & Dash, G. (2022). Green marketing strategies, environmental attitude, and green buying intention: A multi-group analysis in an emerging economy context. *Sustainability*, 14(10), 6107. <https://doi.org/10.3390/su14106107>
- Khalil, S., Ismail, A., & Ghalwash, S. (2021). The rise of sustainable consumerism: evidence from the Egyptian generation Z. *Sustainability*, 13(24), 13804. <https://doi.org/10.3390/su132413804>

- Lebel, L., & Lorek, S. (2008). Enabling sustainable production-consumption systems. *Annual Review of Environment and Resources*, 33(1), 241-275. <https://doi.org/10.1146/annurev.envIRON.33.022007.145734>
- Literat, I., & Kligler-Vilenchik, N. (2023). Climate anxiety as a lens into young people's political expressions on Youtube. *AoIR Selected Papers of Internet Research*. <https://doi.org/10.5210/spir.v2023i0.13449>
- Michel, J. F., Mombeuil, C., & Diunugala, H. P. (2023). Antecedents of green consumption intention: a focus on generation Z consumers of a developing country. *Environment, Development and Sustainability*, 25(12), 14545-14566. <https://doi.org/10.1007/s10668-022-02678-9>
- Mingazova, D., Alanadoly, A. B., & Salem, S. F. (2025). Ethics, Brands and Sustainable Consumption. In *Brands, Branding, and Consumerism: Personal and Social Influences on Consumption* (pp. 345-376). Cham: Springer Nature Switzerland. [https://doi.org/10.1007/978-3-031-80859-3\\_9](https://doi.org/10.1007/978-3-031-80859-3_9)
- Ottman, J. A. (2011). *The new rules of green marketing: Strategies, tools, and inspiration for sustainable branding*. Oakland, CA, USA: Berrett-Koehler Publishers. <https://doi.org/10.4324/9781351278683>
- Peattie, K. (2010). Green consumption: Behavior and norms. *Annual review of environment and resources*, 35(1), 195-228. <https://doi.org/10.1146/annurev-envIRON-032609-094328>
- Rocca, R., Acerbi, F., Fumagalli, L., & Taisch, M. (2023). Development of an LCA-based tool to assess the environmental sustainability level of cosmetics products. *The International Journal of Life Cycle Assessment*, 28(10), 1261-1285. <https://doi.org/10.1007/s11367-023-02219-0>
- Rocca, R., Acerbi, F., Fumagalli, L., & Taisch, M. (2022). Sustainability paradigm in the cosmetics industry: State of the art. *Cleaner Waste Systems*, 3, 100057. <https://doi.org/10.1016/j.clwas.2022.100057>
- Sharma, A. P. (2021). Consumers' purchase behaviour and green marketing: A synthesis, review and agenda. *International Journal of Consumer Studies*, 45(6), 1217-1238. <https://doi.org/10.1111/ijcs.12722>
- Sheresheva, M., Aleksanova, S., & Pavlov, D. (2023). Private labels of retail chains: Prospects of green marketing approach. In *International May Conference on Strategic Management – IMCSM23. Vol. 2* (pp. 77–83). University of Belgrade.
- Sisodiya, S., & Vaidya, S. (2023). Marketing in the Metaverse: An opportunity for virtual marketing for Zoomers (Gen Z). *International Journal of Progressive Research in Engineering Management and Science (IJPREMS)*, 3(1), 109-120. <https://www.doi.org/10.58257/IJPREMS30580>
- Sun, Y., Luo, B., Wang, S., & Fang, W. (2021). What you see is meaningful: Does green advertising change the intentions of consumers to purchase eco-labeled products? *Business Strategy and the Environment*, 30(1), 694-704. <https://doi.org/10.1002/bse.2648>
- Szabo, S., & Webster, J. (2021). Perceived greenwashing: the effects of green marketing on environmental and product perceptions. *Journal of business ethics*, 171, 719-739. <https://doi.org/10.1007/s10551-020-04461-0>
- Tee, P. K., Lim, K. Y., Ng, C. P., & Wong, L. C. (2022). Trust in green advertising: Mediating role of environmental involvement. *International Journal of Academic Research in Business and Social Sciences*, 12(1), 1771-1786. <http://dx.doi.org/10.6007/IJARBS/v12-i1/12046>

- Thangavel, P., Pathak, P., & Chandra, B. (2022). Consumer decision-making style of gen Z: A generational cohort analysis. *Global Business Review*, 23(3), 710-728. <https://doi.org/10.1177/0972150919880128>
- Venciute, D., Mackeviciene, I., Kuslys, M., & Correia, R. F. (2023). The role of influencer–follower congruence in the relationship between influencer marketing and purchase behaviour. *Journal of Retailing and Consumer Services*, 75, 103506. <https://doi.org/10.1016/j.jretconser.2023.103506>
- Vuong, T. K., & Bui, H. M. (2025). The Impact of Environmental and Brand Factors on Customers' Purchase Intentions: A Sustainable Development Perspective. *Journal of the Knowledge Economy*, 1-20. <https://doi.org/10.1007/s13132-025-02717-6>
- Wang, P., Liu, Q., & Qi, Y. (2014). Factors influencing sustainable consumption behaviors: a survey of the rural residents in China. *Journal of Cleaner Production*, 63, 152-165. <https://doi.org/10.1016/j.jclepro.2013.05.007>
- Wijekoon, R., & Sabri, M. F. (2021). Determinants that influence green product purchase intention and behavior: A literature review and guiding framework. *Sustainability*, 13(11), 6219. <https://doi.org/10.3390/su13116219>
- Zhang, X., & Dong, F. (2020). Why do consumers make green purchase decisions? Insights from a systematic review. *International journal of environmental research and public health*, 17(18), 6607. <https://doi.org/10.3390/ijerph17186607>
- Zhang, S., Tan, Q., Xu, G., & Li, J. (2022). Unveiling characteristics and trend of zero waste research: a scientometric perspective. *Environmental Science and Pollution Research*, 29(29), 44391-44403. <https://doi.org/10.1007/s11356-021-18048-3>
- Zhuang, W., Luo, X., & Riaz, M. U. (2021). On the factors influencing green purchase intention: A meta-analysis approach. *Frontiers in psychology*, 12, 644020. <https://doi.org/10.3389/fpsyg.2021.644020>



## REFRAMING PERFORMANCE APPRAISAL THROUGH EMPLOYEE PERCEPTIONS: INSIGHTS FROM THE ALBANIAN BANKING SECTOR

Sllavka Kurti \*, Katerina Vasili, Vasilika Kume

*University of Tirana, Faculty of Economy, Albania*

**Abstract:** The Albanian banking sector is facing growing challenges in attracting and retaining skilled employees, making the effectiveness of performance evaluation systems increasingly important. This study investigates how banking employees perceive the current appraisal practices and identifies the main factors that influence their views. To achieve this, a quantitative research design was employed, using primary data collected through a structured questionnaire distributed to 182 banking professionals across various institutions and roles. To assess the strength and significance of the predictors influencing employees' views on appraisal relevance data were analyzed using descriptive statistics and multiple regression analysis. The analysis revealed that clarity of evaluation criteria ( $\beta = 0.443$ ), objectivity of indicators ( $\beta = 0.342$ ), and linkage to rewards ( $\beta = 0.268$ ) emerged as the key drivers explaining 56.6% of the variance in employees' perceptions of performance appraisal system effectiveness. In contrast, the frequency of evaluations and the quality of the feedback process demonstrated a comparatively weaker influence on employees' perceptions of appraisal system effectiveness. These results suggest that improving the transparency, consistency, and developmental value of performance evaluations could play a crucial role in enhancing employee satisfaction and retention. Strengthening appraisal practices may, therefore, represent an important step for Albanian banks aiming to build a more satisfied, engaged, and resilient workforce.

**Keywords:** Evaluation, performance, employees, perception, feedback.

### 1. INTRODUCTION

In light of recent developments in the Albanian labor market, recruiting and retaining qualified employees has emerged as one of the most pressing challenges for many organizations. These difficulties have exposed longstanding dysfunctions in human resource management practices. While some of these problems are tied to wider economic and global

---

\* Corresponding author: [sllavkakurti@fakultetieconomise.edu.al](mailto:sllavkakurti@fakultetieconomise.edu.al)

Sllavka Kurti, ORCID: 0000-0001-8959-8245

Katerina Vasili, ORCID: 0009-0009-6652-1275

Vasilika Kume, ORCID: 0009-0004-2932-2158

trends, many are internal—such as the lack of well-structured performance appraisal systems, limited training opportunities, and insufficient incentives to keep employees motivated and engaged. The banking sector, in particular, is one of the sectors that has been affected hard, especially after the pandemic. Staff turnover has led banks to offer higher salaries to new recruits, which in turn has created demotivation among long-standing employees who often feel undervalued. These developments raise important questions about how performance is currently evaluated and whether the existing systems are truly fair, consistent, or effective. Employee performance is defined as the efficiency and effectiveness with which employees fulfill their job responsibilities (Dziuba et al., 2020). Raj et al (2023), in their study on performance appraisal noted that performance evaluation is the survey and assessment of the employee presentation during a time period and it is used to comprehend the capacities of an individual for additional development and advancement. This process assists the process of evaluating the development and advancement of employees and also give grounds to representatives to identify and present areas of improvement and give direction to employee's turn of events. Therefore, performance evaluation gives prize to better execution.

This concept is also related to employee satisfaction, where several studies enhance that higher levels of job satisfaction can lead to better performance. On the other hand, employee performance is essential to the success of any organization as it directly impacts productivity, operational efficiency, and overall competitiveness (Nguyen et al., 2020). Employees that are high-performing not only impact reaching organizational objectives, but they also create a positive work environment and reduce turnover (de Waal et al., 2023).

Performance assessments have an impact on both employee growth and improvement of the overall performance of the organization. As for banking sector, performance evaluation is critical for the bank's performance due to being a labor-intensive industry. Banks generally involve official evaluation of the employee's job performance over a fixed period to provide constructive feedback and as well notice strengths and areas for improvement for the employee. These reviews aim to help employees reach their career goals, while they help banks to retain top people and achieve their strategic goals (Dachner et al., 2021). Furthermore, the linkage between performance evaluations and tangible outcomes, such as promotions and rewards, is considered essential for reinforcing employee motivation and organizational commitment (Khan & Almahdi, 2024). Recent studies also highlight that the developmental aspect of feedback—rather than its mere frequency—plays a more decisive role in shaping positive employee perceptions of appraisal systems (Ghani et al., 2022). Collectively, these findings underscore the need for transparent, objective, and development-focused evaluation practices. Despite being noted the importance of performance evaluation in the banking system, and considering that it is one of the most well-regulated and formal sectors in Albania, the area of performance management remains out of standardization leading to different tools and methods used by each bank. Furthermore, banks on their annual report do report activities and training on other human resources practices, however there is little to no studies considering the employee perspective on these matters, especially to performance management. The shortage of skilled professionals in Albania, combined with widespread job opportunities across banks and industries, has made employee turnover increasingly common, leading to substantial organizational challenges. Therefore, it is crucial to examine employee perspectives on the effectiveness of existing performance appraisal methods. Understanding employees' views will offer valuable insights into whether current evaluation practices are perceived as fair and effective, and will help identify specific areas in need of improvement. Enhancing the performance appraisal process is anticipated to foster a better working environment, increase employee satisfaction, and ultimately strengthen organizational performance within the banking sector. This study examines banking employees' views on the effectiveness and

relevance of current appraisal systems, focusing on the factors that shape their perceptions. By integrating employee feedback, banks can refine their evaluation practices, foster a more supportive work environment, and strengthen both employee loyalty and organizational performance.

## 2. LITERATURE REVIEW

Performance evaluation plays a critical role in shaping employee development and organizational effectiveness, particularly in service-oriented sectors such as banking. It involves the systematic review of an employee's performance over a given period and serves multiple functions: identifying individual strengths and development areas, setting goals for improvement, and determining eligibility for promotions, salary adjustments, or training opportunities (Brundin et al., 2021). Earlier literature often used the terms performance evaluation, merit rating, and performance appraisal interchangeably to refer to structured assessments of individual job performance (Bhattacharjee & Karmaker, 1989). Beach (1965) defined the process as a formal evaluation of an employee's contribution and growth potential, while Douglas et al. (1985) emphasized the importance of linking observed job behaviors to performance criteria. Performance evaluation holds particular importance in the banking industry, given its labor-intensive structure and strong reliance on human capital as a primary driver of organizational performance. As a sector where employees directly affect service delivery, risk management, and customer satisfaction, fair and accurate performance assessment is essential. Banks typically rely on a combination of tools such as manager assessments, 360-degree feedback, and behavioral rating scales to monitor employee progress. These processes aim to assess whether job-related goals are achieved, highlight performance gaps, and initiate developmental feedback loops (Armstrong & Taylor, 2020). Despite their utility, traditional evaluation systems are not without criticism. Davydenko et al. (2017) note that biases and lack of communication often undermine the integrity of appraisal outcomes. The fairness and transparency of these systems, or lack thereof, can significantly influence how employees engage with the feedback they receive. Ghani et al. (2022) stress that well-executed evaluations foster employee satisfaction, commitment, and alignment with organizational goals, while poorly designed systems may erode morale and increase turnover.

Modern approaches to evaluation increasingly emphasize the importance of continuous development and employee engagement. For instance, Mishra (2024) highlights a shift toward continuous feedback models, which replace infrequent appraisals with regular conversations and real-time performance tracking. These methods such as the Balanced Scorecard provide a more agile, employee-centered framework that supports continuous improvement and rapid adaptation, while maintaining a strong focus on organizational strategy (Abdullah, 2020). Additionally, self-assessment and peer reviews have gained traction as tools for fostering accountability and reflective practice. While these approaches promote open communication and employee ownership, their effectiveness depends on organizational culture and safeguards against bias (Bucăța & Rizescu, 2017).

The 360-degree feedback system is another widely adopted tool, involving input from supervisors, peers, subordinates, and sometimes external clients (Kuzulu & Iyem, 2016). This method is particularly valued for its holistic perspective and ability to minimize evaluator bias, especially in team-based or customer-facing roles. According to Baroda et al. (2018), anonymity and diverse perspectives encourage honest assessments, making 360-degree feedback a preferred tool in large institutions.

Management by Objectives (MBO) remains a foundational approach, especially in departments where outputs can be clearly quantified. Here, employee performance is measured

against mutually agreed-upon goals, ensuring alignment between individual and organizational priorities (Francis, 2019). Similarly, Behaviourally Anchored Rating Scales (BARS) have proven effective in standardizing performance criteria by linking them to observable behaviours, particularly in customer service and operations roles (Martin-Raugh et al., 2016; Hamidi et al., 2011).

In conclusion, although numerous performance evaluation methods are available, their effectiveness largely depends on contextual elements—particularly the clarity of performance objectives, consistency in implementation, and the extent to which the process is perceived as fair by employees. For the banking sector in Albania, where organizational structures are evolving and staff turnover is a pressing concern, tailoring these tools to local needs is essential.

### **2.1. Employee perception of performance evaluation**

The effectiveness of performance appraisal systems has been extensively studied in human resource management literature, with scholars emphasizing key dimensions such as clarity of objectives, fairness, consistency, and their role in fostering employee development (Armstrong & Taylor, 2020). In the banking sector, effective performance evaluations have been shown to support employee development, enhance performance and engagement, and strengthen alignment between individual and organizational goals (Khan & Almahdi, 2024). Erdogan et al. (2001) argue that transparent and objective evaluation processes are essential for building employee trust and encouraging engagement, whereas poorly implemented systems—characterized by vague criteria or perceived biases—tend to lead to dissatisfaction and demotivation (Davydenko et al., 2017).

In Albania, banks do not follow a unified approach to performance evaluation; often, different methods are used even within the same institution. Although the literature does not prescribe a single best practice for performance evaluation in banking or other sectors, employee dissatisfaction with existing appraisal processes is evident. Differences between organizational expectations and employee experiences negatively affect job satisfaction, work quality, and ultimately contribute to increased staff turnover.

Effective appraisal systems can help employees identify their strengths and weaknesses, set personal development goals, and create action plans for skill enhancement and career advancement (Yesmine et al., 2023). In this context, establishing fair, objective, and transparent evaluation procedures is essential for promoting employee growth. Research highlights that when feedback, coaching, and developmental opportunities are integrated into the appraisal process, continuous learning and improved performance are more likely to occur (Boachie et al., 2012).

Studies consistently show a positive relationship between performance appraisals and employee development. Performance reviews provide critical feedback, guide employees in identifying areas for improvement, and help align their career goals with organizational objectives. Moreover, effective evaluations enable organizations to identify high-performing individuals and invest in their advancement through targeted training and career development initiatives (Yesmine et al., 2023; Khan & Almahdi, 2024). Paes De Faria et al. (2020) emphasize that banks often assess employee performance based on job-related skills, productivity, and communication. Employees are assessed under certain criteria that reveals strengths, weaknesses and growth prospects. These assessments boost their development and satisfaction at work. Clearly defined evaluation criteria help employees better meet performance expectations, thereby supporting skill development and enhancing job satisfaction. As Alti and Almuhrat (2021) suggest, setting evaluation standards that align with both job requirements



and employee career aspirations is critical for fostering sustained professional growth within the banking sector.

## **2.2. Factors Influencing Employee Perceptions of Performance Evaluation Effectiveness**

Employee perceptions of performance evaluation systems are inherently subjective and often shaped by personal experiences (Seotlela & Miruka, 2014). Research suggests that employees who possess a clear understanding of performance objectives and the functionality of appraisal methods are more likely to perceive evaluation processes positively (Onyango, 2013). Similarly, Erdogan et al. (2001) highlight that awareness of the criteria used for goal setting and evaluation fosters greater openness and trust in appraisal systems. Structural inconsistencies within performance evaluation frameworks—particularly the lack of standardized criteria across institutions, and even within departments of the same bank—are perceived by employees as sources of unfairness. This perceived inequity may contribute to higher turnover rates and moderate satisfaction levels reported in the sector. As Paes De Faria et al. (2020) argue, establishing clear evaluation criteria and well-communicated performance expectations can significantly enhance job satisfaction and perceived fairness, ultimately supporting higher employee retention and commitment.

Communication between management and employees plays a critical role in shaping perceptions of performance evaluation. Effective communication regarding organizational goals, objectives, and evaluation standards increases employee understanding of the appraisal process and fosters a more positive attitude towards it (Brand & Pretorius, 2003; Khan & Almahdi, 2024). Moreover, involving employees in the performance evaluation process—particularly in defining performance criteria—has been associated with higher goal accomplishment rates and stronger commitment to the organization (Rahim & Islam, 2019; Lines, 2004). However, many banks fail to involve employees meaningfully in setting evaluation goals and targets, especially in short- and medium-term planning. This exclusion can undermine employees' perceptions of fairness and relevance, reducing their motivation to achieve organizational objectives. Given the evolving dynamics of the Albanian labour market, particularly the high turnover and shortage of skilled professionals in the banking sector, understanding employee perspectives on performance evaluation systems has become increasingly important. This study aims to explore how employees perceive current appraisal practices and to identify the main factors shaping their views. By addressing these issues, the research seeks to contribute to more effective human resource management strategies aimed at improving employee satisfaction, retention, and overall organizational performance.

Accordingly, the study is guided by the following research questions:

RQ1: How do bank employees perceive the relevance of the current performance evaluation system?

RQ2: What are the main factors influencing employee perceptions of performance evaluation effectiveness?

## **3. DATA AND METHODOLOGY**

This study aims to examine employees' perspectives on the performance evaluation process within the Albanian banking sector. Specifically, it seeks to identify the key factors that shape employee perceptions of appraisal effectiveness and assess the extent to which widely recommended practices from the literature—such as feedback sessions, goal-setting for future evaluation periods, and the linkage between evaluations and rewards—are being implemented



in practice. By doing so, the study provides valuable insights into how performance management systems are experienced by employees and where improvements may be necessary to enhance fairness, clarity, and impact. This study employs a quantitative research design to examine employee perceptions of performance evaluation practices in the Albanian banking sector. Primary data were collected through a structured questionnaire distributed to bank employees across various institutions and roles providing a diverse sample in terms of gender, age, experience, and department. As per last publication by the Albanian Association of Banks (2024) the number of employees working in the banking sectors amounts at 7,154, while this questionnaire is completed by 182 employees making 2.5% of the entire population. To ensure anonymity and encourage honest responses, participants were not asked to disclose their bank or hierarchical position, though data on experience and job function were collected. The questionnaire assessed six key dimensions: clarity of criteria, objectivity of indicators, frequency of evaluations, quality of feedback, linkage to promotions, and overall appraisal relevance. Responses were recorded on a five-point Likert scale. Data were analyzed in two phases. Descriptive statistics were used to summarize demographic and response distributions, offering a general overview of trends. Subsequently, multiple linear regression analysis was applied to identify which factors significantly predict employees' perceptions of the relevance and effectiveness of current appraisal systems.

## 4. RESULTS AND DISCUSSION

### 4.1. Descriptive results

The demographic composition of the sample (N = 182) reflects a workforce dominated by female employees (64%), which is consistent with broader employment trends in the Albanian banking sector. Male respondents constituted 36% of the sample. In terms of job function, 74.7% of the participants held back-office positions, while 25.3% were employed in front-office roles, including customer service and direct client engagement.

*Table 1. Demographic Characteristics*

Category	Subgroup	Frequency	Percentage
Gender	Male	66	36%
	Female	116	64%
Age	18–23	18	10%
	24–29	82	45%
	30–35	22	12%
	36–41	32	18%
	42–47	18	10%
	Over 47	10	5%
Job Role	Front-office	46	25.3%
	Back-office	136	74.7%
Experience	< 0.5 years	14	8%
	0.5–1 year	14	8%
	1–2 years	40	22%
	2–5 years	52	28%
	5–10 years	32	18%
	Over 10 years	30	16%

Most respondents were between 24–29 years old (45%), and a significant portion had between 1–5 years of experience (50%), which reflects a relatively young and early-career population.

#### 4.2. Perceptions of Performance Evaluation Relevance

When asked whether they considered the current performance appraisal system relevant, 39% responded affirmatively, while 26% disagreed, and 35% remained neutral. This indicates that a substantial portion of employees either question the utility of current practices or remain undecided—posing a potential risk of disengagement if reforms are not undertaken.

Table 2. Current performance appraisal relevance

Response	Frequency	Percentage
Yes	70	39.02%
Neutral	64	35.16%
No	48	25.82%

#### 4.3. Performance appraisal system key dimensions

To assess which elements of the performance appraisal system most influence employee perceptions, the questionnaire included six key dimensions, presented in the below table.

Table 3. Dimensions of performance appraisal system

Factor	Mean	Std. Deviation	N
Relevance of the performance evaluation indicators	3.14	0.874	182
Clarity of evaluation criteria	3.05	1.001	182
Promotion and other benefits are related to performance evaluation	3.44	1.053	182
Frequency of the performance evaluation	4.55	0.818	182
Coherence and objectivity of indicators	3.78	1.049	182
Feedback received during performance evaluation process	3.54	0.702	182

While frequency of evaluations received the highest mean score ( $M = 4.55$ ), further analysis indicated that clarity of criteria, objectivity of indicators, and rewards linkage were more influential in shaping employee perceptions of appraisal relevance. This finding underscores that quality and fairness in the evaluation process matter more than how often it occurs. These insights suggest that while evaluation is a regular practice in Albanian banks, there are significant gaps in transparency and perceived fairness. Employee perceptions appear to be shaped more by how clearly expectations are communicated and how equitably performance is rewarded, than by the sheer frequency of reviews. Therefore, HR managers in the banking sector should prioritize the objectivity, clarity, and developmental impact of performance evaluation systems to enhance their effectiveness and employee trust. From the descriptive statistics presented above it is indicated that employees working in banks reported high mean values for the considered factors taken into account, while further analysis is needed in order to determine which of these indicators have the main impact in the employee perception. This, should be taken into considerations by the banks operating in Albania whenever they decide on certain policies that affect the above-mentioned factors.

#### 4.4. Regression and Correlation Analysis

The correlation analysis revealed that three key factors had the strongest associations with employees' perceptions of the relevance of performance evaluations. The objectivity and coherence of indicators showed the highest correlation ( $r = 0.61$ ), followed by the clarity and intelligibility of evaluation criteria ( $r = 0.577$ ). These results indicate that while evaluations

may be conducted regularly, their perceived fairness, clarity, and impact on rewards are far more influential in shaping employee attitudes than frequency or feedback alone.

*Table 4. Model Summary (Regression Output)*

Model	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	Std. Error of Estimate	F Change	df1	df2	Sig. F Change
1	0.760	0.578	0.566	0.576	48.138	3	176	0.000

The multiple regression analysis produced a strong correlation coefficient ( $R = 0.760$ ), suggesting that the independent variables (clarity, objectivity, and promotion linkage) collectively explain a substantial portion of the variation in how employees perceive the relevance of performance evaluations. The adjusted  $R^2$  value of 0.566 indicates that approximately 56.6% of the variance in employee perception can be explained by the model. The overall model is statistically significant ( $p < 0.001$ ), confirming the predictive power of the included variables.

*Table 5. Regression Coefficients*

Predictor	B	Std. Error	Beta	t	Sig.
(Constant)	0.270	0.319	—	0.846	0.399
Clarity of evaluation criteria	0.386	0.047	0.443	8.310	0.000
Objectivity and coherence of indicators	0.285	0.052	0.342	5.478	0.000
Promotion and benefits linkage	0.223	0.044	0.268	5.076	0.000
Feedback received	0.137	0.063	0.106	2.175	0.031
Frequency of performance evaluations	0.028	0.069	0.021	0.406	0.685
Relevance of performance indicators	0.041	0.059	0.034	0.695	0.488

From the standardized beta values and significance levels, the most influential predictors were: the clarity of evaluation criteria with the most significant impact on employees' perceptions ( $\beta = 0.443$ ,  $p < 0.001$ ), followed by the objectivity of indicators ( $\beta = 0.342$ ,  $p < 0.001$ ) and the association with promotion and benefits ( $\beta = 0.268$ ,  $p < 0.001$ ). All three predictors were statistically significant at the 0.001 level aligning with prior research emphasizing the role of transparent and merit-based evaluations in fostering employee trust and motivation (Yesmine et al., 2023; Khan & Almahdi, 2024). Likewise, Erdogan et al. (2001) found that intelligibility of evaluation procedures enhances trust and perceived fairness in the system. In contrast, the frequency of evaluations and the feedback mechanism during the evaluation process appear to have limited influence on employee perceptions. While literature often emphasizes the importance of continuous feedback in enhancing engagement and development (Mishra, 2024), our findings suggest that in the Albanian banking context, structural and procedural clarity outweighs the frequency of appraisal discussions. This might reflect the formal culture of the banking industry or point to a lack of meaningful feedback even when evaluations are conducted frequently.

These findings suggest that employees in the Albanian banking sector perceive performance evaluations as moderately relevant, primarily due to deficiencies in transparency, fairness, and consistency. The absence of clearly defined criteria and perceived inequities in reward structures may contribute to employee dissatisfaction and, consequently, higher turnover. Therefore, enhancing the objectivity and clarity of evaluation systems, along with better aligning appraisals with developmental outcomes, could significantly improve the effectiveness of performance management practices in the sector.

#### **4.5. Limitations**

This research faces certain limitations; however, it serves as a laying foundation for further research in performance evaluation process in banking sector. Main limitations are related to the sample size as the questionnaire is distributed in all the banks, while the model explains 57.8% of variance in perception, caution is warranted in generalizing results beyond the sampled institutions. Given the anonymity and lack of hierarchical differentiation in the survey, future studies should explore if perceptions vary across management levels or organizational units. Additionally, the study was conducted at a single point in time, which restricts the ability to capture temporal changes in employee perceptions or evaluate the impact of evolving HR practices over time. Yet, this research is expected to incentivize different institutions to put more focus on performance assessment practices in different sectors and have a more considerate approach of the employee's perspective. Considering the raising issue of lack of competent and trained human resources in different sectors and the recent warning from the Bank of Albania regarding this issue it would necessary to prudently review current human resources practices in the market.

#### **5. CONCLUSION**

This study contributes to the growing body of research on performance management by offering a comprehensive view of how employees in the Albanian banking sector perceive current appraisal systems. Drawing on data from 182 banking professionals, the findings underscore a central question: while performance evaluations are regularly conducted, many employees view them as lacking in clarity, consistency, and fairness. This disconnect between the purpose of performance appraisal and its perceived implementation weakens its intended role as a tool for motivation, development, and retention. Statistical analysis confirmed that the most influential factors shaping employee perceptions are the clarity of the evaluation criteria, the objectivity and coherence of performance indicators, and the degree to which performance is linked to tangible outcomes such as promotions and benefits. These findings are consistent with prior research emphasizing the importance of transparency and fairness in appraisal systems. Notably, other aspects—such as frequency of evaluations and feedback delivery—were found to have less impact in shaping employee perceptions, suggesting that the quality of the process matters more than its frequency. Given the persistent challenges in talent retention and the evolving demands of the labor market in Albania, particularly within the banking sector, these insights carry significant practical implications. Human resource management departments must revisit existing appraisal practices with a focus on standardization, employee involvement, and alignment with individual and organizational goals. A more structured, transparent, and development-oriented approach to performance evaluation can serve not only to improve employee morale but also to strengthen institutional capacity in a highly competitive sector. In conclusion, enhancing performance management systems is not merely an administrative necessity—it is a strategic imperative. By embedding fairness, clarity, and accountability into the evaluation process, banks in Albania can foster a more engaged workforce, reduce employee turnover, and ultimately improve their long-term performance and resilience.

#### **REFERENCES**

Abdullah, N. H. (2020). Evaluating bank performance and measuring employee satisfaction through a balanced scorecard. *IOSR Journal of Business and Management (IOSR-JBM)*,

- 22(11, Ser. I), 65–71. <https://www.iosrjournals.org/iosr-jbm/papers/Vol22-issue11/Series-1/I2211016571.pdf>
- Albanian Association of Banks. (2024). Statistics. <https://aab.al/te-dhena/>
- Alti, A., & Almuhrat, A. (2021). An advanced IoT-based tool for effective employee performance evaluation in the banking sector. *Ingénierie des Systèmes d'Information*, 26(1), 103–108. <https://doi.org/10.18280/isi.260111>
- Armstrong, M., & Taylor, S. (2020). *Armstrong's handbook of human resource management practice* (15th ed.). Kogan Page.
- Baroda, N., Tiwari, A., & Sharma, M. (2018). 360 Degree Performance Appraisal—A Tool for Development, Not Just Evaluation. *International Journal of Management Studies*, 5(1), 39–44. <https://doi.org/10.24297/ijmit.v1i2.1447>
- Beach, D. S. (1965). *Personnel: The management of people at work* (3rd ed.). Macmillan.
- Bhattacharjee, D., & Karmaker, S. S. (1989). Performance evaluation measures of public sector enterprises: A critical review. *The Dhaka University Studies, Part C*, 10(2), 1–15.
- Brand, J. S., & Pretorius, S. G. (2003). Staff perceptions of performance appraisal in a South African tertiary institution. *African Education Review*, 1(1), 96–114. <https://doi.org/10.1080/18146620308566212>
- Boachie-Mensah, F. O., & Seidu, P. A. (2012). Employees' perception of performance appraisal system: A case study. *International Journal of Business and Management*, 7(2), 73–88. <https://doi.org/10.5539/ijbm.v7n2p73>
- Brundin, E., et al. (2021). Emotion in strategic management: A review and future research agenda. *ResearchGate*. <https://www.researchgate.net/publication/354902065>
- Bucăța, G., & Rizescu, A. M. (2017). The role of communication in enhancing work effectiveness of an organization. *Land Forces Academy Review*, 22(1), 49–57. <https://doi.org/10.1515/raft-2017-0008>
- Dachner, A. M., Saxton, B. M., Noe, R. A., & Keeton, K. E. (2021). The future of employee development. *Human Resource Management Review*, 31(2), 100747. <https://doi.org/10.1016/j.hrmr.2019.100747>
- Douglas, J., Klein, S., & Hunt, D. (1985). *The strategic managing of human resources*. John Wiley & Sons.
- Davydenko, V. A., Kaźmierczyk, J., Romashkina, G. F., & Żelichowska, E. (2017). Diversity of employee incentives from the perspective of banks employees in Poland - empirical approach. *Entrepreneurship and Sustainability Issues*, 5(1), 116–126. [http://doi.org/10.9770/jesi.2017.5.1\(9\)](http://doi.org/10.9770/jesi.2017.5.1(9))
- Dziuba, S., et al. (2020). Employees' Job Satisfaction and their Work Performance as Elements Influencing Work Safety. *ResearchGate*. <https://www.researchgate.net/publication/341656571>
- Erdogan, B., Kraimer, M. L., & Liden, R. C. (2001). Procedural justice as a two-dimensional construct: An examination in the performance appraisal context. *The Journal of Applied Behavioral Science*, 37(2), 205–222. <https://doi.org/10.1177/0021886301372004>
- Francis, F. (2019). Management by Objectives (MBO) as an instrument for organizational performance of deposit money banks in Nigeria. *European Journal of Business and Management*, 10(26), 118–125. <https://www.iiste.org/Journals/index.php/EJBM/article/view/44160>
- Ghani, M., et al. (2022). Challenges and Strategies for Employee Retention in the Hospitality Industry: A Review. *ResearchGate*. <https://www.researchgate.net/publication/358976415>

- Hamidi, Y., Najafi, L., Ghiasi, M., Shahhoseini, R., & Emami, H. (2011). Performance evaluation and its effects on employees' job motivation in Hamedan city health centers. *Australian Journal of Basic and Applied Sciences*, 5(12), 1761–1765. <https://www.ajbasweb.com/old/ajbas/2011/December-2011/1761-1765.pdf>
- Khan, M. A., & Almahdi, H. K. (2024). Optimizing Performance Reviews for Enhanced Employee Development in the Banking Sector: A Comprehensive Analysis. [https://ijaem.net/issue\\_dcp/Optimizing%20Performance%20Reviews%20for%20Enhanced%20Employee%20Development%20in%20the%20Banking%20Sector%20A%20Comprehensive%20Analysis.pdf](https://ijaem.net/issue_dcp/Optimizing%20Performance%20Reviews%20for%20Enhanced%20Employee%20Development%20in%20the%20Banking%20Sector%20A%20Comprehensive%20Analysis.pdf)
- Kuzulu, M., & Iyem, C. (2016). The effectiveness of 360-degree performance evaluation: A study in banking sector. *International Journal of Academic Research in Business and Social Sciences*, 6(2), 121–136. <https://doi.org/10.6007/IJARBS/v6-i2/2025>
- Lines, R. (2004). Influence of participation in strategic change: Resistance, organizational commitment and change goal achievement. *Journal of Change Management*, 4(3), 193–215. <https://doi.org/10.1080/1469701042000221695>
- Martin-Raugh, M. P., Kell, H. J., Carney, L. M., Inglese, P. A., Chen, L., & Feng, G. (2016). Exploring methods for developing behaviorally anchored rating scales for evaluating structured interview performance. *ETS Research Report Series*, 2016(1), 1–19. <https://doi.org/10.1002/ets2.12152>
- Mishra, S. (2024). The Future of Performance Management: Shifting from Annual Reviews to Continuous Feedback. Retrieved from <https://www.researchgate.net/publication/383846204>
- Nguyen, T. D. N., & Nguyen, L. T. (2020). The key strategies for measuring employee performance in companies: A systematic review. *Sustainability*, 14(14017), 1–20. <https://doi.org/10.3390/su142114017>
- Onyango, P. (2013). Effects of performance appraisal on employee productivity: A case study of World Health Organization. *International Journal of Social Sciences and Entrepreneurship*, 1(11), 324–337.
- Paes De Faria, A., Carvalho, M. D. M., & Batista, M. D. G. (2020). Performance evaluation systems and employee satisfaction: A study in the Brazilian banking sector. *Journal of Management Development*, 39(1), 1–15. <https://doi.org/10.1108/JMD-06-2019-0253>
- Rahim, S. A., & Islam, S. M. S. (2019). Performance appraisal system of Mercantile Bank Limited: An evaluation. *Journal of Business and Retail Management Research*, 13(4), 303–310. <https://doi.org/10.24052/JBRMR/V13IS04/ART-28>
- Raj, R., et al. (2023). The study of remote working outcome and its influence on firm performance. <https://www.sciencedirect.com/science/article/pii/S259029112300133X>
- Seotlela, R. P., & Miruka, C. (2014). Implementation of a performance management system in South Africa: Successes and challenges. *Mediterranean Journal of Social Sciences*, 5(9), 203–214. <https://doi.org/10.5901/mjss.2014.v5n9p203>
- de Waal, A. A., Burrell, J., Drake, S., Sampa, C., & Mulimbika, T. (2023). The high-performance organization: Proposed definition and measurement of its performance. *ResearchGate*. <https://www.researchgate.net/publication/349041235>
- Yesmine, S., Hoque, R., & Hassan, M. M. (2023). The Role of Performance Appraisal in Employee Development: Evidence from the Banking Sector. *International Journal of Human Resource Studies*, 13(1), 101–118. <https://doi.org/10.5296/ijhrs.v13i1.20629>



## STRENGTHENING STRATEGIC AND FINANCIAL STABILITY IN SCIENTIFIC INSTITUTES WITH IMPLEMENTATION OF STRATEGIC RISK MANAGEMENT

Marija Jonović<sup>1</sup> \*, Lidija Barjaktarović<sup>2</sup>

<sup>1</sup> MMI Bor, Serbia

<sup>2</sup> Singidunum University, Belgrade, Serbia

**Abstract:** <sup>†</sup>This study aims to develop a comprehensive Strategic Risk Management (SRM) framework aligned with the COSO ERM for improving strategic and financial performance in Scientific Institutes. Conducted in a nationally significant Serbian institute, the research evaluates SRM's effectiveness in addressing weaknesses, mitigating threats, and leveraging opportunities. A primary SWOT analysis survey, conducted from June 26 to July 1, 2024, involved 214 participants, with a 55.6% response rate (119 respondents). Findings highlight a sustainable business strategy and SRM's effectiveness in mitigating risks across financial, operational, asset-related, and strategic domains. Financial challenges include declining net profit and persistent negative financial results. Despite the decline in business revenues and net profit, effective asset and capital management, supported by previously accumulated reserves, enabled the Institute to maintain financial stability. To address these risks, the study emphasizes cost management, diversification, and investment in innovation to strengthen financial sustainability and competitiveness. This research underscores SRM's pivotal role in building resilience, advancing institutional goals, and enhancing adaptability for scientific institutes with national importance.

**Keywords:** SRM, COSO ERM, financial sustainability, SWOT analysis, innovation.

### 1. INTRODUCTION

This study builds upon the findings of Jonović et al. (2024), initially presented at the 55th International October Conference in Kladovo, hosted by the Mining and Metallurgy Institute Bor in partnership with the Technical Faculty in Bor, University of Belgrade.

---

\* Corresponding author: [marija.jonovic.23@singimail.rs](mailto:marija.jonovic.23@singimail.rs)

Marija Jonović, ORCID: 0009-0000-8418-2523

Lidija Barjaktarović, ORCID: 0000-0002-5630-8595

<sup>†</sup> To ensure the confidentiality of the Institute, the authors will refrain from disclosing its name in the research. For future reference, the terms "Institute" or "Scientific research organization" will be used throughout the text.

Additionally, it integrates insights from Jonović et al. (2025), forthcoming in the Journal Mining and Metallurgy Engineering Bor (Issue 1/2025). The research explores the influence of Strategic Risk Management (SRM) within a scientific research institute, maintaining anonymity to uphold confidentiality. By employing COSO ERM (Committee of Sponsoring Organizations – Enterprise Risk Management) framework, the study underscores the significance of applying robust SRM strategies. Primary research utilizing SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis provides a nuanced perspective on the institute's strategic strengths, weaknesses, opportunities, and risks. Secondary research complements this by evaluating financial indicators, revealing the impact of Strategic Risk Management (SRM) connected with the COSO ERM organizational stability. To gauge the efficacy of managing strategic risks, financial data spanning 2020 to 2023 was sourced from the Serbian Business Register Agency (SBRA), in compliance with Serbian accounting regulations for fiscal and calendar-year reporting. Metrics analyzed include total assets, equity; business income, expenses and result; financial result and net profit. This approach provides a comprehensive insight and points to poor risk management in the Institute's operations.

The subject of the research is the application of the combined use of SWOT analysis (primary research) and financial data analysis (secondary research) to assess the impact of COSO ERM on strategic risks and financial stability in the Scientific Institute. Considering that the topic is under-researched, the aim of the paper is to direct research towards the development of a more comprehensive SRM for operational and financial improvements in the work of Scientific Institutes. Unlike the previous two papers, this study presents a comprehensive analysis based on SWOT methodology, supplemented by financial indicators, providing a complete overview of strategic management within the Institute of National Importance for the Republic of Serbia.

The paper is organized into four main sections. The first section provides an introduction to the study, setting the stage for the research. The second section outlines the methodology, explaining the approach and techniques used. The third section presents the findings of the primary research, offering insights derived from data analysis. Finally, the last section delivers the conclusion, summarizing key points and implications.

## **2. LITERATURE REVIEW**

Risk is a factor that all organizations face, regardless of the business organization model. (Panić, 2024) Risk management has become an imperative of modern business, not only because of the needs of the enterprise itself, but also because of the international regulation imposed on the financial sector particularly, the issue that has advanced through institutional risk management (Barjaktarović & Ječmenica, 2011). Although uncertainty and risk represent an integral part of the economic business, risk as a scientific field has a short history (Barjaktarović, 2015). Strategic management in research organizations involves the impact of environmental changes at both national and international levels, taking into account the specificities of scientific research work. Consequently, a comprehensive integration of strategic management characteristics and the research process is required to create an applicable framework for these organizations. (Mousurovic, 2018) According to the Strategy of scientific and technological development of the Republic of Serbia for the period 2021 to 2025 "the power of knowledge", the risk analysis overview by specific goals of the strategy includes: ensuring the necessary conditions for dynamic development of science, technological development, and innovation; increasing the efficiency of resource utilization within the scientific research system; nurturing excellence in science and technological development; strengthening the competitive advantage of the economy; focusing research on societal challenges and priorities;



and enhancing international cooperation. The practice of risk management is commonly known as "enterprise-wide risk management" (ERM). SRM has been described as a subset of ERM, even though the term SRM is believed to be much older than the term ERM (Bromiley et al., 2016). SRM is the process of developing insight to understand what could go wrong that would affect the achievement of a given strategy, and adopting appropriate mitigating actions. (Frigo, & Anderson, 2011) ERM can be used by organizations of any size. If an organization has a mission, a strategy, and objectives—and the need to make decisions that fully consider risk—then ERM can be applied. It can and should be used by all kinds of organizations, from small businesses to community-based social enterprises to government agencies to Fortune 500 companies. (COSO ERM 2017)

A scientific research institute thrives at the strategic level when its overall strategy, the actions of those executing it, and the organization's actual business outcomes remain in sync. Maintaining this alignment ensures that strategic goals translate effectively into tangible operational results.

### **3. DATA AND METHODOLOGY**

The primary research, a SWOT analysis includes a complete questionnaire conducted at the Institute of National Importance for the Republic of Serbia. A variety of methodological approaches were applied in conducting the SWOT analysis during the preparation of the anonymous survey. These included employee interviews, quantitative analysis techniques, and illustrative methods for presenting research outcomes, and the deductive approach for formulating conclusions. The SWOT analysis was undertaken to evaluate the Institute's current status and pinpoint areas for improvement, encompassing both risks and opportunities. Recognized as a critical tool in strategic planning, SWOT analysis aids organizations in aligning their strategies with business demands (Valentin 2001).

This study features a SWOT analysis crafted to guide research toward establishing a more comprehensive SRM framework aimed at enhancing operational efficiency and financial performance within Scientific Institutes. The thorough survey design and integration of diverse methodological approaches significantly enhance the reliability and depth of the findings. Detailed results from the SWOT analysis will be elaborated in Chapter 4. The primary survey is structured into four sections, corresponding to the key components of SWOT: Strengths, Weaknesses, Opportunities, and Threats. It comprises 39 questions, grouped into six subcategories, ranging from the highest-rated to the lowest-rated aspects. The survey explores: Potential strengths within the internal framework of the Institute; Potential weaknesses within the internal framework of the Institute; Potential opportunities arising from the external environment of the Institute; and Threats posed by the external environment of the Institute. Respondents provided their input by selecting from one of five possible ratings. This meticulous design ensures a robust foundation for future strategic planning and decision-making. The answers were analysed using a Likert scale from 1 to 5 (where a rating of 1 means strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree). The anonymous survey with closed-ended questions was conducted from June 26, 2024, to July 1, 2024, on a sample of 214 respondents. Out of the total number of respondents, 119 employees completed the survey, of which 86 are PhD holders (72.27%), 31 have a Master's degree (26.05%), and 2 respondents have university-level education (1.68%), resulting in a response rate of 55.6% (presented by Figure 1).

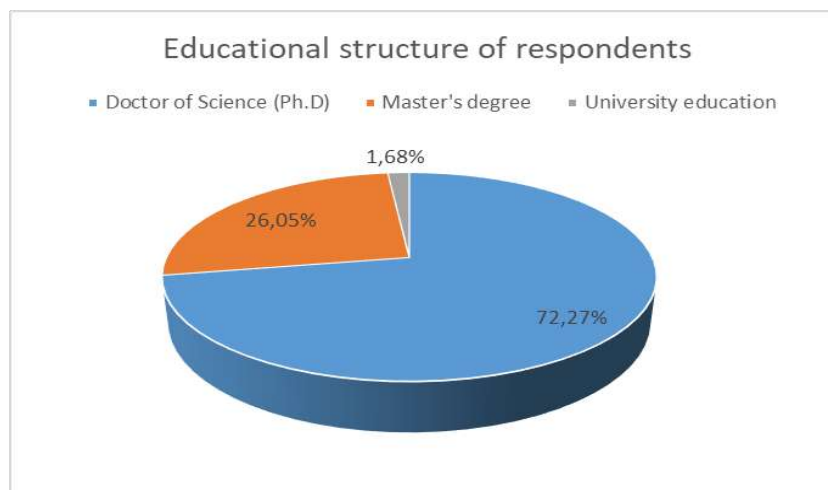


Figure 1. Overview of the educational structure of respondents

The structure of professional titles among respondents (presented by Figure2) provides valuable insights into the composition of expertise within the scientific research institute, highlighting its strengths, weaknesses, opportunities, and threats in the SWOT analysis. Here's an explanation: the highest proportion of respondents belong to the category of Doctor of Science - Scientific Advisor (28.57%), followed closely by senior research associates (23.53%). This indicates that the institute benefits from a strong presence of top-tier professionals with extensive expertise. Their role as scientific advisors and leaders fosters high-quality research and strategic decision-making. Research associates with Doctor of Science degrees (18.49%) and Master's degrees (12.61%) provide a solid base of mid-level researchers who actively contribute to the institute's research output. Master's degree trainees represent only 9.24%. Although they are important for long-term growth and innovation, their relatively small percentage may indicate challenges in attracting or retaining young talent. Categories such as "University education - professional title" (1.68%) and "Other" (1.68%) are quite limited. This could signal a lack of auxiliary staff who perform operational and administrative roles essential for supporting research activities. This structure emphasizes the institute's strengths in expertise and experience while highlighting areas such as talent retention, support roles, and succession planning that require strategic attention. Addressing these gaps proactively will enable the institute to mitigate risks and capitalize on its opportunities.

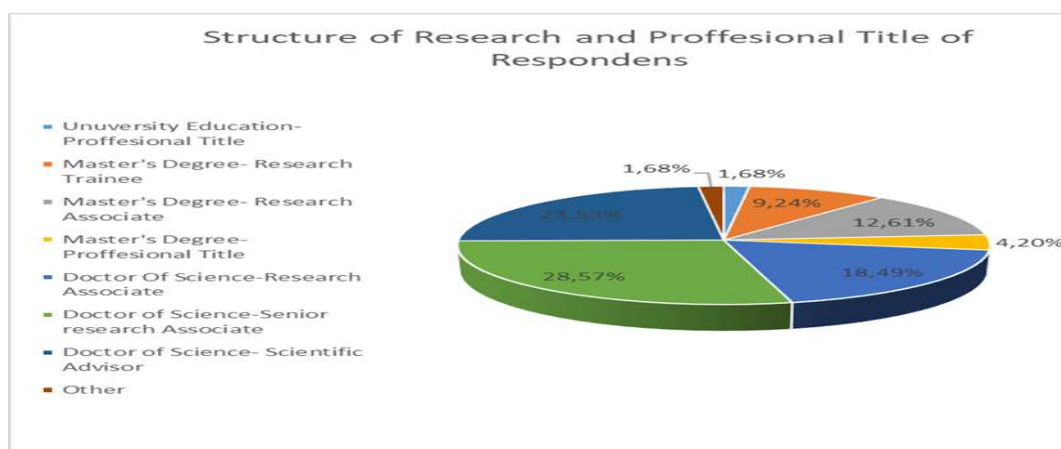


Figure 2. Structure of research and professional title of respondents

## 4. RESULTS AND DISCUSSION

The findings of the research are organized into two sections as follows: 1) strategic risk assessment for the scientific research organization based on financial data. Authors created the table 1, on the basis of SBRA's data and it provides a detailed overview of relevant financial indicators for SRM of the institute. 2) SWOT (primary research) analysis presented by figures 3, 4, 5, and 6.

### 4.1. Strategic Risk Assessment for a Scientific Research Organization based on financial data presented in financial reports

To assess how effectively strategic risks are being managed (with the primary business activity 7219, which relates to research and experimental development in natural and technical-technological sciences), secondary research was conducted using publicly accessible data (nevertheless on the quality) from the SBRA for the period 2020 to 2023. This dataset provides a comprehensive picture of the organization's financial health and good risk management practices, including critical metrics such Total assets and Capital/Equity from Balance Sheet; and Operating/Business revenues, expenses and result; financial result and Net profit from Income Statement. It emphasizes the importance of effective SRM for better financial performance.

*Table 1.* Financial overview of a Scientific Research Organization for the period 2020-2023 in RSD 000

Year	2020	2021	2022	2023
Total assets	212,858	236,947	257,883	335,171
Capital / Equity	132,546	137,049	138,506	138,762
Business income	558,624	624,090	701,521	799,068
Business expenses	548,644	619,496	699,610	798,310
Business results	9,980	4,594	1,911	0.758
Financial result	-405	45	-59	-123
Net profit	10,264	4,503	1,457	955

Source: (SBRA's data for the period 2020 to 2023)

According to the law the institute is obliged to report about financial risks which include credit risk, market risk (the main are foreign exchange and interest rate risks), liquidity risks, as well as capital risk management.

Business revenues, expenses and result are crucial for SRM. It can be noticed that there was an increase of business income and expenses due to the fact that the institute was focused on the based activity. However it was influenced by COVID-19 pandemic and post-pandemic in terms of keeping the health of employees and continuing with the business: and inflation caused globally by the war in Ukraine (which impacted the costs incurred by the Institute during and after 2022) which had impact on the cost of material and services which the Institute use i.e. business expenses had higher increase comparing the business revenues. It had an impact of achieved business result which used to have decreasing trend in the analysed period. The institute incurred losses in its financial results due to negative foreign-exchange and interest rate differences. Furthermore, the management of the company reported that they didn't use any financial derivate in order to mitigate those risks. Moreover, it should be mentioned that the institute had positive other result which had decreasing trend in analysed period. Finally, it can be noticed that net-profit had decreasing trend in analysed period. Based on financial data

from the income statement, the institute should enhance its SRM practices in the future, focusing on revenue management and profitability.

The Institute had reserves from previous periods, which ensured its stability. Overall, asset management was effective, as its value increased during the analysed period. Based on this indicator, the organization was successful in the domain of SRM. Capital management was also efficient in the context of SRM. Capital had grown from 132,546 in 2020 to 138,762 in 2023. This was due to the achieved non-distributed profit from the previous period, which had an increasing trend.

#### 4.2. SWOT analysis

To carry out a more detailed assessment, it is recommended to conduct a SWOT analysis and develop a comprehensive risk management strategy.

##### Strengths:

- Highest score: Publishing in prestigious scientific journals (4.66) reflects a strong academic reputation.
- Lowest score: Collaboration with other scientific and educational institutions in Serbia (3.89), while positive, suggests room for enhancement.
- Average score: Innovativeness in developing new products, services, or technologies (4.20) highlights creativity and scientific advancement.
- Conclusion: The Institute's strengths lie in its publication quality, innovation, and collaborative efforts, contributing to academic credibility and technological progress.

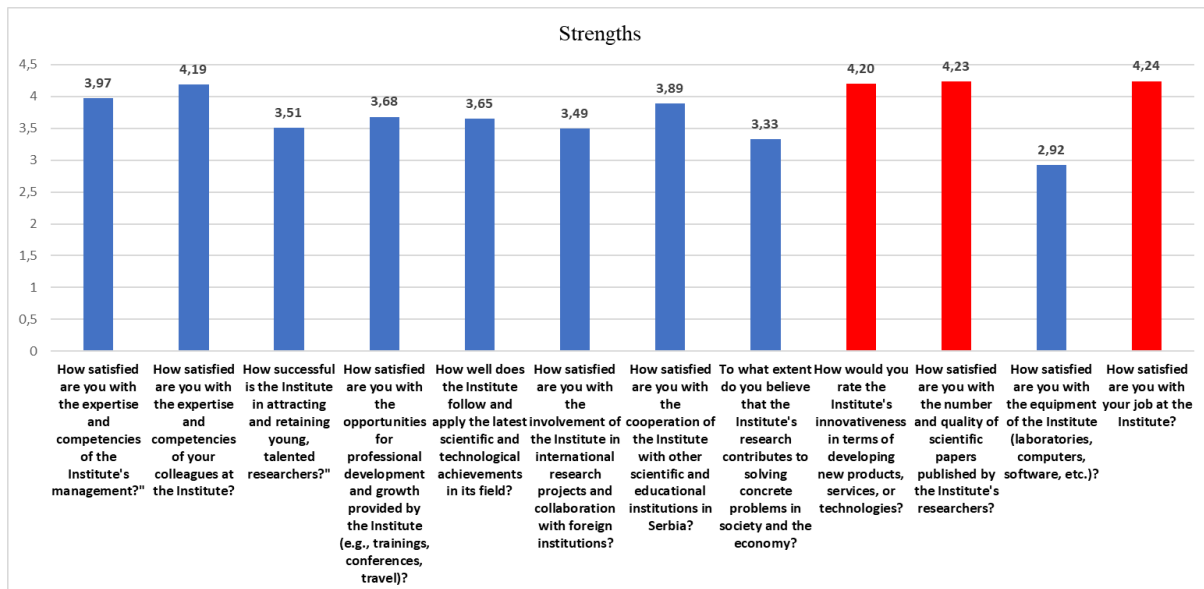


Figure 3. Potential strengths of the external business context in the period 2021-2024

Legend: Possible strengths: >4.20; Sustainable context: >2.60<4.20; Possible weaknesses: <2.60

##### Weaknesses:

- Highest score: Work atmosphere (3.92), although satisfactory, indicates scope for improvement in creating a motivating environment.
- Lowest score: Knowledge and technology transfer (3.08), signaling challenges in applying research outputs practically.

- Average score: Salary and benefits (3.71) require attention for better talent retention and satisfaction.
- Conclusion: Addressing weaknesses like technology transfer and employee compensation can enhance internal operations and external relevance.

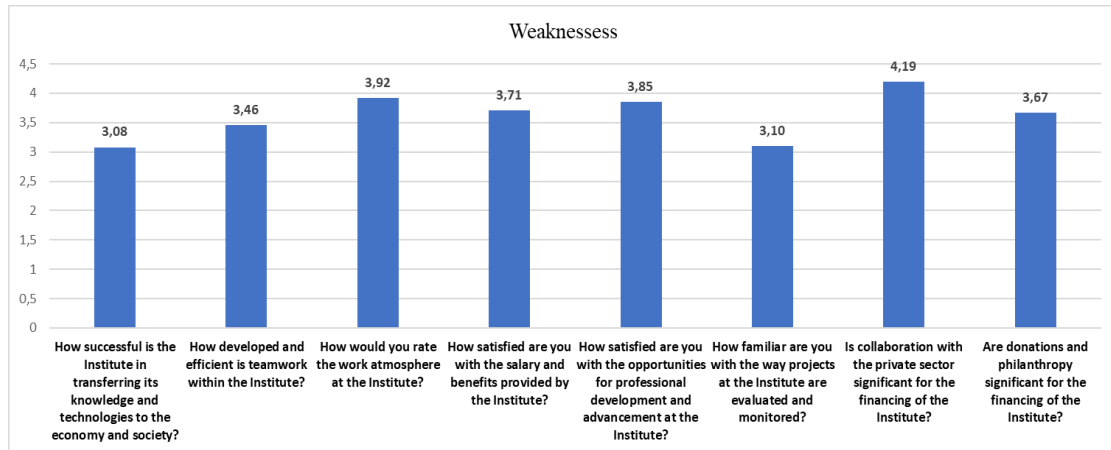


Figure 4. Potential weaknesses of the external business context in the period 2021-2024

Legend: Possible strengths: >4.20; Sustainable context: >2.60<4.20; Possible weaknesses: <2.60

### Opportunities:

- Highest score: National projects and competitions (4.65) offer excellent avenues for funding and showcasing expertise.
- Lowest score: Collaboration with companies and industry (4.05) holds potential for practical research applications.
- Average score: Popularization of science (4.54) can enhance societal engagement and visibility.
- Conclusion: Leveraging opportunities like national initiatives and public science outreach can boost both impact and recognition.

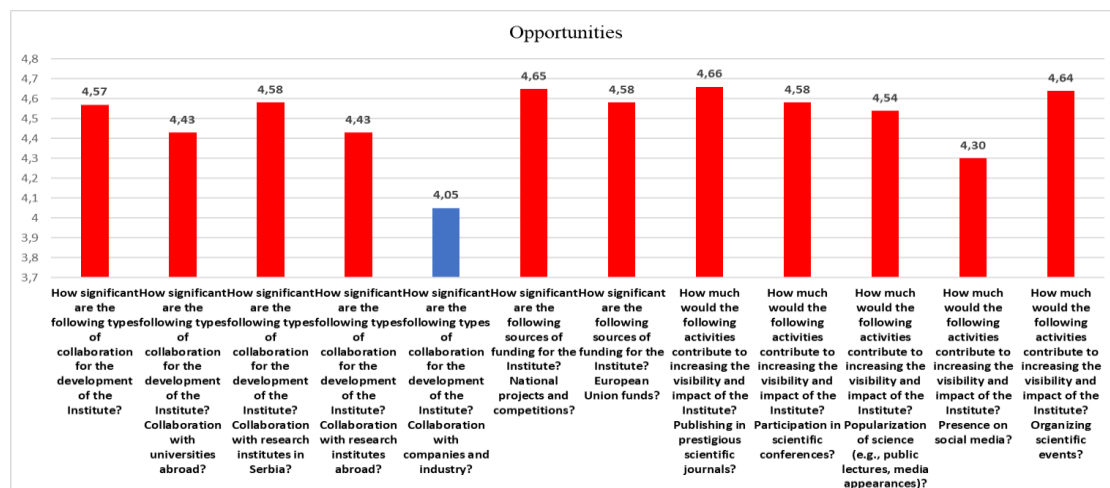


Figure 5. Potential weaknesses of the external business context in the period 2021-2024

Legend: Possible strengths: >4.20; Sustainable context: >2.60<4.20; Possible weaknesses: <2.60

### Threats:

- Highest score: Brain drain (4.03) poses a significant risk to retaining intellectual talent.

- Lowest score: Reduction in science budget (3.22), threatening resource availability.
- Average score: Competition from other institutions (3.57) requires differentiation to sustain relevance.
- Conclusion: Proactively tackling threats like brain drain and funding challenges is crucial for securing the Institute's strategic position.

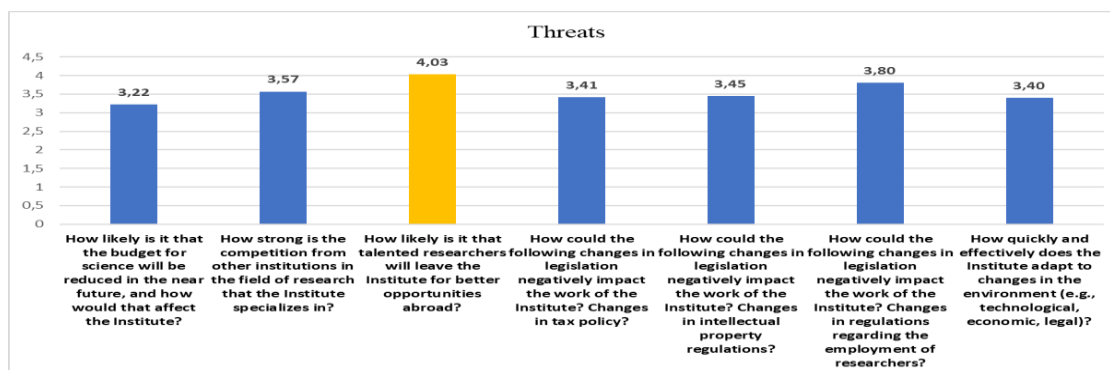


Figure 6. Potential weaknesses of the external business context in the period 2021-2024

Legend: Possible strengths: >4.20; Sustainable context: >2.60<4.20; Possible weaknesses: <2.60

With an average SWOT score of 3.86, the Institute demonstrates resilience against potential threats. However, targeted strategies for retaining qualified personnel and improving infrastructure can further strengthen its strategic position and ensure long-term sustainability.

## 5. CONCLUSION

The research is important as it highlights strengthening strategic and financial stability in Scientific Institutes with SRM and the application of COSO ERM principles in an Institute of National Importance for the Republic of Serbia. The financial indicators of the Institute highlight significant challenges in revenue management and profitability, particularly in the context of the COVID-19 pandemic and the post-pandemic period. The Institute recorded a significant decrease in business results, financial results, and net profit during the period from 2020 to 2023, indicating financial uncertainty and potential inefficiencies in operations. To enhance SRM, the Institute should optimize risk assessment mechanisms, diversify revenue sources, and improve investment strategies, ensuring sustainable financial stability and greater adaptability to external economic challenges. The implementation of innovative SRM methods, aligned with COSO ERM, can contribute to better financial risk planning and management, strengthening the Institute's competitive advantage and long-term sustainability within the scientific research community. The low score for equipment (2.92) suggests inadequate infrastructure, which could impede cutting-edge research. Strategic vulnerabilities include reliance on operational revenue and limited diversification, making the Institute susceptible to external changes, while external funding risks and difficulties in retaining young researchers further challenge innovation and growth. Addressing these risks through enhanced strategic planning, investment in infrastructure, diversification of income sources, and fostering innovation will be critical for achieving financial stability, strengthening operational efficiency, and ensuring long-term resilience in scientific research institutions. Connecting these factors with a sustainable business strategy (SWOT analysis) with an average rating 3.86 ensures greater financial stability, operational efficiency, and long-term resilience, which is the core objective of the Institute in the context of SRM and the application of COSO ERM principles.

## ACKNOWLEDGMENT

This work was financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Contract on realization and financing of the scientific research work of the Mining and Metallurgy Institute Bor in 2025, contract number: 451-03-136/2025-03/ 200052.

## REFERENCES

- Barjaktarović, L. (2015). Risk management (5<sup>th</sup> ed.), (Upravljanje rizikom) (5. izd.), University of Singidunum, Belgrade. (Foreword, III), (Predgovor, III.) ISBN: 978-86-7912-603-0. (in Serbian)
- Barjaktarović, L., Pindžo, R., Djulić, K., & Vjetrov, A. (2017). Implementation of the ERM concept in Serbia: comparative analysis – real sector and financial sector. *Banking, (Bankarstvo)*, 46(2), p.50–67. <https://doi.org/10.5937/bankarstvo1702050B>
- Barjaktarovic, L., Ječmenica, D. (2011), Review of the Implementation of Basel II Standards in the Banking Sector of Serbia, (Osvrt na implementaciju standarda Bazela II u poslovanje bankarskog sektora Srbije), *Management* 59, p. 71-77. [https://management-stari.fon.bg.ac.rs/index.php?option=com\\_content&view=article&id=116%3Aosvrt-na-implementaciju-standarda-bazela-ii-u-poslovanje-bankarskog-sektora-srbije&catid=18&lang=sr](https://management-stari.fon.bg.ac.rs/index.php?option=com_content&view=article&id=116%3Aosvrt-na-implementaciju-standarda-bazela-ii-u-poslovanje-bankarskog-sektora-srbije&catid=18&lang=sr). (in Serbian)
- Bromiley, P., Rau, D. & McShane, M.K. 2016. Can strategic risk management contribute to enterprise risk management? Strategic management perspective. *Finance Faculty Publications*, (3): p.140-156. <https://doi.org/10.2139/ssrn.2512477>.
- Committee of Sponsoring Organizations /COSO/ (2017). COSO ERM Integrating with Strategy and Performance. Accessed 01/25/2025. [https://www.coso.org/files/ugd/3059fc\\_61ea5985b03c4293960642fdce408eaa.pdf](https://www.coso.org/files/ugd/3059fc_61ea5985b03c4293960642fdce408eaa.pdf)
- Frigo, M.L. & Anderson, R.J. 2011. What is strategic risk management? *Strategic Finance*, 92(10): p.21-22. [https://www.markfrigo.com/what\\_is\\_strategic\\_risk\\_management\\_-\\_strategic\\_finance\\_-\\_april\\_2011.pdf](https://www.markfrigo.com/what_is_strategic_risk_management_-_strategic_finance_-_april_2011.pdf); Accessed 2021/5/26.
- Jonović, M., Barjaktarović, L., Stevanović, M., Bugarin, D. (2024). Transforming risks into opportunities through the strategic management of a scientific institute. The book of proceedings – International October conference on mining and metallurgy - 55th IOC 2024 Kladovo, Mining and Metallurgy institute Bor & Tehnical Faculty Bor, University of Belgrade, Serbia, p.435- 440. [https:// DOI: 10.5937/IOC24435J 40](https://doi.org/10.5937/IOC24435J40).
- Jonović, M., Barjaktarović, L., Bugarin, D. (2025). “Strengthening Strategic and Financial Stability in Scientific Institutes with SRM” *Journal Mining and Metallurgy Engineering Bor*, 1/2025, in press.
- Mousurovic, M. (2018). Integrated Strategic Management Model in Scientific Research Organizations (Integrirani model strateškog upravljanja u naučnoistraživačkim organizacijama). Doctoral Dissertation, University of Belgrade, Faculty of Organizational Sciences, p.253-260. UDK no: 005.8, <https://eteze.bg.ac.rs/application/showtheses?thesesId=6283>. (in Serbian).
- Ministry of Science and Technological Development, Strategy for scientific and technological development of the Republic of Serbia for the period from 2021 to 2025 "The power of knowledge" (Strategija naučnog i tehnološkog razvoja Republike Srbije za period od 2021. do 2025. godine „Moć znanja). p.75.

- <https://nitra.gov.rs/images/ministarstvo/dokumenta/Strategija-nauc-tehnol-razvoj-RS-Moc-znanja.pdf>. Accessed 4/20/2025. (in Serbian).
- Panić, M. (2024) Enterprise risk management using the finea-ahp approach 38-48. International May Conference on Strategic Management Original research. University of Belgrade, Technical Faculty in Bor, Serbia, International May Conference on Strategic Management – IMCSM24 May 2024, Bor, Republic of Serbia, Volume XX, Issue (1) (2024), p. 38-48. <https://DOI: 10.5937/IMCSM24004P>
- Serbian Business Registers Agency (2020-2024). <https://www.apr.gov.rs/registers/financial-statements/search-of-published-financial-statements.4289.html>. Accessed 2/8/2025.
- Valentin, E. K. (2001). Swot Analysis from a Resource-Based View. Journal of Marketing Theory and Practice, 9(2), p.54–69. <https://doi.org/10.1080/10696679.2001.11501891>.





## CREATING CUSTOMER VALUE IN PRIVATE MEDICAL CLINICS BASED ON AN OMNICHANNEL INTERACTION SYSTEM

Marina Sheresheva<sup>1</sup>, Ekaterina Yudina<sup>2</sup>, Daniel Pavlov<sup>3,\*</sup>

<sup>1,2</sup>*Lomonosov Moscow State University, Russia;* <sup>3</sup>*University of Ruse “Angel Kanchev”, Bulgaria*

**Abstract:** The purpose of this study is to develop theoretical and methodological approaches and empirical tools that ensure the creation of value for the patient in private clinics through the integration of an omnichannel interaction system. The study includes an analysis of the integration of various communication channels and their impact on the medical services value perception. Modern concepts of consumer value, customer behavioral models, and value co-creation principles were used as a methodological basis. The empirical part was based on a mixed design that included qualitative interviews with experts and quantitative patient surveys (n=619). The results of the study confirmed the significance of personalized communications through digital and traditional channels on the growth of patient satisfaction and loyalty. The introduction of omnichannel systems integrating various communication channels improves the quality of interaction with patients, which leads to an improvement in their overall experience. Omnichannel solutions allow private clinics to create a continuous and consistent customer journey, increasing satisfaction and loyalty.

**Keywords:** relationship marketing, digital communication channels, omnichannel interaction system, healthcare, Russia

### 1. INTRODUCTION

The rapid development of information technologies has contributed to the expansion of the ways companies interact with customers, which has allowed them to create additional value for customer (Barwitz & Maas, 2018). At the same time, with the advent of multiple channels of interaction between companies and consumers, the issue of customer experience management has become much more complex. The variety of channels makes it difficult to ensure consistency and a unified approach to customer service, which in turn affects their overall brand experience.

To solve these problems, companies actively seek to coordinate and integrate their channels, improving the quality of service. This involves the implementation of omnichannel

---

<sup>1</sup> Corresponding author: [dpavlov@uni-ruse.bg](mailto:dpavlov@uni-ruse.bg)

Marina Sheresheva, ORCID: <https://orcid.org/0000-0002-8153-7111>

Ekaterina Yudina, ORCID: <https://orcid.org/0009-0003-5453-952X>

Daniel Pavlov, ORCID: <https://orcid.org/0000-0002-4515-2206>

solutions that allow you to synchronize and optimize the interaction between online and offline points of contact (Gao et al., 2021).

The role of patients is becoming increasingly important in the healthcare systems that are gradually moving away from the paternalistic model of doctor-patient interaction based on the authority to a model focused on the principle of patient autonomy (McColl-Kennedy et al., 2017). The focus on the needs of clients and their active participation in value co-creation has become crucial in the modern system of providing medical services (Rathert et al., 2013; McColl-Kennedy et al., 2012). A deep understanding of clients' needs and priorities plays an important role, as it allows medical companies to build effective communications, improve service quality and attract more clients. As a result, it becomes a source of competitive advantage in conditions of high competition and similarity of the services offered.

In this paper, we present the results of the study conducted in 2024-2025. The main research goal was to develop methods for creating customer value in private medical clinics using an omnichannel interaction system.

## **2. LITERATURE REVIEW**

In the highly competitive contemporary markets, where products and services have increasingly similar characteristics, and consumer demands and expectations are constantly growing and changing, the ability to understand customer and create customer value is crucial for companies to gain significant competitive advantage (Parasuraman, 1997; Arslan, 2020). Accordingly, one of the most important tasks is to correctly define customer value and increase service attractiveness for the target audience. This approach leads to increased brand awareness and consumer loyalty in the long term (Van Boerdonk et al., 2021; Chakraborty & Paul, 2023). In this regard, issues of customer value creation have attracted considerable attention from academics and practitioners (Sun & Su, 2012; Zeithaml et al., 2020).

Currently, customer value concepts are increasingly based on the principles of value co-creation, where client becomes an active participant in the process (Eggert et al., 2018; Sheth, 2020). This is especially relevant for service-oriented industries such as healthcare, where quality and individual approach are becoming key factors in customer satisfaction and gaining sustainable competitive advantage (Saxena et al., 2021; Hidayat, Idrus, 2023). In the field of medical services, value co-creation is manifested through the patient involvement in the treatment process and the provision of personalized solutions (Samsa & Yüce, 2022).

Over time, the concept of multi-channel interaction has evolved to reflect changes in technology and consumer demands. In the past, companies tended to use only phone calls or face-to-face meetings to communicate with customers. However, with the development of technology and the growing expectations of customers accustomed to interacting through various channels such as email, social media, and chat rooms, businesses have begun to adapt their strategies to meet these new market needs (Moreira et al., 2023).

The benefits of an omnichannel approach are the synchronicity and integration of all channels. This removes company-consumer barriers and improves customer experience (Gao et al., 2021). For example, a customer can start the product selection process in a mobile app and complete it in a physical store, demonstrating the integration of data and communication within an omnichannel system (Buldeo Rai et al., 2019).

Modern clinics use telemedicine platforms so that patients can participate in their treatment plans development, share their preferences, and receive recommendations tailored to their specific needs. According to (Zeithaml et al., 1996), such interaction increases customer satisfaction by ensuring their involvement in the service delivery process and creating a trusting relationship. An example is the provision of chronic disease management programs, where

patients have access to regular consultations, to educational resources, as well as personalized recommendations developed based on their health data analysis (Sheth, 2020). This contributes not only to improving the quality of service, but also to strengthening patient loyalty, which is especially important in the context of increasing competition in the healthcare industry (Setyawan et al., 2020; Hidayat & Idrus, 2023).

In general, omnichannel approaches allow doctors and clinics to establish effective communication with patients through a variety of modern platforms. Thanks to the coordinated work of all channels, a feeling of individual approach and attention to the needs of each patient is created.

### 3. MATERIALS AND METHODS

To obtain empirical data, a series of semi-structured in-depth interviews with healthcare experts were conducted, as well as two independent surveys using questionnaires developed by the authors.

The main purpose of in-depth interviews was to identify the factors influencing the medical services value perception, as well as methods and tools of interaction with patients. The surveys helped us to obtain quantitative data to test the hypotheses put forward.

The following issues were discussed during the interviews:

- main trends in the Russian medical market related to communications and digitalization;
- the role of an omnichannel system in improving interactions between a clinic and patients;
- key elements of an omnichannel system (automation, multichannel communication, CRM integration);
- factors affecting patient satisfaction and loyalty;
- typical communication problems in medical organizations;
- the impact of omnichannel approach on business performance.

Six expert interviews were conducted with participants who have significant experience in healthcare marketing and management, as well as the implementation of omnichannel systems. All answers had high relevance for the purposes of the study.

Based on the literature analysis and expert interviews, we put forward the following hypotheses:

*H1: Personalized communication increases patient satisfaction.*

*H2: Most primary patients aged 35 to 44 make an appointment through a contact center.*

*H3: The main problem of the CC as a channel for recording primary patients is the busyness of operators and long waits for a response.*

*H4: The frequency of patient attendance at an appointment is higher for those respondents who receive automated reminders in WhatsApp*

At the second stage of the study, two independent surveys were organized:

- a survey of 360 respondents to test hypotheses H1 and H4;
- a survey of 259 respondents using A/B testing to prove hypotheses H2 and H3.

All survey participants were primary patients of the *Poliklinika.ru* platform who did not use services through the voluntary health insurance (VHI) system.

## 4. RESULTS

### 4.1. Omnichannel systems in the Russian healthcare market

In Russia, the healthcare market is facing a number of challenges, while competition in the healthcare sector continues to grow, especially private medical services segment (BusinesStat, 2023). Therefore, it is extremely important for private medical organizations to pay special attention to customer relations in order to gain and maintain competitive advantages. One of the possible options is the introduction of an omnichannel interaction system, which helps to better understand patients' needs and desires. This, in turn, leads to increased patient satisfaction.

There is currently insufficient information about the implementation of an omnichannel system of interaction in Russian medical organizations. Nevertheless, a number of well-known examples can be noted.

Thus, the *Family Doctor* clinic has brought the customer notification system to a single standard, so that all information is provided to customers in the same way, regardless of the selected recording channel: calls, using the website or mobile application.

The introduction of an omnichannel system in the *My Doctor* medical center has significantly improved the organization of communication with patients and increased the efficiency of communication channels. Among the innovations are automation of recordings and appointment management, and a voice robot has been integrated to remind patients of upcoming visits, which automatically calls patients on the eve of their appointment, replacing the need to manually make calls to operators. To simplify record management, integration with the *My Doctor* CRM system was performed. This allows patients and operators to work with records directly via a chatbot, with automatic data updates in the system without employee intervention. These measures allowed not only to speed up processes, but also to increase customer satisfaction, thanks to faster and more coordinated service.

The introduction of trigger mailings and the customer data platform (CDP) has increased the revenue share to 22% of *Evalar*, a manufacturer of dietary supplements. CDP allows you to create a single customer database for the purpose of analyzing, monitoring and managing customer interactions, which in particular helps to control the customer experience at all stages and integrate communication flows. Among the automatic trigger mailings, the most effective were mailings related to items thrown into the basket, leaving product reviews for bonus points, and encouraging repeat purchases by accruing points that burn during the week (Mindbox, 2024).

Thus, marketing in healthcare is not just about promotion, it is more about the stable relationships with patients at every stage of their treatment at the clinic.

In the context of digitalization, medical institutions should use new technologies to provide patients with an easy and affordable way to obtain information and services to gain competitive advantages: improving the perception of the clinic helps to increase trust and commitment from customers, as well as reduce the cost of attracting new customers.

### 4.2. Empirical research results

#### 4.2.1. Results of interviews with healthcare experts

All experts emphasized the importance of omnichannel in building communication with patients. Trigger mailings and reminders, which are automated using CRM systems, are one of the main tools that can improve the quality of patient care. Transparency of interaction with

patients was also highlighted as a key factor in building loyalty. However, in the process of implementing a CRM system, experts also highlight the problem of insufficient processing of patient feedback.

Despite the availability of systems for collecting data and feedback, in some cases medical organizations do not use all the possibilities for a full-fledged analysis and processing of the information received, which reduces the effectiveness of CRM and leads to a loss of trust on the part of patients. It is important that clinics not only collect feedback, but also respond to it in a timely manner, giving patients the confidence that their opinion matters.

Thus, the introduction of CRM systems in medical institutions has a significant impact on improving the quality of patient care, improving the internal organization of processes and strengthening customer loyalty.

#### 4.2.2. Survey results

Key factors that influence the effectiveness of interaction with patients in private medical institutions have been identified. The survey results show that the introduction of omnichannel interaction systems significantly increases the value of medical services for clients, and improves their satisfaction and loyalty.

One of the most significant results of the study is the confirmation of the hypothesis *H1: personalized communication increases patient satisfaction*. Patients receiving personalized messages such as reminders and recommendations report a higher level of comfort and trust in medical facilities, which contributes to an increase in their loyalty and satisfaction with the services they receive.

In addition, the study confirmed the importance of choosing an appointment channel. For patients aged 35-44 years, the contact center remains the preferred channel, which indicates the need for convenient and accessible telephone communication. However, with the development of digital technologies and the increasing availability of mobile applications, we can expect a change in preferences towards online channels. This implies the need for medical institutions to adapt their recording processes to meet new patient requirements.

In addition, automated reminders of upcoming appointments and tests, especially through messengers such as WhatsApp, significantly increase patient turnout. This confirms the importance of implementing such technologies to improve the accuracy and effectiveness of communication with patients, which directly affects their behavior and increases their involvement in healthcare processes.

The introduction of omnichannel systems integrating various communication channels (phone, e-mail, messengers and mobile apps) improves the quality of interaction with patients, which leads to an improvement in their overall experience. Omnichannel solutions allow clinic to create a continuous and consistent customer journey, increasing satisfaction and loyalty.

However, the study also revealed existing problems associated with the implementation of omnichannel systems, such as limited technical and financial resources of medical institutions, especially in small clinics. Despite these difficulties, there are successful examples of omnichannel implementation, such as in Polyclinic.ru, demonstrate that with proper process configuration and integration of various communication channels, it is possible to significantly improve the clinic efficiency and the quality of patient care.

## 5. CONCLUSIONS

After conducting a survey, we can conclude that implementing omnichannel systems helps private clinics to increase the value of medical services, improve patient satisfaction and thus to become more competitive in the healthcare market.

Based on the results of the study, recommendations were formulated for private medical organizations that relate to various aspects of patient interaction, with an emphasis on personalization, record availability, and customer retention.

As for *personalization*, one of the key steps is to segment the patient base based on their demographic and behavioral characteristics. This allows you to adapt the style and tone of communication, providing a more accurate and individualized approach. The introduction of personalization elements in letters is an important step that helps to increase the response and improve the quality of interaction with patients. In addition, it is important to integrate a personalized approach into the omnichannel strategy, which will allow maintaining a uniform style and level of individual approach in all communication channels. Regular testing of communication effectiveness is also important to optimize emails and increase response.

As for the recommendations on the *initial flow of patients*, it is important to take into account that now most patients choose to call the contact center for recording, and maintaining the convenience of this communication channel remains relevant. However, when forming a communication strategy, it is necessary to take into account not only the current, but also the future target audience. The study showed that patients between the ages of 18 and 34 are increasingly choosing to make an appointment via instant messengers, in particular via WhatsApp. This generation will become the core audience in the coming years, and ignoring their preferences may lead to missing out on important potential for long-term engagement.

As part of the recommendations on *recording accessibility*, it was revealed that there is a problem of a long wait for a response when recording via WhatsApp. More than 40% of the respondents using this channel expressed dissatisfaction with the response rate. Given that the 18-34-year-old audience actively uses messengers and will become the main segment of the customer base in the coming years, it is extremely important to urgently optimize the processing of requests via WhatsApp. To solve this problem, it is recommended to implement a chatbot for the initial processing of requests, as well as expand the staff of operators working in messengers. These measures will increase responsiveness and improve interaction with patients.

Finally, recommendations for *patient retention* include expanding the practice of sending automated reminders via WhatsApp, especially for primary patients and patients with a high probability of non-attendance. It is recommended to redirect reminders from less effective channels such as SMS and PUSH to WhatsApp for key segments where it is technically and legally possible. It is also important to integrate WhatsApp reminders into standard communication scenarios and regularly monitor turnout metrics to confirm the sustainability of the effect and the effectiveness of this strategy.

The implementation of the proposed recommendations will improve the communication process with patients, increase their satisfaction, and ensure higher efficiency of all recording and interaction channels.

## REFERENCES

- Arslan, I. K. (2020). The importance of creating customer loyalty in achieving sustainable competitive advantage. *Eurasian Journal of Business and Management*, 8(1), 11-20. <https://doi.org/10.15604/ejbm.2020.08.01.002>
- Barwitz, N., & Maas, P. (2018). Understanding the omnichannel customer journey: determinants of interaction choice. *Journal of interactive marketing*, 43(1), 116-133. <https://doi.org/10.1016/j.intmar.2018.02.001>
- Buldeo Rai, H., Mommens, K., Verlinde, S., & Macharis, C. (2019). How does consumers' omnichannel shopping behaviour translate into travel and transport impacts? Case-study of a footwear retailer in Belgium. *Sustainability*, 11(9), 2534. <https://doi.org/10.3390/su11092534>
- BusinesStat (2023). *The medical services market in Russia: demo report*. [https://businessstat.ru/images/demo/medicine\\_russia\\_demo\\_businessstat.pdf](https://businessstat.ru/images/demo/medicine_russia_demo_businessstat.pdf)
- Chakraborty, D., & Paul, J. (2023). Healthcare apps' purchase intention: A consumption values perspective. *Technovation*, 120, 102481. <https://doi.org/10.1016/j.technovation.2022.102481>
- Eggert, A., Ulaga, W., Frow, P., & Payne, A. (2018). Conceptualizing and communicating value in business markets: From value in exchange to value in use. *Industrial marketing management*, 69, 80-90. <https://doi.org/10.1016/j.indmarman.2018.01.018>
- Gao, W., Fan, H., Li, W., & Wang, H. (2021). Crafting the customer experience in omnichannel contexts: The role of channel integration. *Journal of business research*, 126, 12-22. <https://doi.org/10.1016/j.jbusres.2020.12.056>
- Hidayat, K., & Idrus, M. I. (2023). The effect of relationship marketing towards switching barrier, customer satisfaction, and customer trust on bank customers. *Journal of Innovation and Entrepreneurship*, 12(1), 29. <https://doi.org/10.1186/s13731-023-00270-7>
- McColl-Kennedy, J. R., Snyder, H., Elg, M., Witell, L., Helkkula, A., Hogan, S. J., & Anderson, L. (2017). The changing role of the health care customer: review, synthesis and research agenda. *Journal of Service Management*, 28(1), 2-33. <https://doi.org/10.1108/JOSM-01-2016-0018>
- McColl-Kennedy, J. R., Vargo, S. L., Dagger, T. S., Sweeney, J. C., & Kasteren, Y. V. (2012). Health care customer value cocreation practice styles. *Journal of service research*, 15(4), 370-389. <https://doi.org/10.1177/1094670512442806>
- Moreira, A., Alves, C., Machado, J., & Santos, M. F. (2023). An overview of omnichannel interaction in health care services. *Mayo Clinic Proceedings: Digital Health*, 1(2), 77-93. <https://doi.org/10.1016/j.mcpdig.2023.03.002>
- Parasuraman, A. (1997). Reflections on gaining competitive advantage through customer value. *Journal of the Academy of Marketing Science*, 25, 154-161. <https://doi.org/10.1007/BF02894351>
- Payne, A. F., Storbacka, K., & Frow, P. (2008). Managing the co-creation of value. *Journal of the Academy of Marketing Science*, 36, 83-96. <https://doi.org/10.1007/s11747-007-0070-0>
- Rathert, C., Wyrwich, M. D., & Boren, S. A. (2013). Patient-centered care and outcomes: a systematic review of the literature. *Medical care research and review*, 70(4), 351-379. <https://doi.org/10.1177/1077558712465774>
- Samsa, Ç., & Yüce, A. (2022). Understanding customers hospital experience and value co-creation behavior. *The TQM Journal*, 34(6), 1860-1876. <https://doi.org/10.1108/TQM-09-2021-0282>

- Saxena, S., Amritesh, & Misra, S. C. (2021). Consumer value preferences in healthcare: insights for value-centred management. *Journal of Creating Value*, 7(2), 219-231. <https://doi.org/10.1177/23949643211042246>
- Setyawan, F. E. B., Supriyanto, S., Ernawaty, E., & Lestari, R. (2020). Understanding patient satisfaction and loyalty in public and private primary health care. *Journal of public health research*, 9(2), jphr-2020. <https://doi.org/10.4081/jphr.2020.1823>
- Sheth, J. N. (2020). Customer value propositions: Value co-creation. *Industrial marketing management*, 87, 312-315. <https://doi.org/10.1016/j.indmarman.2019.10.012>
- Sun, H., & Su, Z. (2012). New thoughts of customer value study. *Physics Procedia*, 24, 1232-1237. <https://doi.org/10.1016/j.phpro.2012.02.184>
- Van Boerdonk, P. J. M., Krikke, H. R., & Lambrechts, W. D. B. H. M. (2021). New business models in circular economy: A multiple case study into touch points creating customer values in health care. *Journal of cleaner production*, 282, 125375. <https://doi.org/10.1016/j.jclepro.2020.125375>
- Zeithaml, V. A., Berry, L. L., & Parasuraman, A. (1996). The behavioral consequences of service quality. *Journal of marketing*, 60(2), 31-46. <https://doi.org/10.1177/002224299606000203>
- Zeithaml, V. A., Verleye, K., Hatak, I., Koller, M., & Zauner, A. (2020). Three decades of customer value research: paradigmatic roots and future research avenues. *Journal of Service Research*, 23(4), 409-432. <https://doi.org/10.1177/1094670520948134>





## IDENTIFICATION OF FACTORS FOR ANALYSIS AND EVALUATION OF HEIs PERFORMANCE

Nedeljka Živković<sup>1\*</sup>, Maja Glogovac<sup>2</sup>, Isidora Milošević<sup>3</sup>

<sup>1</sup> *Belgrade Business and Arts Academy of Applied Studies, Belgrade, Serbia*

<sup>2</sup> *University of Belgrade, Faculty of Organizational Sciences, Belgrade, Serbia*

<sup>3</sup> *University of Belgrade, Technical Faculty in Bor, Bor, Serbia*

**Abstract:** Analysing and evaluating various aspects of performance in HEIs requires a systematic approach. Higher Education Institutions (HEIs) are the foundation for the development of every society. By analysing and evaluating organisational performance, valuable information is gained for potential improvements in the future. HEIs should analyse, measure, and assess the achievement of results in relation to their goals, strategy, and policy. Analysing and evaluating organisational performance enables a comprehensive understanding of the organisation's strengths and weaknesses. The research was conducted among employees in HEIs by testing employees' attitudes. A questionnaire was used in the research. The aim of this study is to apply Exploratory Factor Analysis (EFA) based on original variables from the widely accepted standard ISO 9004:2018 guidelines for achieving sustainable success to analyse and evaluate organisational performance. The results of the factor analysis confirm that all obtained values are above the satisfactory values, thereby confirming the reliability of the data. For analysing and evaluating performance in HEIs, it is crucial to identify and understand the factors that may lead to improvements in overall organisational performance in the future. Based on the variables related to performance indicators, analysing and evaluating performance, conducting internal reviews, self-assessment, and re-evaluating the obtained information can improve performance in the future.

**Keywords:** Organizational performance, Quality, Higher Education Institutions (HEIs), Exploratory Factor Analysis (EFA)

---

\* Corresponding author: [nedeljka.zivkovic@bpa.edu.rs](mailto:nedeljka.zivkovic@bpa.edu.rs)

Nedeljka Živković, ORCID: 0000-0001-6663-7467

Maja Glogovac, ORCID: 0000-0003-3268-8543

Isidora Milošević, ORCID: 0000-0001-5539-8253

## 1. INTRODUCTION

In order to improve the quality of the organisation, systems for measuring organisational performance are increasingly being adopted (Oladimeji et al., 2025). The concept of quality management has developed in proportion to the development of society and the adaptation to market changes. Organisations must expand their operations to achieve societal satisfaction, i.e., the satisfaction of all stakeholders (Deleryd & Fundin, 2025). Increasing competition in the market demands a higher level of product/service quality through the improvement of organisational performance (Sfreddo et al., 2021). In this regard, all organisational systems should make continuous efforts to invest in improving the quality level in order to adapt their operations to contemporary market trends (Wolniak, 2019). In the global environment, performance improvement is a high-priority issue for all organisations (Carvalho et al., 2023). Organisational performance is directly linked to quality management (Kuo & Tsai, 2019). Poor or low levels of quality will directly and negatively affect the competitive advantage of the organisational system (Clemons & Jance, 2024).

All organisations, regardless of type, form, or nature, must establish a systematic approach for analysing and evaluating organisational performance (ISO, 9004). In order to understand, measure, and evaluate organisational performance, it is necessary to highlight the key aspects related to performance evaluation. Organisational performance can be measured in various ways but may also be influenced by different variables (Antony et al., 2022). Collected and available information must be analysed and evaluated to update the organisation's context, strategy, policy, and goals. In this sense, indicators may refer to strategic, operational, and financial performance (Antony et al., 2022). The quality of business performance depends on the previously mentioned groups of performance (Ruso et al., 2024). Information from these performances may relate to aspects that describe the status of activities, processes, and resources, both internal and external environments, as well as the identification of information that may relate to potential performance improvements within organisations.

For the improvement of organisational performance, it is essential to intensify efforts to monitor all activities related to project ideas and solutions (Larsson et al., 2025). Organisations must analyse and evaluate their progress in relation to business performance during the achievement of planned results compared to strategic organisational goals (ISO, 9004). Certain authors, such as Akpa et al. (2021), point out that research shows if employees are committed and share the same values as the organisation as a whole, this can contribute to improving performance in the direction of achieving strategic goals and increasing efficiency and effectiveness. This stems from the fact that there is a close link between organisational culture and business performance. Business excellence of organisational systems consists of a value system that encompasses organisational culture, values, and employees within organisations (Araújo & Sampaio, 2014). Regardless of whether they are profit or non-profit organisations, organisational performance represents a highly significant aspect for all organisations, whether they are of a manufacturing or service nature (Akpa et al., 2021).

Although in the past the concept of quality and the measurement of organisational performance was primarily associated with industrial production, today, in the global market, these concepts are almost equally represented in service sectors. In this regard, the aim of this paper is to identify the influencing factors for performance measurement in higher education institutions through the application of the statistical method of factor analysis. There is a lack of literature addressing the dimensions of organisational performance in higher education institutions (Khalaf et al., 2024). Considering the existing gap in the literature regarding the potential for improving organisational performance (Nandi, 2022), this research takes a step

forward in identifying factors and analysing indicators that are derived and suitable for evaluating performance in higher education institutions.

## 2. LITERATURE REVIEW

For the survival of service organisations in today's dynamic market environment, increasing attention is being paid to improving quality levels, reducing costs, and enhancing efficiency and effectiveness to ensure the survival of organisational systems in a competitive market (Anwar & Abdullah, 2021). Quality improvement is positively associated with the enhancement of performance in organisational systems (Bayo-Moriones & de la Torre, 2022). Investment in improving quality management can prevent the transfer of problems to subsequent phases, as identifying root causes can prevent further errors that may impact organisational performance (Bayo-Moriones & de la Torre, 2022). In this way, quality management contributes to the reduction of variation and promotes activities aimed at the continuous improvement of organisational performance. In order to improve efficiency and effectiveness, organisations are increasingly adopting performance measurement systems (Oladimeji et al., 2025). Organisational performance is an indicator of the achievement of organisational goals (Dyer & Reeves, 1995). There is a close connection between internal audits conducted within organisations and performance improvement, and the information obtained in this way can be utilised by all interested parties (Hammood & Dammak, 2023). It is highly important for organisations to measure organisational performance. Performance measurement, or a snapshot of the current state, can be carried out based on financial and non-financial indicators (Kaplan & Norton, 1992). In the past, the measurement, analysis, and evaluation of organisational performance was intended for commercial organisations, whereas today, that is no longer the case; on the contrary, non-profit organisations are also interested in this type of analysis in order to survive in a competitive market (Makki et al., 2023; Kiriri, 2022).

Although in the past the concept of quality was primarily associated with industry, today this paradigm is equally present in service sectors. This particularly applies to higher education institutions (HEIs), which play a key role in societal development (Kiriri, 2022). HEIs must adopt a performance measurement system to meet the requirements of all interested parties and ensure survival in a competitive market (Makki et al., 2023). HEIs must establish approaches that will ensure sustainability and resilience to all challenges in today's market environment (Al-Bahi et al., 2021). It is believed that if HEIs conduct performance measurement and evaluation, this may have a positive effect on potential future improvements (Kiriri, 2022). The activities of business processes related to the measurement and evaluation of information should be carried out so that organisations can monitor their progress and make effective decisions (ISO, 9004). The field of higher education is a specific domain, and it is highly complex to create universal indicators that can be applied across all HEIs (Makki et al., 2023). The performance measurement system in HEIs must be such that it includes all interested parties (Kiriri, 2022). However, it is also necessary to consider the fact that various stakeholders of HEIs have increased their expectations (Kiriri, 2022). Internationalisation has created a globally competitive market, and the managerial structures of HEIs must, for the purpose of ensuring business sustainability, conduct measurement of the overall performance of both academic and non-academic processes (Yeung, 2018). Scientific and technological development creates significant opportunities for the economic progress of a country (Cimil & Plotnic, 2021). Comprehensive performance measurement in the field of higher education can be conducted through the creation of Key Performance Indicators (KPIs), followed by the analysis and evaluation of performance for potential improvements (Varouchas et al., 2018). For the analysis and evaluation of the information obtained in HEIs, it is crucial to identify and understand the

factors that lead to the improvement of organisational performance (Chaiya & Ahmad, 2021). A comprehensive approach to performance measurement based on applied indicators will, in the future, lead to improvements that initially contribute to achieving business sustainability in HEIs (Yeung, 2018). Analysing and evaluating performance in HEIs is a complex task, as performance must be considered from the perspective of the most important stakeholders (Matosas-López et al., 2019). The field of higher education is a major driver of social development, and performance analysis and evaluation are also significant from the perspective of university/faculty rankings on prestigious league tables (Meier & Schiopu, 2020). Like all other organisations, HEIs should have a clear framework for understanding the steps involved in creating performance indicators, analysing and evaluating performance, conducting internal reviews, self-assessment, and re-evaluating the information obtained during performance measurement (ISO, 9004).

### **3. DATA AND METHODOLOGY**

Based on the literature review, it is concluded that it is necessary to select variables for the analysis and evaluation of performance in HEIs. Accordingly, variables were selected from relevant literature (ISO, 9004). The selected variables were fully adopted in their original form. All proposed variables were included in a questionnaire completed by teaching staff and part of the non-teaching staff in HEIs (employees in the Student Services Office and the Office for the Organisation of Teaching and Exams). The questionnaire, which comprised demographic and seven professional questions, was developed using Google Forms and distributed via email.

Data were collected using both Cyrillic and Latin script versions of the questionnaire. After data collection, the responses were coded and integrated into a single Excel spreadsheet. A total of 374 responses were collected. Responses were obtained based on the attitudes of HEI employees using a five-point Likert scale. The data were processed using the statistical package SPSS for Exploratory Factor Analysis.

### **4. RESULTS AND DISCUSSION**

According to the demographic structure analysis based on respondents' gender, 176 male and 198 female participants took part in the study. Furthermore, based on job position within HEIs, 63 participants were administrative staff, 63 were teaching associates/assistants, and 248 were professors. Regarding work experience, 29 respondents had up to 30 years of experience, 94 were in the 31–40 age group, 124 in the 41–50 age group, 88 in the 51–60 age group, and 39 respondents were over 60 years old. In terms of founding structure, 339 participants were from public HEIs, while 35 were from HEIs founded by private individuals. Following the demographic analysis, the statistical technique of Exploratory Factor Analysis (EFA) was applied. The multivariate statistical technique known as Exploratory Factor Analysis has found application across all fields (Hair et al., 2014). This technique is widely used in the social sciences and also in the field of higher education (Williams et al., 2010). For this purpose, EFA was used in this study with the aim of reducing the amount of data. Through factor analysis, researchers attempt to identify a smaller set of factors within the correlations between variables (Williams et al., 2010). EFA requires a large dataset, and it is recommended that the sample size be greater than 100 (Hair et al., 1995). To analyse internal consistency in this study, Cronbach's Alpha coefficient was used. It is recommended that the value of Cronbach's Alpha be above 0.5 (Cronbach, 1951). Values above 0.7 suggest that the data are satisfactory, while values of 0.8 or higher indicate that all items are internally consistent (Ho, 2006). In this study, the value of Cronbach's Alpha coefficient was 0.965, indicating

satisfactory data reliability. Table 1 presents the variables related to the Analysis and Evaluation of Organisational Performance along with Cronbach's Alpha coefficient, the Spearman-Brown test, and the Omega test. In addition to the analysis of Cronbach's Alpha coefficient, the Spearman-Brown test can also be conducted, which indicates the suitability of the data. The recommended values for these indicators should be above 0.7 (Eisinga et al., 2013). The Omega test is also used to assess reliability (Flora, 2020; Green et al., 2016). The obtained value of 0.965 exceeds the recommended threshold of 0.7. Table 1 shows internal consistency.

*Table 1.* Measurement of internal consistency

Variables	Cronbach's alfa	Spearman-Brown	Ω
Performance analysis and evaluation (AEP-1)	0,965	0,923	0,965
Performance indicators applied (AEP-2)			
Performance analysed (AEP-3)			
Performance evaluated (AEP-4)			
Internal audits (AEP-5)			
Self-evaluation (AEP-6)			
Review (AEP-7)			

To assess the suitability of the data, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity are used (Williams et al., 2010). KMO values range from 0 to 1. The recommended threshold for the KMO test is  $p < .05$  (Shrestha, 2021), while the value obtained in this study is 0.941. In addition to the KMO test, Bartlett's test of sphericity is also used to evaluate data adequacy (Ho, 2006). Table 2 presents the results of the KMO and Bartlett's tests.

*Table 2.* KMO i Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,941
Bartlett's Test of Sphericity	Approx. Chi-Square	3095,983
	df	21
	Sig.	,000

Table 3 shows the indicators of the EFA analysis. All obtained values are above 0.7, confirming that the indicators show good values within the construct of Analysis and Evaluation of Organisational Performance. The obtained values range from 0.861 to 0.930.

*Table 3.* Factor analysis

AEP_1	,914
AEP_2	,924
AEP_3	,926
AEP_4	,930
AEP_5	,902
AEP_6	,861
AEP_7	,917

## 5. CONCLUSION

The use of Exploratory Factor Analysis enabled a comprehensive assessment of the reliability of data for the Analysis and Evaluation of Organisational Performance in HEIs. All obtained values from the factor analysis are above the satisfactory thresholds, confirming the exceptional reliability of the data. HEIs need to establish systematic approaches for analysing and evaluating organisational performance. The field of higher education is a specific service sector with a range of sensitive processes. In this regard, creating indicators for analysing and evaluating organisational performance is quite challenging due to the heterogeneity of HEIs (Falch et al., 2022). Given the lack of literature addressing the potential for improving organisational performance (Nandi, 2022), this research takes a step forward by identifying factors and analysing indicators that are derived and suitable for evaluating and assessing performance in higher education institutions. This research can be used by HEI management structures for potential improvements in organisational performance. Future research directions could focus on other variables that might impact organisational performance improvements. Additionally, future studies may involve other stakeholders of HEIs, such as students and employers, who, alongside employees, are among the most important stakeholders of HEIs. Further research in this direction could provide a more comprehensive analysis that can be used to improve performance as well as meet the expectations of all stakeholders in HEIs. Future research may also encompass the analysis and measurement of performance at the institutional level of HEIs.

## ACKNOWLEDGMENT

This manuscript is based upon work from COST Action CA22124 - ECO4ALL, “EU Circular Economy Network for All: Consumer Protection through reducing, reusing, repairing,” supported by COST (European Cooperation in Science and Technology—[www.cost.eu](http://www.cost.eu)) and the Ministry of Science, Technological Development and Innovations of the Republic of Serbia, contract numbers 451-03-137/2025-03/200131.

## REFERENCES

- Akpa, V. O., Asikhia, O. U., & Nneji, N. E. (2021). Organizational culture and organizational performance: A review of literature. *International Journal of Advances in Engineering and Management*, 3(1), 361-372. <https://doi.org/10.35629/5252-0301361372>
- Al-Bahi, A. M., Abd-Elwahed, M. S., & Soliman, A. Y. (2021). Implementation of sustainability indicators in engineering education using a combined balanced scorecard and quality function deployment approaches. *Sustainability*, 13(13), 7083. <https://doi.org/10.3390/su13137083>
- Antony, J., Swarnakar, V., Cudney, E., & Pepper, M. (2022). A meta-analytic investigation of lean practices and their impact on organisational performance. *Total Quality Management & Business Excellence*, 33(15-16), 1799-1825. <https://doi.org/10.1080/14783363.2021.2003194>
- Anwar, G., & Abdullah, N. N. (2021). The impact of Human resource management practice on Organizational performance. *International journal of Engineering, Business and Management (IJEEM)*, 5. <https://dx.doi.org/10.22161/ijeem.5.1.4>
- Araújo, M., & Sampaio, P. (2014). The path to excellence of the Portuguese organisations recognised by the EFQM model. *Total Quality Management & Business Excellence*, 25(5-6), 427-438. <https://doi.org/10.1080/14783363.2013.850810>

- Bayo-Moriones, A., & de la Torre, R. (2022). Analysing the relationship between QM, performance appraisal and pay for performance. *Total Quality Management & Business Excellence*, 33(9-10), 1056-1083. <https://doi.org/10.1080/14783363.2021.1933422>
- Carvalho, A. M., Sampaio, P., Rebentisch, E., McManus, H., Carvalho, J. Á., & Saraiva, P. (2023). Operational excellence, organizational culture, and agility: bridging the gap between quality and adaptability. *Total Quality Management & Business Excellence*, 34(11-12), 1598-1628. <https://doi.org/10.1080/14783363.2023.2191844>
- Chaiya, C., & Ahmad, M. M. (2021). Success or failure of the Thai higher education development—Critical factors in the policy process of quality assurance. *Sustainability*, 13(17), 9486. <https://doi.org/10.3390/su13179486>
- Cimil, D., & Plotnic, O. (2021). European Union view on Personal Data in Intellectual Property Rights. *Eastern European Journal for Regional Studies (EEJRS)*, 7(1), 92-106. <https://doi.org/10.53486/2537-6179.7-1.05>
- Clemons, R., & Jance, M. (2024). Defining Quality in Higher Education and Identifying Opportunities for Improvement. *SAGE Open*, 14(3), <https://doi.org/10.1177/21582440241271155>
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *psychometrika*, 16(3), 297-334.
- Deleryd, M., & Fundin, A. (2025). Towards societal satisfaction in a fifth generation of quality—the sustainability model. *Total Quality Management & Business Excellence*, 36(3-4), 292-308. <https://doi.org/10.1080/14783363.2020.1864214>
- Dyer, L. H., & Reeves, T. (1995). Human resource strategies and firm performance: What do we know and where do we need to go? *International Journal of Human Resource Management*, 6, 656– 670.
- Eisinga, R., Grotenhuis, M. T., & Pelzer, B. (2013). The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown?. *International journal of public health*, 58, 637-642. <https://doi.org/10.1007/s00038-012-0416-3>
- Falch, T., Iversen, J. M. V., Nyhus, O. H., & Strøm, B. (2022). Quality measures in higher education: Norwegian evidence. *Economics of Education Review*, 87, 102235. <https://doi.org/10.1016/j.econedurev.2022.102235>
- Flora, D. B. (2020). Your coefficient alpha is probably wrong, but which coefficient omega is right? A tutorial on using R to obtain better reliability estimates. *Advances in Methods and Practices in Psychological Science*, 3(4), 484-501. <https://doi.org/10.1177/2515245920951747>
- Green, S. B., Yang, Y., Alt, M., Brinkley, S., Gray, S., Hogan, T., & Cowan, N. (2016). Use of internal consistency coefficients for estimating reliability of experimental task scores. *Psychonomic bulletin & review*, 23, 750-763. <https://doi.org/10.3758/s13423-015-0968-3>
- Hair Jr, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis with readings*. Prentice-Hall, Inc..
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Exploratory factor analysis. Multivariate data analysis*, Pearson Education Limited. Harlow, England (Seventh Edition)
- Hammood, A. M., & Dammak, S. (2023). The mediating role of the balanced scorecard in the relationship between internal control and the financial reports
- Ho, R. (2006) *Handbook of Univariate and Multivariate Data Analysis and Interpretation with SPSS*. <https://doi.org/10.1016/j.econmod.2020.04.020>



- International Organization for Standardization (2018). ISO 9004:2018 Quality management—Quality of an organization — Guidance to achieve sustained success, International Organization of Standardization, Switzerland.
- Kaplan, R. & Norton, D., (1992). The Balanced Scorecard: Measures that Drive Performance. *Harvard Business Review*. 70(1), 71–99.
- Khalaf Alateyyat, S., Jaaron, A. A., & Igudia, E. (2024). Unveiling the status of TQM-performance link in the private, public, and third sectors: a systematic review. *Total Quality Management & Business Excellence*, 35(9-10), 938-970. <https://doi.org/10.1080/14783363.2024.2348660>
- Kiriri, P. N. (2022). Management of Performance in Higher Education Institutions: The Application of the Balanced Scorecard (BSC). *European Journal of Education (EJED)*, 5(1), 144-158.
- Kuo, T., & Tsai, G. Y. (2019). The effects of employee perceived organisational culture on performance: the moderating effects of management maturity. *Total Quality Management & Business Excellence*, 30(3-4), 267-283. <https://doi.org/10.1080/14783363.2017.1302327>
- Larsson, D., Ratnayake, R. C., & Samarakoon, S. M. (2025). Enhancing Performance in Engineering-To-Order Projects: Integrating Digital Value Stream Mapping and Green Lean Practices. *Engineering Management Journal*, 1-18. <https://doi.org/10.1080/10429247.2025.2464719>
- Makki, A. A., Alqahtani, A. Y., Abdulaal, R. M., & Madbouly, A. I. (2023). A novel strategic approach to evaluating higher education quality standards in university colleges using multi-criteria decision-making. *Education Sciences*, 13(6), 577. <https://doi.org/10.3390/educsci13060577>
- Matosas-López, L., Bernal-Bravo, C., Romero-Ania, A., Palomero-Ilardia, I., (2019). Quality Control Systems in Higher Education Supported by the Use of Mobile Messaging Services. *Sustainability*, 11(21), 6063; <https://doi.org/10.3390/su11216063>
- Meier, V., Schiopu, I., (2020). Enrollment expansion and quality differentiation across higher education systems. *Economic Modelling*. Vol. 90, p43-53. 11p.
- Nandi, E. (2022). Governance, performance and quality in higher education: Evidences from a case study. *Contemporary Education Dialogue*, 19(1), 37-58. <https://doi.org/10.1177/09731849211056380>
- Oladimeji, O., Keathley-Herring, H. H., & Cross, J. A. (2025). Understanding the Interrelationships Between Organizational Performance Measurement System Implementation Variables. *Engineering Management Journal*, 37(1), 71-89. <https://doi.org/10.1080/10429247.2024.2361219>
- quality. *International Journal of Professional Business Review: Int. J. Prof. Bus. Rev.*, 8(1), 14. <https://doi.org/10.26668/businessreview/2023.v8i1.1060>
- Ruso, J., Milošević, I., Stojanović, A., Glogovac, M., Rakić, A., & Arsić, S. (2024). Regional variations in digital transformation: the impact of industry 5.0 on business quality performance. *Total Quality Management & Business Excellence*, 35(15-16), 1879-1899. <https://doi.org/10.1080/14783363.2024.2416171>
- Sfreddo, L. S., Vieira, G. B. B., Vidor, G., & Santos, C. H. S. (2021). ISO 9001 based quality management systems and organisational performance: a systematic literature review. *Total Quality Management & Business Excellence*, 32(3-4), 389-409. <https://doi.org/10.1080/14783363.2018.1549939>
- Shrestha, N. (2021). Factor analysis as a tool for survey analysis. *American journal of Applied Mathematics and statistics*, 9(1), 4-11. <https://doi.org/10.12691/ajams-9-1-2>



- Varouchas, E., Sicilia, M.A., & Sánchez-Alonso, S., (2018). Towards an integrated learning analytics framework for quality perceptions in higher education: a 3-tier content, process, engagement model for key performance indicators. *Behaviour & Information Technology*, Vol. 37 Issue 10/11, p1129-1141. <https://doi.org/10.1080/0144929X.2018.1495765>
- Williams, B., Onsman, A., & Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Australasian journal of paramedicine*, 8, 1-13. <https://doi.org/10.33151/ajp.8.3.93>
- Wolniak, R. (2019). The level of maturity of quality management systems in Poland—results of empirical research. *Sustainability*, 11(15), 4239. <https://doi.org/10.3390/su11154239>
- Yeung, S. M. C. (2018). Linking ISO 9000 (QMS), ISO 26000 (CSR) with accreditation requirements for quality indicators in higher education. *Total quality management & business excellence*, 29(13-14), 1594-1611. <https://doi.org/10.1080/14783363.2017.1282310>



## SustainAbility: WHEN CAPITAL LETTER MATTERS

Mario Carrassi<sup>1\*</sup>, Anna Argese<sup>1</sup>, Teresa D'Andrea<sup>1</sup>, Tomasz Ingram<sup>2</sup>

<sup>1</sup> *Università degli studi di Bari Aldo Moro, Dipartimento di Economia e Finanza, Bari, Italy*

<sup>2</sup> *The University of Economics in Katowice, Faculty of Economics, Poland*

**Abstract:** Sustainability, while widely recognized as a global imperative, often struggles to bridge the gap between intention and action (Rockström et al., 2009; Raworth, 2017). This paper introduces the concept of SustainAbility, which reframes traditional sustainability by emphasizing the development of cognitive, behavioral, and systemic abilities necessary for lasting and transformative change (Sterling, 2011; Bandura, 1977). SustainAbility shifts the focus from static goals to dynamic processes, recognizing that long-term sustainability requires a skill-based, adaptive approach (Meadows, 2008; Kahneman, 2011). Drawing on insights from behavioral economics (Thaler & Sunstein, 2008), systems thinking (Senge, 1990) and educational psychology (Kolb, 1984), this paper explores the theoretical foundations and policy implications of SustainAbility. Key areas of focus include the role of education in cultivating systems literacy, corporate strategies for embedding SustainAbility into decision-making and participatory policymaking to build institutional resilience (Ostrom, 1990; Geels, 2011). By redefining SustainAbility through the lens of abilities, this paper advocates for a paradigm shift that integrates knowledge and emphasizes equitable and inclusive frameworks (Sen, 1999; Agyeman et al., 2002).

**Keywords:** Cognitive abilities, behavioral change, systems thinking, resilience, education for SustainAbility.

### 1. INTRODUCTION

The concept of SustainAbility has become a cornerstone of global discourse, influencing policy making, corporate strategy, and societal priorities and encompassing the interconnected dimensions of environmental preservation, economic stability, and social equity. However, sustainability efforts often falter in practice, focusing heavily on specific targets while overlooking the dynamic processes and capacities required for lasting change (Meadows, 2008).

---

\* Corresponding author: [mario.carrassi@uniba.it](mailto:mario.carrassi@uniba.it)

Mario Carrassi, ORCID: 0000-0002-2111-4459

Anna Argese, ORCID: 0009-0004-6128-3152

Teresa D'Andrea, ORCID: 0009-0008-3370-3892

Tomasz Ingram, ORCID: 0000-0002-4161-6261

This paper introduces SustainAbility, a reimagined framework that focuses from static outcomes to the abilities needed for enduring transformation. SustainAbility emphasizes the development of cognitive, behavioral, and institutional capacities that enable individuals and organizations to bridge persistent gaps between knowledge and action, fostering resilience and adaptability in the face of global challenges (Carrassi, 2016). Rooted in interdisciplinary insights from behavioral economics, systems thinking, and educational psychology, SustainAbility offers a transformative pathway for operationalizing sustainability across education, corporate strategies, and community engagement.

The remainder of this paper explores SustainAbility in depth. It first grounds the concept in theoretical foundations, focusing on cognitive and behavioral barriers and the systemic processes that underpin SustainAbility transitions. It, then, examines practical applications in key sectors, followed by an analysis of policy implications, challenges, and future directions.

## 2. THEORETICAL FOUNDATIONS

SustainAbility has long been regarded as a normative construct, guiding humanity toward ecological preservation, economic viability, and social justice. However, a purely goal-oriented approach often remains insufficient when detached from the concrete capacities required to realize sustainable transformations. A growing body of scholars emphasizes that sustainability must be reconceptualized not only as a goal, but as a set of abilities—individual, organizational, and systemic—that enable enduring transformation (Wiek et al., 2011; Barth & Michelsen, 2013). This shift aligns with our reinterpretation of SustainAbility, in which ability is both the condition and the driver of enduring sustainable real effects. The concept of SustainAbility highlights the balance between the environmental, social and economic dimensions and also includes concepts such as intergenerational equity, ecological thresholds and resilience, reflecting a deeper understanding of the interconnected and dynamic nature of global challenges (Rockström et al., 2009). However, traditional sustainability frameworks have often been critiqued for focusing excessively on end goals rather than the dynamic processes required to achieve them. As Meadows (2008) and Raworth (2017) have argued, an overemphasis on static targets has led to fragmented policies and limited long-term success, highlighting the importance of cultivating adaptive capacities to aligning systemic processes with behavioral insights. These shortcomings underline the need for an alternative approach - SustainAbility - that integrates the development of capacities necessary for sustainable action. In this context, SustainAbility proposes the cultivation of cognitive, behavioral, and systemic abilities for fostering lasting and transformative change (Bandura, 1977; Sterling, 2011). Behavioral economics provides valuable insights into biases that obstruct long-term thinking. For instance, present bias leads individuals and institutions to prioritize immediate benefits over future gains, while status quo bias reinforces inertia and resists necessary change (Tversky & Kahneman, 1974; Thaler & Sunstein, 2008). Other cognitive challenges, such as loss aversion—the tendency to prioritize avoiding losses over acquiring equivalent gains—further complicate decision-making. SustainAbility emphasizes designing interventions to mitigate these biases, such as using “nudges” to influence decision-making environments and align individual behaviors with SustainAbility goals (Thaler & Sunstein, 2008; Kahneman, 2011). Equally important is the contribution of systems thinking, which underscores the complexity and interconnectedness of sustainable challenges. Traditional linear approaches to problem-solving are inadequate in addressing issues such as climate change or resource depletion, characterized by feedback loops, emergent properties, and cascading effects. Systems thinking offers a holistic perspective, enabling individuals and organizations to navigate the uncertainty and complexity inherent in sustainable transitions (Senge, 1990; Meadows, 2008). By fostering

systems literacy, SustainAbility equips stakeholders to identify leverage points and design interventions that account for real effects. Educational psychology further enriches the SustainAbility framework by providing insights into how individuals learn and adopt sustainable practices. Experiential learning models, such as Kolb's (1984) cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation, are particularly relevant for fostering systems literacy and critical thinking. Sterling (2011) emphasizes that education for sustainability must go beyond knowledge transfer to empower learners to challenge unsustainable norms and develop context-specific solutions. SustainAbility integrates these pedagogical principles to ensure that cognitive and behavioral abilities are nurtured effectively. Theories of sociotechnical transitions add another dimension to SustainAbility by examining how systemic change unfolds over time. These frameworks explore the interplay between technological innovation, institutional evolution, and societal behavior, offering insights into the conditions necessary for scaling SustainAbility initiatives across sectors such as energy, transportation, and agriculture (Geels, 2011). By integrating these perspectives, SustainAbility underscores the importance of fostering collaboration among diverse stakeholders to facilitate systemic transformation.

SustainAbility also emphasizes adaptive management, a strategy that integrates iterative learning, stakeholder participation and feedback mechanisms to navigate uncertainty and change effectively (Ostrom, 1990; Levin et al., 2012). Closely aligned with resilience thinking, adaptive management prioritizes the capacity of systems to absorb shocks, recover from disturbances, and maintain their core functions over time (Folke et al., 2010). By addressing these foundational principles, SustainAbility establishes itself as a dynamic and interdisciplinary framework capable of bridging persistent gaps between knowledge and action.

### 3. ABILITIES AS A PILLARS OF SUSTAINABILITY

At the core of SustainAbility lies the recognition that achieving meaningful and enduring sustainable transitions requires developing specific abilities — categorized as cognitive, behavioral, and institutional — that enable individuals, organizations, and systems to adapt, innovate, and thrive in the face of complex challenges. By emphasizing the cultivation of these abilities, SustainAbility offers a transformative framework that aligns with the complexity and uncertainty of global challenges (Fig.1).

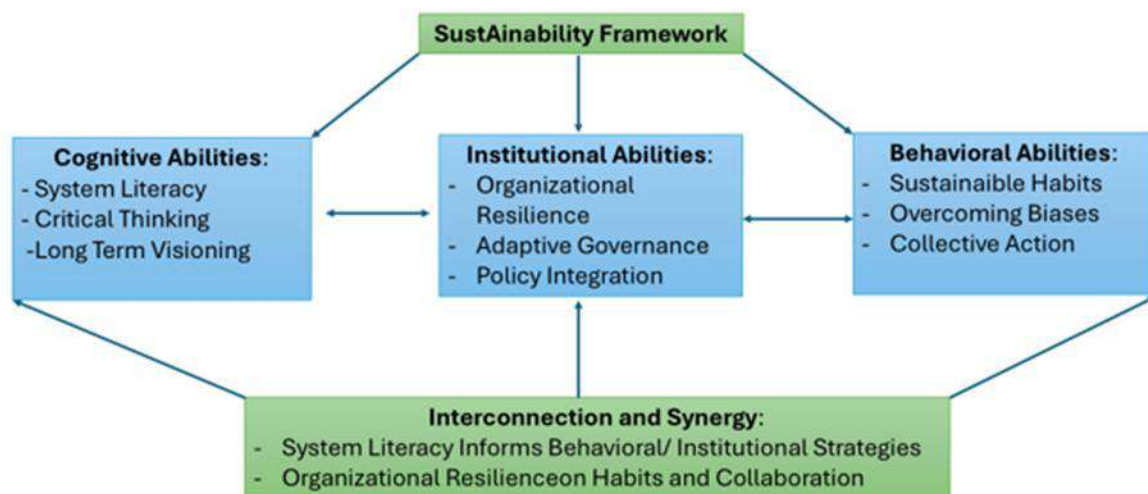


Figure 1. The SustainAbility Framework

The SustainAbility framework integrates cognitive, behavioral, and institutional abilities as key pillars for achieving systemic resilience and transformation. Cognitive abilities, such as system literacy and long-term visioning, provide the foundation for understanding SustainAbility challenges. Behavioral abilities, including sustainable habits and collective action, translate this understanding into practical actions. Institutional abilities, like organizational resilience and adaptive governance, ensure systemic capacities for sustained change. The framework emphasizes the synergy among these domains, with cognitive insights shaping behavioral and institutional strategies, fostering collaboration and adaptability for lasting SustainAbility.

The first pillar of SustainAbility is cognitive abilities, which provide the intellectual foundation for understanding and addressing the interconnected nature of sustainable challenges. Systems literacy, as a key component, refers to the capacity to comprehend the interrelations, feedback loops, and emergent properties within ecological, social, and economic systems. As Meadows (2008) and Senge (1990) have demonstrated, systems literacy enables individuals to move beyond linear thinking and to appreciate the complexity of issues such as climate change and biodiversity loss, identifying leverage points where small interventions can yield system-wide benefits. Critical thinking, involving questioning assumptions, evaluating evidence, and exploring alternatives, is equally crucial (Sterling, 2011). Furthermore, cognitive abilities include long-term visioning, which entails the capacity to think beyond immediate gains and envision sustainable futures. This ability, as highlighted by Raworth (2017), is vital for anticipating emerging trends and adapting strategies to align with long-term SustainAbility objectives.

While cognitive abilities provide the foundation for understanding sustainable challenges, the second pillar- behavioral abilities - translate this understanding into action by fostering sustainable habits and decision-making processes at both individual and collective levels. Daily behaviors-such as reducing energy consumption, minimizing waste, and making environmentally conscious purchasing decisions-are fundamental to SustainAbility. Behavioral economics, as demonstrated by Thaler and Sunstein (2008), offers insights into how subtle interventions, or nudges, can encourage pro-environmental behaviors without limiting individual freedom. Beyond individual habits, behavioral abilities also involve addressing and overcoming cognitive biases that hinder sustainable decision-making (Kahneman, 2011). Moreover, behavioral abilities extend to collective action, as many SustainAbility challenges, such as resource management and climate adaptation, requiring coordinated efforts across communities. Building trust, fostering collaboration and promoting shared responsibility are essential for mobilizing collective action, as Ostrom (1990) has shown in her work on managing common-pool resources.

In addition to cognitive and behavioral abilities, the third pillar institutional abilities are essential for embedding SustainAbility into governance structures and operational frameworks. Institutional abilities encompass the structural and systemic capacities needed to implement and sustain transformative change. Organizational resilience, for example, is a critical institutional ability that enables organizations to adapt to evolving challenges while maintaining their core functions. This includes the ability to manage crises, optimize resource use and innovate in response to disruptions. Waddock (2016) and Folke et al. (2010) highlight the importance of resilience as a foundation for long-term sustainability. Similarly, adaptive governance is a key institutional ability that allows policies and strategies to evolve in response to changing circumstances and stakeholder needs. Levin et al. (2012) argue that inclusive and iterative governance models, which incorporate diverse perspectives and feedback mechanisms, are crucial for navigating uncertainty and fostering stakeholder trust. Finally, institutional abilities involve the integration of policies across sectors, ensuring coherence and alignment between

environmental regulations, economic incentives, and social welfare initiatives. Geels (2011) emphasizes that policy integration is essential for avoiding fragmentation and maximizing the impact of sustainability initiatives.

Behavioral change is central to sustainability, and its success often hinges on the degree to which individuals are intrinsically motivated. According to Deci and Ryan (2000), intrinsic motivation, driven by autonomy, competence, and relatedness, leads to sustained engagement with sustainability practices. Sustainability leverages this insight by designing interventions that align with individuals' internal motivations, ensuring that behavioral shifts are not only immediate but enduring.

Although they are distinct, these abilities are deeply interconnected and their synergy is crucial to the success of sustainability. For instance, systems literacy, a cognitive ability, enhances long-term visioning and strategic foresight, which in turn inform behavioral shifts and institutional policies. Similarly, the resilience of organizations depends on the pro-environmental habits and collaborative efforts of individuals within those organizations. Sustainability thrives when these abilities are developed in harmony, creating a holistic approach to addressing sustainability challenges.

Measuring the development and impact of these abilities is essential for assessing the progress of sustainability initiatives. Traditional performance indicators, such as carbon footprint or resource efficiency metrics, are insufficient for capturing the dynamic processes that sustainability emphasizes. Innovative metrics are required to evaluate cognitive, behavioral, and institutional abilities. For example, systems-thinking assessments and critical-thinking evaluations can provide insights into cognitive development, while behavioral metrics such as reductions in energy use or increased adoption of sustainable practices can track changes in individual and collective behavior (Thaler & Sunstein, 2008). Institutional metrics, including resilience indices and governance quality assessments, can reflect an organization's ability to adapt and thrive in changing contexts (Folke et al., 2010). By developing robust measurement frameworks, sustainability can ensure that the cultivation of abilities translates into tangible and sustained outcomes.

### **3.1. Ecological Awareness and Sustainability: Driving Behavioral Change in Companies**

Ecological awareness, defined as the recognition of the interconnectedness between human activity and environmental systems, is pivotal for embedding sustainability into corporate behavior. In the context of businesses, ecological awareness transcends mere knowledge of environmental issues and reflects a commitment to rethinking processes, values, and goals to align with regenerative practices. This shift is particularly dependent on fostering a culture of mindfulness, which acts as a mechanism for deepening ecological awareness and driving intentional, sustainable behavioral change at all organizational levels (Brown & Kasser, 2005; Amel et al., 2017). Companies that internalize these principles are better positioned to address systemic challenges such as climate change and resource depletion while maintaining competitiveness and resilience. Mindfulness, a practice emphasizing awareness and present-centered intentionality, has been shown to improve decision-making by reducing cognitive biases and fostering emotional intelligence (Rosenberg, 2004; Doni, 2021). Within corporate contexts, mindfulness supports the integration of ecological awareness into strategic planning by encouraging leaders and employees to reflect on the long-term impacts of their actions on natural systems. Research suggests that mindfulness enhances intrinsic motivation for pro-environmental behaviors, creating a cultural shift that prioritizes sustainability over short-term economic gains (Amel et al., 2017). This cultural transformation is essential for embedding

SustainAbility as an organizational ability, enabling companies to adapt to evolving environmental and societal demands.

Operationalizing ecological awareness requires structural changes that align corporate behaviors with principles of SustainAbility. Systems thinking, as outlined by Meadows (2008), provides the analytical tools necessary for understanding feedback loops and dependencies within ecological and economic systems. By applying this approach, companies can design processes that reduce waste, improve resource efficiency, and foster circular practices. However, achieving such systemic changes depends on fostering ecological awareness at the individual and collective levels. Orr (1992) emphasizes that ecological literacy - awareness coupled with actionable knowledge - is a prerequisite for meaningful behavioral change. In this sense, mindfulness-based training programs serve as a critical tool for cultivating ecological awareness among employees and decision-makers, enabling them to navigate the complexities of SustainAbility effectively.

#### **4. PRACTICAL APPLICATION OF SustainAbility**

The principles of SustainAbility extend beyond theoretical constructs, offering practical solutions to pressing challenges. By focusing on the development and application of cognitive, behavioral, and institutional abilities, SustainAbility provides a framework for implementing change across various domains. These include education, corporate practices, community engagement, and technological innovation. Each of these areas demonstrates the potential for SustainAbility to reshape how societies can translate abstract ideas into transformative action.

##### **4.1. Education and Training**

Education plays a pivotal role in SustainAbility, as it forms the foundation for cultivating the cognitive and critical thinking skills necessary for informed decision-making. Systems literacy, which involves understanding the interconnectedness of ecological, social, and economic systems, is central to this effort. Sterling (2011) highlights the importance of integrating systems thinking into educational curricula to empower students to grasp the complexity of sustainable challenges. For instance, interdisciplinary courses that combine environmental science, economics and policy analysis encourage students to approach problems holistically rather than through isolated disciplinary lenses.

Experiential learning further enhances the educational impact by engaging learners in real-world applications of SustainAbility principles. Kolb's (1984) model of experiential learning, which emphasizes the interplay between concrete experience, reflective observation, abstract conceptualization, and active experimentation, has proven effective in fostering critical thinking and systems literacy. Field-based projects, such as local ecosystem restoration or renewable energy design initiatives, exemplify how experiential learning can encourage students to address sustainability creatively and collaboratively. Additionally, SustainAbility hackathons and workshops, which bring together diverse participants to tackle environmental and social problems, provide opportunities for hands-on learning and innovation.

Education for SustainAbility is not limited to formal institutions but extends into professional training and community-based learning. Lifelong learning initiatives play a crucial role in ensuring that individuals continue to develop their abilities throughout their careers and lives.

## **4.2. Corporate Practices**

The corporate sector plays a pivotal role in advancing Sustainability, as businesses possess significant capacity to drive meaningful change by embedding Sustainability into their core strategies and operations. Rather than treating sustainability as a peripheral concern, effective approaches integrate it as a fundamental component of organizational purpose (Waddock, 2016). This strategic integration not only enhances corporate Sustainability performance but also promotes systemic change across entire industries, demonstrating the potential for businesses to lead by example.

Technological innovation is a key enabler of Sustainability within corporations. Cutting-edge tools such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) are increasingly employed to improve resource efficiency and monitor sustainability metrics. Blockchain, for instance, enhances supply chain transparency by verifying ethical sourcing practices (Geels, 2011), while AI optimizes logistics, reducing fuel consumption and associated emissions (Brynjolfsson & McAfee, 2014). Beyond operational improvements, corporations are investing heavily in renewable energy solutions like solar and wind, aligning their long-term strategies with net-zero emissions goals. These innovations not only contribute to environmental objectives but also position corporations as leaders in the transition to a sustainable economy.

Employee engagement and organizational culture are equally critical, companies can foster employee participation by offering training programs, hosting Sustainability workshops, and incentivizing eco-friendly behaviors. Examples include financial rewards for sustainable commuting practices or initiatives that encourage remote work to reduce carbon footprints (Thaler & Sunstein, 2008). Leadership plays a central role in these efforts, with sustainability officers and executive teams championing the integration of ethical principles into daily operations and corporate missions (Waddock, 2016). A culture that actively prioritizes Sustainability empowers employees to align their personal and professional values with organizational goals.

Collaboration with stakeholders further amplifies corporate efforts. Partnerships with governments, non-profits, and academic institutions can lead to shared value through co-developed green infrastructure projects or the establishment of industry-specific ethical guidelines (Meadows, 2008). Such partnerships enable corporations to pool resources and knowledge, magnifying their impact on sustainable goals.

By adopting circular economy practices companies are minimizing waste and maximizing resource efficiency. They redesign supply chains to ensure materials can be reused or recycled, thereby reducing environmental impact. (Raworth, 2017). By embracing such models, corporations not only enhance their sustainability credentials but also reduce costs and create new business opportunities.

Sustainable finance is another area where the integration of environmental, social, and governance (ESG) factors into investment decisions is becoming increasingly prevalent. (Rockström et al., 2009). By embedding ESG principles into their financial strategies, corporations not only attract socially conscious investors but also enhance their long-term profitability and resilience.

## **4.3. Community Engagement**

Communities are integral to the implementation of Sustainability, serving as both beneficiaries and agents of sustainable practices. Participatory governance models offer a powerful mechanism for aligning sustainability initiatives with community priorities. By



involving local stakeholders in decision-making processes, these models foster trust, ownership, and accountability. Ostrom (1990) has demonstrated the effectiveness of participatory governance in managing common-pool resources, such as forests and fisheries, where collaboration and shared responsibility are essential for success.

Equity and inclusivity are central to SustainAbility's approach to community engagement. Programs that focus on skill development in marginalized communities illustrate how sustainability can address social inequalities while advancing environmental goals.

Urban settings provide a unique opportunity to apply SustainAbility through community-driven initiatives. As Elmqvist et al. (2013) emphasize, integrating ecosystem services into urban planning not only enhances resilience but also fosters active community participation. Projects such as green roofs, urban agriculture and biodiversity corridors exemplify how local engagement can align with broader sustainability goals. Community-driven initiatives also highlight the importance of local adaptation strategies. Rainwater harvesting systems in arid regions or urban gardening projects in underserved neighborhoods demonstrate how localized knowledge and resources can address global challenges effectively.

#### **4.4. Technological Tools**

Technology plays a transformative role by providing tools to support the development and application of abilities across domains. Artificial intelligence (AI) is particularly impactful, offering solutions to complex challenges through data analysis and predictive modeling. For instance, AI platforms have been used to optimize renewable energy grids, balancing supply and demand in real time and reducing overall energy waste (Rockström et al., 2009). These advancements illustrate how cognitive abilities, such as systems thinking, can be enhanced through technological support. The role of technology in Sustainability extends beyond efficiency gains; it also supports the cognitive and institutional abilities required for systemic change. Brynjolfsson and McAfee (2014) argue that tools like artificial intelligence and blockchain can revolutionize Sustainability governance. For instance, AI-powered systems optimize resource use by analyzing complex datasets, while blockchain ensures transparency and accountability in supply chain management. Digital education platforms further expand access to Sustainability training, enabling individuals worldwide to develop critical abilities, offering courses on systems thinking, climate change, and sustainable business practices, reaching diverse learners and fostering a global culture of ethical behaviour. Blockchain technology also contributes to SustainAbility by enhancing transparency and accountability in supply chains, ensuring compliance with SDG's standards. (Geels, 2011).

Education, corporate practices, community engagement, and technology do not function in isolation but interact to create synergies that amplify their collective impact, reflecting the interconnected nature of SustainAbility and its systemic approach to addressing global challenges.

### **5. POLICY IMPLICATIONS OF SUSTAINABILITY**

Policy is the foundation for embedding SustainAbility principles into societal structures, guiding behavior and decision-making across multiple levels of governance. Traditional sustainable policies have often prioritized measurable outcomes, such as reducing carbon emissions or preserving natural resources. While these goals remain essential, they frequently neglect the capacities required to achieve and sustain them over time. SustainAbility addresses this oversight by focusing on the development of cognitive, behavioral, and institutional abilities as the drivers of long-term transformation. By integrating these principles into policy

design, governments and organizations can create adaptive frameworks that respond to evolving challenges and foster systemic resilience.

Addressing transboundary challenges, such as climate change and resource scarcity, requires global cooperation. The United Nations Development Programme (2020) emphasizes the need for capacity-building initiatives that equip countries with the institutional and cognitive abilities necessary for adaptive governance. These efforts align with SustainAbility's focus on fostering resilience and inclusivity across diverse contexts. Policies rooted in SustainAbility emphasize the cultivation of abilities across all levels of society. Cognitive abilities, for instance, are critical for equipping individuals with the skills necessary to understand and address the complexity of SustainAbility challenges. Governments can promote these abilities through policies that embed systems literacy and critical thinking into educational curricula. Sterling (2011) Behavioral abilities are equally important in driving sustainable practices. Policymakers can design interventions that align individual behaviors with societal goals, leveraging insights from behavioral economics to encourage pro-SustainAbility actions. For instance, economic incentives, such as subsidies for renewable energy adoption or carbon taxes, have proven effective in shaping consumer choices and reducing environmental impacts (Thaler & Sunstein, 2008; Kahneman, 2011).

Institutional abilities, which encompass the structural and systemic capacities needed to implement and sustain change, are central to SustainAbility's policy framework. Policies that strengthen institutional resilience, such as those supporting adaptive governance, enable organizations and governments to respond dynamically to emerging challenges. Levin et al. (2012) argue that adaptive governance models, which incorporate iterative learning and stakeholder participation, are essential for navigating the uncertainty inherent in sustainable transitions. These models allow policies to evolve in response to new data, ensuring their continued relevance and effectiveness.

SustainAbility also emphasizes equity in policy design, advocating for participatory governance models that include marginalized voices. Fraser (2009) critiques top-down SustainAbility frameworks for perpetuating global inequalities and calls for a reimagined political space where vulnerable communities can influence decision-making processes. By embedding equity into its principles, SustainAbility ensures that no stakeholder is excluded from the transition to SustainAbility."

## **6. CHALLENGES AND CRITICISM OF SUSTAINABILITY**

SustainAbility offers a forward-thinking framework that emphasizes abilities as the cornerstone of achieving real and long-term goals. However, its implementation is fraught with challenges that require careful examination to ensure feasibility and effectiveness. These challenges range from resistance to change, issues of equity and inclusivity, difficulties in measurement, balancing priorities, and navigating complex trade-offs. Critiques surrounding its practicality and scalability further highlight the need for adaptive and strategic responses.

One significant barrier to SustainAbility is resistance to change, which occurs at both individual and institutional levels. On an individual level, deeply entrenched habits and cognitive biases often hinder the adoption of new perspectives or behaviors. For example, present bias leads individuals to prioritize immediate benefits over long-term gains, making transitions such as moving from fossil fuels to renewable energy particularly challenging (Kahneman, 2011; Thaler & Sunstein, 2008). At an institutional level, organizations and governments often resist transformative policies due to structural rigidity and short-term priorities. Established investments in existing systems create path dependencies, particularly in sectors like energy and transportation that obstruct innovation and adaptability (Geels, 2011).

Addressing these barriers requires a combination of education and incentives. Public awareness campaigns can enhance systems literacy, fostering a deeper understanding of the interconnectedness of sustainability challenges. Meanwhile, policy tools, such as subsidies for renewable energy or tax incentives for green innovation, can align economic interests with sustainability goals, reducing institutional inertia and encouraging change.

Another challenge is the measurement of abilities, which is crucial for translating SustainAbility into actionable strategies. Traditional metrics, such as GDP growth or carbon emissions reductions, often fail to capture the dynamic and process-oriented nature of SustainAbility. Instead, assessing cognitive, behavioral, and institutional abilities requires innovative tools that go beyond static outcomes. For example, systems literacy might be evaluated through scenario-based exercises that test an individual's ability to apply complex concepts (Meadows, 2008). Behavioral shifts can be measured through changes in habits, such as energy conservation or recycling, tracked using surveys or digital tools. Institutional abilities, such as resilience and adaptability, may be assessed through governance quality reviews or disaster preparedness simulations. Advances in technology, such as artificial intelligence and blockchain, offer further opportunities to enhance measurement capabilities (Geels, 2011). AI can analyze behavioral and institutional data patterns, while blockchain ensures transparency in tracking progress. Moreover, participatory evaluation frameworks engage stakeholders directly, allowing them to provide feedback on their cognitive and behavioral development, as well as institutional practices. Despite these advances, challenges remain in balancing short-term and long-term goals. SustainAbility's emphasis on long-term processes often conflicts with the urgency of addressing immediate crises. Policymakers and organizations frequently prioritize short-term solutions, driven by political and economic pressures, which undermine sustainability initiatives and exacerbate existing challenges (Levin et al., 2012). Communicating the long-term benefits is therefore critical, whether through targeted outreach, storytelling, or emphasizing how investments in abilities can simultaneously address immediate concerns, such as job creation in renewable energy transitions (Raworth, 2017).

## 7. CONCLUSIONS

This paper has argued for SustainAbility as a paradigm shift, emphasizing the importance of developing cognitive, behavioral and institutional abilities to bridge the persistent disconnect between ambition and action in addressing global challenges. The traditional concept of sustainability, defined through static goals and outcome-focused frameworks, has often struggled to translate theoretical aspirations into lasting systemic change. Our alternative interpretation argues that SustainAbility can reframe this challenge, advocating for a dynamic and adaptive approach that prioritizes processes, capacities and inclusivity over mere end states. By conceptualizing SustainAbility, moreover, as an intrinsic ability, it expands the theoretical foundation of sustainability, emphasizing its behavioral and systemic dimensions.

At the heart of this framework lies the recognition that meaningful and enduring ethical transitions are contingent upon the integration of cognitive, behavioral, and institutional abilities.

Recognizing that transitions often exacerbate existing inequalities, participatory governance and capacity-building initiatives are critical for ensuring that all stakeholders—not only those in resource-rich or developed contexts—are empowered to contribute to and benefit from sustainability efforts. However, the realization of SustainAbility is not without its challenges: resistance to change, entrenched biases and institutional inertia represent significant barriers to the widespread adoption of this framework. Furthermore, the need to balance short-

term crises with long-term capacity-building complicates the policy landscape, requiring innovative approaches to communication, incentive structures and cross-sector collaboration.

In conclusion, SustainAbility offers a comprehensive and adaptive framework that moves beyond static goals to focus on the processes and abilities necessary for transformative change. By foregrounding cognitive, behavioral and institutional capacities, SustainAbility not only bridges the gap between intention and action but also lays the groundwork for a more resilient, equitable and inclusive future.

This framework, while ambitious, provides a critical lens through which to reimagine the pathways toward a sustainable world, aligning knowledge, practice and policy in service of enduring systemic transformation.

## REFERENCES

- Agyeman, J., Bullard, R. D., & Evans, B. (2002). Exploring the Nexus: Bringing Together SustainAbility, Environmental Justice and Equity. *Space and Polity*, 6(1), 77-90. <https://doi.org/10.1080/13562570220137907>
- Amel, E., Manning, C., Scott, B., & Koger, S. (2017). Beyond the Roots of Human Inaction: Fostering Collective Effort Toward Ecosystem Conservation. *Science*, 356(6335), 275–279. <https://doi.org/10.1126/science.aal1931>
- Bandura, A. (1977). Self-efficacy: Toward a Unifying Theory of Behavioral Change. *Psychological Review*, 84(2), 191-215. <https://doi.org/10.1037/0033-295X.84.2.191>
- Barth, M., & Michelsen, G. (2013). Learning for change: An educational contribution to sustainability science. *SustainAbility Science*, 8(1), 103–119. <https://doi.org/10.1007/s11625-012-0181-5>
- Brown, K. W., & Kasser, T. (2005). Are Psychological and Ecological Well-Being Compatible? The Role of Values, Mindfulness, and Lifestyle. *Social Indicators Research*, 74(2), 349–368. <https://doi.org/10.1007/s11205-004-8207-8>
- Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. W.W. Norton & Company.
- Carrassi, M. (2016). Can the Understanding of Economics Lead to Conscious SustainAbility? The Example of Love. In *The Contribution of Love, and Hate, to Organizational Ethics (Research in Ethical Issues in Organizations, Vol. 16, pp. 123-137)*. Emerald Group Publishing Limited. <https://doi.org/10.1108/S1529-209620160000016014>
- Deci, E. L., & Ryan, R. M. (2000). The “What” and “Why” of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry*, 11(4), 227-268. [https://doi.org/10.1207/S15327965PLI1104\\_01](https://doi.org/10.1207/S15327965PLI1104_01)
- Doni, F. (2021). *Corporate SustainAbility and Responsibility: Accounting for Society and the Environment*. Routledge.
- Elmqvist, T., et al. (2013). *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*. Springer.
- Folke, C., et al. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society*, 15(4), 20. <https://www.jstor.org/stable/26268226>
- Fraser, N. (2009). *Scales of Justice: Reimagining Political Space in a Globalizing World*. Columbia University Press.
- Geels, F. W. (2011). The Multi-Level Perspective on SustainAbility Transitions: Responses to Seven Criticisms. *Environmental Innovation and Societal Transitions*, 1(1), 24-40. <https://doi.org/10.1016/j.eist.2011.02.002>
- Kahneman, D. (2011). *Thinking, Fast and Slow*. Farrar, Straus and Giroux.

- Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Prentice-Hall.
- Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the Tragedy of Super Wicked Problems: Constraining Our Future Selves to Ameliorate Global Climate Change. *Policy Sciences*, 45(2), 123-152. <https://doi.org/10.1007/s11077-012-9151-0>
- Meadows, D. H. (2008). *Thinking in Systems: A Primer*. Chelsea Green Publishing.
- Orr, D. W. (1992). *Ecological Literacy: Education and the Transition to a Postmodern World*. SUNY Press.
- Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.
- Raworth, K. (2017). *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Chelsea Green Publishing.
- Rockström, J., et al. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society*, 14(2), 32.
- Rosenberg, E. L. (2004). Mindfulness and Consumerism. *Journal of Consumer Research*, 31(2), 285–292. <http://dx.doi.org/10.1037/10658-007>
- Sen, A. (1999). *Development as Freedom*. Oxford University Press.
- Senge, P. M. (1990). *The Fifth Discipline: The Art & Practice of The Learning Organization*. Doubleday.
- Sterling, S. (2011). Transformative Learning and SustainAbility: Sketching the Conceptual Ground. *Learning and Teaching in Higher Education*, 5, 17-33.
- Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving Decisions About Health, Wealth, and Happiness*. Yale University Press.
- Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. *Science*, 185(4157), 1124-1131.
- United Nations Development Programme (2020). *Capacity Development for Sustainable Development*.
- Waddock, S. (2016). Foundational Memes for a New Narrative About the Role of Business in Society. *Humanistic Management Journal*, 3(1), 91-105. <https://doi.org/10.1007/s41463-016-0012-4>
- Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science*, 6(2), 203–218. <https://doi.org/10.1007/s11625-011-0132-6>



## EVALUATING TRANSATLANTIC CRUISE SERVICE QUALITY: AN INTEGRATED SERVQUAL AND IPA APPROACH

**Predrag Đorđević\*, Anđelka Stojanović, Ivica Nikolić**

*University of Belgrade, Technical Faculty in Bor, Serbia*

**Abstract:** This study investigates the service quality of transatlantic cruises by applying the SERVQUAL model combined with Importance-Performance Analysis (IPA) and gap analysis. Transatlantic cruises are a unique segment within the rapidly growing cruise tourism industry, where high service quality is crucial for customer satisfaction and loyalty. Despite its importance, empirical research applying robust service quality frameworks to this specific sector is still limited. This research utilizes a quantitative survey approach using a structured SERVQUAL questionnaire. Gap analysis revealed negative gaps across all five SERVQUAL dimensions, indicating that passenger's perceptions consistently fell short of their expectations. The Responsiveness, Reliability, and Empathy dimensions showed the largest gaps highlighting critical areas for improvement. A modified IPA analysis identified specific attributes requiring immediate attention, such as service timeliness and staff responsiveness to passenger requests. Additionally, it provided strategic guidance for resource allocation according to the categorization of other quality service attributes. The findings from the integrated IPA and gap analysis reveal a consistent pattern of performance deficits across all evaluated attributes, thereby highlighting the necessity for comprehensive service quality improvements within the observed transatlantic cruise operator. This study provides valuable insights for cruise service providers seeking to improve service delivery and passenger satisfaction.

**Keywords:** Service quality, SERVQUAL, Cruise tourism, IPA, Gap analysis

### 1. INTRODUCTION

In the contemporary landscape of the global tourism industry cruise services have emerged as one of the fastest growing segments, experiencing significant transformation over recent decades. Transatlantic cruises, in particular, offer a distinctive segment within this

---

\* Corresponding author: [pdjordjevic@tfbor.bg.ac.rs](mailto:pdjordjevic@tfbor.bg.ac.rs)

Predrag Đorđević, ORCID: 0000-0002-8210-174X  
Anđelka Stojanović, ORCID: 0000-0001-7254-4646  
Ivica Nikolić, ORCID: 0000-0003-1986-4653

industry, characterized by extended voyages and a focus on providing comprehensive onboard services and amenities. As such, the evaluation of service quality in this context becomes paramount for ensuring customer satisfaction and fostering long-term loyalty. Service quality is defined as the consumer's judgment of a service's overall excellence or superiority. It is perceived quality that differs from objective quality (Yoon & Cha, 2020) and is recognized as a key determinant of business success.

Cruise tourism represents one of the fastest-growing segments within the global travel and leisure industry. Among its many subcategories, transatlantic cruises offer unique experiential value, combining long-haul travel with wide-ranging onboard services. As competition intensifies among cruise operators, maintaining high service quality has become essential for securing customer satisfaction and loyalty. Unlike traditional hospitality environments, cruise ships operate as self-contained service ecosystems where the quality of service significantly influences various stages of the passenger journey, from check-in and dining to entertainment and disembarkation (Arasli et al., 2020).

In this context, measuring and managing service quality poses distinct challenges. The SERVQUAL model, developed by Parasuraman et al. (1988), provides a structured, multidimensional framework that compares passengers' pre-travel expectations with their post-travel perceptions. This gap-based approach has been widely adopted in hospitality, health care, retail, and more recently, maritime tourism. However, empirical applications of this service quality model in cruise tourism remain still limited, particularly in the transatlantic sector. Furthermore, there is a growing need to complement SERVQUAL insights with actionable strategic tools like the Importance-Performance Analysis matrix developed by Martilla and James (1977), which helps service managers prioritize resource allocation.

This paper investigates the service quality of transatlantic cruises using the SERVQUAL model, a widely recognized framework for assessing the gap between customer expectations and perceptions of delivered service (Prasad & Verma, 2022). The goal of this research is to provide practical insights into the dynamics of service quality in the cruise industry, to assist cruise operators in improving their service delivery strategies and enhancing overall passenger satisfaction.

## **2. LITERATURE REVIEW**

The measurement of service quality in the tourism and hospitality sectors has long been a subject of academic interest. Research indicates that high service quality can lead to increased customer satisfaction, profitability, customer loyalty, retention, and a positive corporate image (Alonazi et al., 2023; Daniel & Berinyuy, 2010).

Despite the growing academic interest in the cruise sector, research regarding service quality remains relatively fragmented, primarily due to the field's multidisciplinary character and its comparatively recent emergence. Much of the existing literature has focused on business, management, and economics aspects. While quantitative studies have covered service quality, cruise attributes and perceived value, qualitative approaches have also been used to a lesser extent on topics such as branding and corporate sustainability (Yoon & Cha, 2020).

Service quality in cruise tourism encompasses multiple dimensions, including tangible elements like ship infrastructure and intangible aspects such as emotional satisfaction and interpersonal interactions with staff. In the context of cruise services, these dimensions are interpreted through both human interactions (e.g., crew professionalism, responsiveness) and environmental features (e.g., ship cleanliness, amenities). Yulianti (2020) conducted an empirical investigation of global cruise service quality and passenger loyalty, identifying tangible elements such as cabin comfort and ship facilities as primary satisfaction drivers.

These findings align with those of Mikuličić et al. (2024), who systematically reviewed maritime passenger transport and found SERVQUAL's dimensions to be especially effective when supplemented with context-specific servicescape variables.

Recent empirical studies show a growing interest in applying the SERVQUAL model to evaluate service quality in the cruise industry. It remains one of the most frequently employed instruments for such assessments due to its ability to identify gaps across five service quality dimensions: tangibles, reliability, responsiveness, assurance, and empathy (Milana, 2018; Parasuraman et al., 1988). Originally designed for service environments like banking and healthcare, this model has since been adapted to suit hospitality contexts including hotels, resorts, and cruise lines (Alonazi et al., 2023). For instance, a study conducted by Alonazi et al. (2023) assessed the impact of service quality on tourists' satisfaction and corporate image, as well as their intentions to increase their expenditures and revisit. The findings indicated that four SERVQUAL dimensions (reliability, responsiveness, assurance and empathy) significantly influenced tourist satisfaction, highlighting the model's relevance in post-COVID-19 cruise tourism recovery efforts.

However, SERVQUAL alone may not be sufficient for strategic decision-making. Integrating the assessment of service quality with strategic management tools such as the IPA matrix enables decision makers to convert diagnostic findings into actionable priorities. The IPA matrix evaluates both perceived performance and the importance of specific service attributes (Deng & Pierskalla, 2018), allowing managers to allocate resources more effectively. The synergistic application of these two methods provides a robust framework for understanding and enhancing service quality in the cruise tourism industry by identifying both the gaps in service delivery and the key areas where managerial efforts should be concentrated.

Importance-Performance Analysis is a widely used methodology to evaluate customer satisfaction by analyzing the relationship between the importance of service attributes and their actual performance. This approach has been extensively applied in various sectors, including maritime tourism and service quality (Dwyer et al., 2016; Simpson et al., 2020) to identify areas that require improvement and prioritize resources effectively.

Collectively, these studies highlight the relevance of using SERVQUAL and IPA in tandem to assess, interpret and act upon service quality data within the context of cruise tourism. However, their applications to transatlantic cruises remain scarce. This paper addresses that gap by offering a comprehensive evaluation of passenger experiences on transatlantic voyages through the integrated use of these two analytical tools.

### **3. RESEARCH METHODOLOGY**

This study adopted a quantitative survey designed to assess service quality and customer satisfaction in the cruise tourism sector. The chosen approach allowed for measuring cruise passengers' expectations and perceptions of service quality, and for assessing how these perceptions impacted their overall satisfaction.

Data were collected using a self-administered structured questionnaire on a sample of 230 respondents. Cruise passengers rated both their pre-cruise expectations and post-cruise perceptions of service quality on a 5-point Likert scale (1-5). The initial questionnaire, serving as the foundational instrument for assessing service quality, was adapted from the work of Lai (2004) and subsequently modified and validated through practical application. The questionnaire included 22 SERVQUAL items (paired expectation vs. perception) covering five RATER dimensions: Tangibles (4 items), Reliability (5 items), Responsiveness (4 items), Assurance (5 items), and Empathy/Customer Relations (4 items), consistent with the



SERVQUAL framework (Lonial et al., 2010). In addition, respondents provided demographic information (sex, age group, number of previous cruises, and education level).

The theoretical foundation for assessing service quality in this research is the widely applied SERVQUAL model, an attribute-based measurement method for service quality (Akbaba, 2006) which is measured by evaluating the gap between customer expectations of the service and their perceptions of the received service (Perception - Expectation). The model comprises five core RATER dimensions of service quality. Tangibles refer to the physical elements associated with the service environment, including the appearance of facilities, equipment and personnel. Reliability is the ability to perform the promised service dependably and accurately. Responsiveness is the willingness to help customers and provide prompt service. Assurance refers to the knowledge and courtesy of employees and their ability to inspire trust and confidence among customers. Empathy refers to the degree of personalized care and individual attention provided to customers.

The SERVQUAL model presents a conceptual framework that outlines various discrepancies affecting how customers assess service quality. Although the original formulation identified five key gaps, subsequent revisions of the model expanded this framework to encompass seven primary gaps (Daniel & Berinyuy, 2010). In this study the gap five was measured, which is considered the true measure of service quality from the customer's perspective. This gap score analysis was performed by calculating the difference between customer perception ratings and their expectation ratings (P - E). In general, a positive gap means performance exceeds expectation, whereas a negative gap indicates the service is falling short of what customers expect.

A modified Importance-Performance Analysis was conducted using mean expectation as the importance score and mean perception as the performance score for each service attribute (item). Theoretically, using expectations as a stand-in for importance in IPA should be applied cautiously, however many researchers have used SERVQUAL expectation scores as a proxy for importance, when collecting separate importance ratings was not feasible (Liestyanti & Prawiraatmadja, 2021; Tzeng & Chang, 2011).

A combination of IPA and gap analysis helps provide more information on the differences between importance (sometimes represented by expectations) and performance (sometimes represented by satisfaction) to examine service quality (Choi et al., 2018). While IPA provides a visual analysis of importance and performance on a grid, gap analysis specifically focuses on the numerical difference between the two. The combination helps to provide more information on these differences after conducting an IPA. The results are typically visualized on a two-dimensional grid, commonly divided into four distinct quadrants: "Keep up the good work" (high importance, high performance), "Potential overkill" (low importance, high performance), "Low priority" (low importance, low performance), and "Concentrate here" (high importance, low performance) (Deng & Pierskalla, 2018; Zhang & Chow, 2004).

This framework serves as a diagnostic tool, facilitating the identification of attributes where a product or service is underperforming or overperforming in achieving its objectives. Statistical analysis was performed using a specialized statistical package SPSS.

## **4. RESULTS AND DISCUSSION**

### **4.1. Descriptive statistics**

Table 1 presents the demographics of the respondents. Slightly more respondents were female (51.7%) than male (48.3%). The age distribution was skewed toward older passengers:

only 2.6% were aged 18-25, while the largest groups were ages 45-55 (39.6%) and 55 and above (37.4%). Most respondents were relatively experienced cruisers: 42.6% had taken three or more cruises previously. The majority had higher education (81.7% with a bachelor's degree or higher). In summary, the sample consisted mainly of well-educated older adults who are mostly seasoned cruise customers.

*Table 1. Demographic characteristics of respondents (N = 230)*

Variable	Category	Frequency	Percentage (%)
Sex	Male	111	48.3%
	Female	119	51.7%
Age (years)	18-25	6	2.6%
	25-35	11	4.8%
	35-45	36	15.7%
	45-55	91	39.6%
	55+	86	37.4%
Number of Cruises (prior trips)	1	52	22.6%
	2	80	34.8%
	≥ 3	98	42.6%
Education Level	Primary school	6	2.6%
	High school	36	15.7%
	Junior college	95	41.3%
	Graduate degree	93	40.4%

#### 4.2. SERVQUAL Analysis

The SERVQUAL gap (perception minus expectation) was calculated for each RATER dimension as the mean of perception items minus the mean of expectation items. In cruise tourism, tangibles include the design and upkeep of the vessel, the cleanliness and comfort of cabins and public spaces, staff presentation (e.g., uniforms and grooming), and the quality of printed or digital information provided to guests. Reliability is demonstrated by adherence to schedules (e.g., embarkation, excursions), the accuracy of reservations and billing, and the consistency of service delivery across different departments on board. Responsiveness takes into account how quickly and efficiently crew members respond to guest inquiries, requests, or complaints, and their readiness to provide assistance throughout the voyage. In the cruise setting, assurance is reflected in staff competence, multilingual communication skills, visible safety procedures and the demeanor of crew members who interact directly with passengers. On a cruise ship empathy can be seen in how staff accommodate dietary or accessibility needs,

remember guests' names, offer tailored recommendations, or demonstrate cultural sensitivity during service interactions.

Based on the statistical analysis, mean gaps were negative and statistically significant in all five dimensions (Tangibles, Assurance, Reliability, Responsiveness, Empathy), indicating that customer perceptions fell short of expectations (Table 2). For example, the Tangibles dimension had a mean expectation of 4.55 (SD = 0.50) and a mean perception of 3.60 (SD = 0.66), yielding a mean gap of -0.95 (SD = 0.56,  $t(229) = -25.83$ ,  $p < 0.001$ ). Similarly, all other dimensions showed large negative gaps (-0.90 to -1.14) with  $p < 0.001$ . These negative gap scores conform to Parasuraman's service-quality gap model, where a negative gap (perceived quality is less than expected quality) signifies service underperformances. In practical terms, cruise passengers rated all aspects of service below their high expectations, suggesting systemic quality deficiencies across RATER dimensions.

*Table 2. Mean expectation and perception scores by dimension*

Dimension	Mean Expectation (SD)	Mean Perception (SD)	Gap ( $\bar{P} - \bar{E}$ )	Paired $t$ -test	Sig
Tangibles	4.55 (0.50)	3.60 (0.66)	-0.95	-25.83	*
Assurance	4.67 (0.50)	3.77 (0.57)	-0.90	-26.30	*
Reliability	4.65 (0.45)	3.52 (0.43)	-1.13	-39.69	*
Responsiveness	4.65 (0.62)	3.51 (0.74)	-1.14	-22.68	*
Empathy	4.77 (0.56)	3.68 (0.58)	-1.09	-28.20	*

*Note: \*All gaps are significantly different from zero at  $p < 0.001$*

These results indicate that customers' expectations consistently exceeded their experiences in every dimension. From a managerial standpoint, this consistent deficiency in service quality highlights a critical need for targeted strategic improvements in service delivery processes. In particular, dimensions with the largest gaps (Responsiveness, Reliability and Empathy) represent areas of greatest concern. These findings are consistent with the SERVQUAL framework, wherein negative gap scores indicate that the service delivery is falling to satisfy standards anticipated by customers (Daniel & Berinyuy, 2010). The statistically significant gaps (all  $p < 0.001$ ) confirm that these discrepancies are unlikely due to chance.

#### **4.3. Modified Importance-Performance Analysis (IPA) and gap analysis**

The analysis followed standard procedures for Importance-Performance Analysis and gap analysis of service attributes. The provided dataset was prepared based on the mean Importance (expectation) and Performance (perception) ratings for each of 22 items. First, the gap was calculated for each item. Paired-sample  $t$ -tests (two-tailed) were conducted for each attribute to assess whether the mean gap differed significantly from zero (Table 3). An attribute with a negative gap indicates performance below expectation, which typically results in decreased customer satisfaction based on disconfirmation paradigm (Deng & Pierskalla, 2018).

Table 3. Gap analysis for quality service attributes

Ranking	Attributes	Importance	Performance	Gap	t-value	Sig
1	RES3	4.78	3.34	-1.44	14.4	*
2	REL2	4.79	3.40	-1.39	13.9	*
3	ASR4	4.87	3.61	-1.26	12.6	*
4	RES1	4.77	3.52	-1.25	12.5	*
5	CRE2	4.79	3.55	-1.24	12.4	*
6	RES4	4.76	3.53	-1.23	12.3	*
7	REL3	4.55	3.36	-1.19	11.9	*
8	CRE3	4.87	3.69	-1.18	11.8	*
9	TAN4	4.79	3.62	-1.17	11.7	*
10	REL1	4.77	3.60	-1.17	11.7	*
11	TAN3	4.66	3.50	-1.16	11.6	*
12	CRE4	4.76	3.70	-1.06	10.6	*
13	REL5	4.70	3.66	-1.04	10.4	*
14	ASR3	4.81	3.85	-0.96	9.6	*
15	REL4	4.45	3.59	-0.86	8.6	*
16	CRE1	4.63	3.78	-0.85	8.5	*
17	ASR2	4.81	3.98	-0.83	8.3	*
18	TAN1	4.53	3.78	-0.75	7.5	*
19	ASR5	4.45	3.72	-0.73	7.3	*
20	TAN2	4.21	3.51	-0.70	7.0	*
21	ASR1	4.40	3.71	-0.69	6.9	*
22	RES2	4.28	3.66	-0.62	6.2	*

Note: \*All gaps are significantly different from zero at  $p < 0.001$

In this analysis, item abbreviations were used to represent the five service quality dimensions. Tangibles (TAN1-TAN4) refer to physical facilities and appearance. Assurance (ASR1-ASR5) measures staff competence and trustworthiness. Reliability (REL1-REL5) assesses consistency and accuracy in service delivery. Responsiveness (RES1-RES4) covers promptness and willingness to help passengers. Customer Relations (CRE1-CRE4), also associated with Empathy, reflects personalized attention and care for passengers. These abbreviations will be used to streamline discussion across tables, figures, and analysis.

Next, the IPA matrix was constructed by plotting each item's mean importance on the vertical axis and mean performance on the horizontal axis (Figure 1). Crosshairs were placed at the grand mean of importance (4.66) and performance (3.62) scores, thus dividing the plot into four quadrants. Finally, a combined IPA - gap analysis was performed by adding a 45° iso-priority diagonal line through the origin ( $P = I$ ). Points above this line have performance exceeding importance (positive disconfirmation), while points below have performance below importance (negative disconfirmation). This diagonal line thus visually highlights the magnitude and direction of each gap alongside the quadrant placement (Boley et al., 2017).

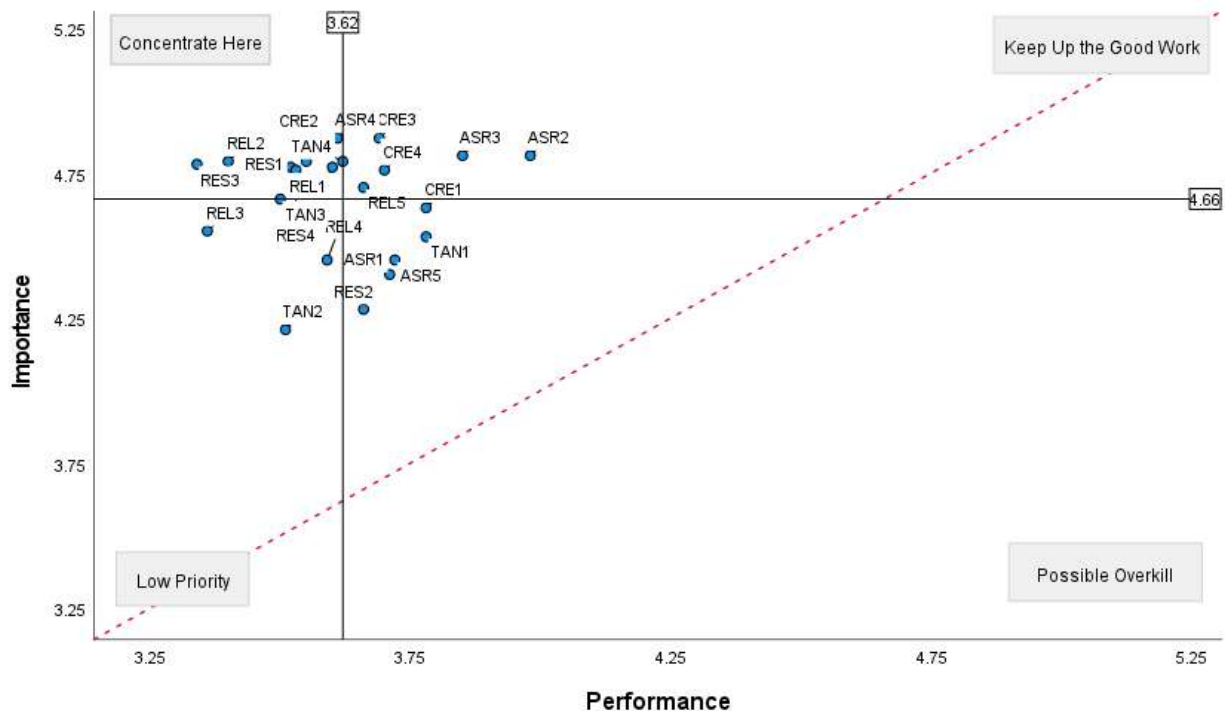


Figure 1. Combined gap analysis and IPA

The results of the Importance-Performance Analysis revealed how passengers rated each of the 22 service quality items based on their position within one of the four IPA quadrants. Their placement identifies key areas for improvement, strengths to maintain, and potential resource reallocation.

Concentrate Here (High Importance, Low Performance) items exhibit both exceptionally high expectation and pronounced underperformance, demanding immediate action. For example, REL2 (Services provided at promised time, events start without delay) showed a gap of -1.39, and RES3 (Employees react quickly in handling requests/complaints) had the largest gap at -1.44. Similarly, ASR4, RES1, RES4 and CRE2 all fall here. These reflect critical deficiencies in reliability (timeliness) and responsiveness (prompt assistance). Their combination of critical importance to passengers and substantial performance shortfalls indicates these are the service dimensions most urgently in need of process improvements, additional training, or resource allocation.

Keep Up the Good Work (High Importance, High Performance) attributes meet passenger expectations and reflect organizational strengths. For instance, ASR2 (Staff members are competent in performing their duties) and ASR3 both achieved high performance, with smaller gaps (-0.83 and -0.96, respectively). Equally, CRE3 (Staff members show sympathy and are reassuring when problems occur), CRE4 and TAN1 (A modern fleet of ships is maintained) occupy this quadrant. These items represent core competencies of the staff. Management should continue investing in staff training and safety communication to sustain these positive perceptions.

Possible Overkill (Low Importance, High Performance). Here, resources may be reallocated without harming satisfaction as these attributes exceed passenger expectations but are not highly valued. ASR5, TAN2 (Attractive ambience and decor), ASR1, RES2 (Employees promptly inform passengers of service/event timings), and TAN1 are plotted here with modest gaps (-0.62 to -0.75). While maintaining acceptable levels is important, some

effort currently devoted to these areas could be shifted toward the Concentrate Here attributes to close more impactful service gaps.

Low Priority (Low Importance, Low Performance) quadrant includes service aspects that passengers rate as less critical and where performance is also lower. Examples include TAN4 (Brochures, menus, and price lists are visually appealing and easy to understand), CRE1 (Employees give individual attention to passengers' specific needs), as well as TAN3. Although these items underperform, their lower importance suggests that immediate strategic focus elsewhere will yield greater returns. Basic standards should be maintained, but significant new investments are not recommended here.

According to Choi et al. (2018), while traditional IPA is effective, it has limitations in strategic analysis. Introducing the concept of a service quality gap model is a way to correct or enhance the traditional IPA model. Using the IPA grid along with the gap analysis's iso-rating line provides multidimensional information that aids in improving the precision of resource distribution strategy. The 45° iso-rating or iso-priority line in Figure 1 serves as a visual indicator for gap analysis, separating the graph into two areas based on the relationship between importance and performance (Deng & Pierskalla, 2018). Based on the Figure 1, all of the service quality items are positioned above the line which is consistent with findings from some previous studies (Boley et al., 2017; Choi et al., 2018). Quality attributes plotted above this line indicate situations where importance exceeds performance. These are considered negative gap points. According to the sources, this pattern indicates that management attention is required for all measured attributes because performance fails to meet importance.

## 5. CONCLUSION

This study evaluated the service quality of transatlantic cruises using an integrated model incorporating SERVQUAL, gap analysis and Importance-Performance Analysis. The results demonstrate a consistent pattern of service quality underperformances on all five SERVQUAL dimensions (Tangibles, Reliability, Responsiveness, Assurance, and Empathy), as evidenced by negative gaps between passenger expectations and perceptions. Passengers expected a greater level of service quality than what they experienced on board.

The gap analysis highlighted Responsiveness, Reliability and Empathy as the dimensions with the most substantial deficiencies, indicating where the highest managerial attention is needed. In practical terms, this means that passengers are often faced with delays or unfulfilled promises and slower-than-expected service, which can undermine satisfaction and loyalty. The subsequent IPA, enhanced by incorporating the gap analysis perspective, provided more granular insights for strategic decision-making. Attributes falling into the "Concentrate here" quadrant, such as the timeliness of service delivery and the promptness of staff response to requests, demand immediate corrective action due to their high importance and low performance ratings. Conversely, attributes in the "Keep up the good work" quadrant, like staff competence and reassurance, represent existing strengths that should be maintained and leveraged. Areas identified as "Possible overkill" and "Low priority" suggest opportunities for potential resource reallocation toward more critical service aspects.

The consistent positioning of all service attributes above the iso-priority line in the combined IPA-gap analysis underscores that, from the passengers' perspective, performance lags behind importance across the board. This indicates the necessity for comprehensive improvement efforts.

In conclusion, this study contributes to the limited body of research on service quality, specifically within the transatlantic cruise segment. By synergistically applying SERVQUAL and IPA, it offers actionable insights for cruise operators. Addressing the identified gaps,

particularly in responsiveness and reliability, is of the utmost importance for enhancing passenger satisfaction, fostering loyalty and maintaining competitiveness in this market, which is experiencing significant expansion. Future efforts should focus on implementing identified targeted strategies to close these service quality gaps and continuously monitor passenger perceptions to ensure sustained service excellence.

## ACKNOWLEDGMENT

The research presented in this paper was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the funding of scientific and research work at the University of Belgrade, Technical Faculty in Bor, according to contract with registration number 451-03-137/2025-03/ 200131.

## REFERENCES

- Akbaba, A. (2006). Measuring service quality in the hotel industry: A study in a business hotel in Turkey. *International Journal of Hospitality Management*, 25(2), 170–192. <https://doi.org/10.1016/j.ijhm.2005.08.006>
- Alonazi, B. S., Hassan, T. H., Abdelmoaty, M. A., Salem, A. E., Saleh, M. I., Helal, M. Y.,...Aleedan, M. H. (2023). Tourist behavior in the cruise industry post-covid-19: An examination of service quality, corporate image, and intentions to pay and revisit. *Sustainability*, 15(11), 8623. <https://doi.org/10.3390/su15118623>
- Arasli, H., Saydam, M. B., & Kilic, H. (2020). Cruise travelers' service perceptions: a critical content analysis. *Sustainability*, 12(17), 6702. <https://doi.org/10.3390/su12176702>
- Boley, B. B., McGehee, N. G., & Hammett, A. T. (2017). Importance-performance analysis (IPA) of sustainable tourism initiatives: The resident perspective. *Tourism Management*, 58, 66–77. <http://dx.doi.org/10.1016/j.tourman.2016.10.002>
- Choi, H., Ann, S., Lee, K.-W., & Park, D. (2018). Measuring Service Quality of Rural Accommodations. *Sustainability*, 10, 443. <http://dx.doi.org/10.3390/su10020443>
- Daniel, C. N., & Berinyuy, L. P. (2010). *Using the SERVQUAL model to assess service quality and customer satisfaction* Umea University. Umea School of Business.
- Deng, J., & Pierskalla, C. D. (2018). Linking importance-performance analysis, satisfaction, and loyalty: A study of Savannah, GA. *Sustainability*, 10(3), 704. <https://doi.org/10.3390/su10030704>
- Dwyer, L., Armenski, T., Cvelbar, L. K., Dragičević, V., & Mihalic, T. (2016). Modified Importance-performance analysis for evaluating tourism businesses strategies: comparison of Slovenia and Serbia. *International Journal of Tourism Research*, 18(4), 327–340. <https://doi.org/10.1002/jtr.2052>
- Lai, T. L. (2004). Service quality and perceived value's impact on satisfaction, intention and usage of short message service (SMS). *Information Systems Frontiers*, 6, 353–368. <https://doi.org/10.1023/B:ISFI.0000046377.32617.3d>
- Liestyanti, A., & Prawiraatmadja, W. (2021). Service quality in the public service: A combination of SERVQUAL and importance-performance analysis. *Journal of International Conference Proceedings*, 4(3), 320–331. <https://doi.org/10.32535/jicp.v4i3.1323>
- Lonial, S., Menezes, D., Tarim, M., Tatoglu, E., & Zaim, S. (2010). An evaluation of SERVQUAL and patient loyalty in an emerging country context. *Total Quality Management*, 21(8), 813–827. <https://doi.org/10.1080/14783363.2010.487663>

- Martilla, J. A., & James, J. C. (1977). Importance-Performance Analysis. *Journal of Marketing*, 41(1), 77–79. <https://doi.org/10.2307/1250495>
- Mikulčić, J. Ž., Kolanović, I., Jugović, A., & Brnos, D. (2024). Evaluation of Service Quality in Passenger Transport with a Focus on Liner Maritime Passenger Transport-A Systematic Review. *Sustainability*, 16(3), 1125. <https://doi.org/10.3390/su16031125>
- Milana, E. (2018). Impact of job satisfaction on public service quality: Evidence from Syria. *Serbian Journal of Management*, 13(2), 233–250. <https://doi.org/10.5937/sjm13-14734>
- Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: a multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, 64(1), 12–40. [https://doi.org/10.1016/S0022-4359\(88\)90026-6](https://doi.org/10.1016/S0022-4359(88)90026-6)
- Prasad, R. K., & Verma, S. (2022). Service quality measures: systematic literature review and future research directions. *International Journal of Management Practice*, 15(1), 9–23. <http://dx.doi.org/10.1504/IJMP.2022.10043388>
- Simpson, G. D., Patroni, J., Teo, A. C., Chan, J. K., & Newsome, D. (2020). Importance-performance analysis to inform visitor management at marine wildlife tourism destinations. *Journal of Tourism Futures*, 6(2), 165–180. <https://doi.org/10.1108/JTF-11-2018-0067>
- Tzeng, G.-H., & Chang, H.-F. (2011). Applying Importance-Performance Analysis as a Service Quality Measure in Food Service Industry. *Journal of technology management & innovation*, 6, 106–115. <http://dx.doi.org/10.4067/S0718-27242011000300008>
- Yoon, Y., & Cha, K. C. (2020). A qualitative review of cruise service quality: case studies from Asia. *Sustainability*, 12(19), 8073. <https://doi.org/10.3390/su12198073>
- Yulianti, I. (2020). *An empirical examination of passenger loyalty and its antecedents in the global cruise industry* [A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy, Lincoln University]. <https://hdl.handle.net/10182/14229>
- Zhang, H. Q., & Chow, I. (2004). Application of importance-performance model in tour guides' performance: evidence from mainland Chinese outbound visitors in Hong Kong. *Tourism Management*, 25(1), 81–91. [https://doi.org/10.1016/S0261-5177\(03\)00064-5](https://doi.org/10.1016/S0261-5177(03)00064-5)





## APPLYING DIFFERENTIATION IN BUSINESS ENGLISH EFL CLASSROOMS: A STRATEGIC APPROACH TO ENHANCING LANGUAGE ACQUISITION AND PROFESSIONAL READINESS

Slavica Stevanović \*, Sandra Vasković

*University of Belgrade, Technical Faculty in Bor, Serbia*

**Abstract:** In the diverse and dynamic context of English as a Foreign Language (EFL) instruction, particularly in Business English courses at the university level, differentiation stands out as a critical strategic management principle. By tailoring teaching strategies to accommodate varied learner needs, differentiation enhances language acquisition, fosters engagement, and prepares students for professional success in global business environments. This article explores the theoretical foundations, practical applications, and strategic benefits of differentiation in Business English EFL classrooms, with a focus on customizing content, processes, and assessments to address diverse proficiency levels, cultural backgrounds, and career aspirations. A proposed case study illustrates how differentiation can be implemented in a future Business English course, offering a model for educators to optimize learning outcomes and align with industry demands.

**Keywords:** Differentiation, EFL classroom, strategic approach, professional readiness.

### 1. INTRODUCTION

Business English, a specialized branch of EFL, equips university students with the linguistic and professional competencies required for global workplaces, including skills in writing reports, negotiating contracts, and delivering presentations. However, EFL classrooms are inherently diverse, with students varying in language proficiency, learning styles, cultural perspectives, and career goals. The strategic management principle of differentiation—adapting strategies to deliver unique value (Porter, 1985)—is ideally suited to address this diversity. In education, differentiation involves customizing content (what students learn), process (how they learn), and product (how they demonstrate learning) to meet individual needs (Tomlinson, 2014). This article examines how differentiation can transform Business English EFL

---

\* Corresponding author: [sstevanovic@tfbor.bg.ac.rs](mailto:sstevanovic@tfbor.bg.ac.rs)

Slavica Stevanović, ORCID: 0000-0001-7026-0412  
Sandra Vasković, ORCID: 0000-0002-1624-841X

classrooms into inclusive, engaging, and career-focused learning environments, proposing a case study to demonstrate its practical application in a future course.

## **2. THEORETICAL FRAMEWORK**

Differentiation is grounded in educational and strategic theories that emphasize individualized value creation. Vygotsky's Zone of Proximal Development (ZPD) posits that learning is most effective when tasks are slightly beyond a learner's current ability but achievable with tailored support (Vygotsky, 1978). In EFL, this translates to scaffolding techniques like sentence starters or peer collaboration, adjusted to individual proficiency levels. Gardner's theory of multiple intelligences (1983) further supports differentiation by recognizing diverse learner strengths (e.g., linguistic, visual-spatial, interpersonal), which can be leveraged in Business English tasks such as role-plays or visual presentations. From a strategic perspective, differentiation aligns with Porter's competitive advantage framework, where unique value delivery—here, customized learning experiences—ensures superior outcomes (Porter, 1985).

Empirical research validates differentiation's efficacy in EFL settings. Richards and Rodgers (2014) argue that learner-centered approaches, including differentiation, enhance motivation and engagement by addressing individual needs. Alavinia and Farhady (2012) found that differentiated instruction in EFL classrooms improved vocabulary acquisition and oral fluency, particularly in mixed-ability groups. Additionally, a study by Santangelo and Tomlinson (2012) demonstrated that differentiation fosters self-efficacy, critical for language learners navigating complex professional tasks. These findings underscore differentiation's potential to bridge proficiency gaps and prepare students for industry demands.

### **2.1. Strategic Importance of Differentiation in Business English**

Business English courses are uniquely positioned to benefit from differentiation due to their focus on practical, profession-oriented skills. Students must master diverse competencies, from drafting emails to conducting cross-cultural negotiations, often under time constraints. Differentiation ensures these skills are taught in ways that resonate with learners' abilities and aspirations, maximizing engagement and retention. For example, a student aiming for a logistics role may prioritize supply chain terminology, while another targeting marketing may focus on persuasive communication. By aligning content with career goals, differentiation enhances relevance and motivation.

Moreover, differentiation supports cross-cultural competence, a critical skill in global business. EFL classrooms often include students from varied cultural backgrounds, and Business English tasks like negotiations or presentations require sensitivity to cultural norms (e.g., indirect communication in Asian business contexts). Differentiation allows instructors to incorporate culturally relevant scenarios, preparing students for real-world interactions. This strategic alignment with industry needs positions differentiation as a cornerstone of effective Business English instruction.

### **2.2. Applying Differentiation in Business English EFL Classrooms**

Implementing differentiation requires intentional planning across three dimensions: content, process, and product. Below are expanded strategies, informed by the theoretical and empirical foundations, to guide educators in Business English EFL settings:

- **Content Differentiation:**
  - o **Tiered Materials:** Provide resources at varying complexity levels to match proficiency. For instance, beginners might use simplified business emails, while advanced learners analyze authentic financial reports or TED Talks on leadership. This ensures all students engage with meaningful content within their ZPD.
  - o **Career Relevance:** Tailor topics to students' professional goals. For industrial management students, content might focus on supply chain logistics, while marketing majors explore branding strategies. Incorporating industry-specific case studies (e.g., a negotiation with a multinational supplier) enhances applicability.
  - o **Cultural Integration:** Embed culturally relevant scenarios to reflect students' contexts or target markets. For example, a negotiation task might contrast direct Western communication with relationship-focused Asian approaches, fostering cultural awareness.
- **Process Differentiation:**
  - o **Flexible Grouping:** Alternate between homogeneous (same proficiency) and heterogeneous (mixed proficiency) groups. Homogeneous groups allow targeted instruction, such as vocabulary drills for beginners, while heterogeneous groups promote peer learning, with advanced students modeling fluency.
  - o **Scaffolding Techniques:** Provide structured support like sentence starters for writing tasks or role-play scripts for oral practice, gradually reducing assistance as students gain confidence. Advanced learners can tackle open-ended tasks, such as designing a marketing pitch.
  - o **Active Learning:** Incorporate varied activities—think-pair-share, simulations, or debates—to cater to different learning styles (visual, auditory, kinesthetic). For example, visual learners might analyze infographics, while kinesthetic learners participate in role-plays.
- **Product Differentiation:**
  - o **Varied Assessments:** Offer multiple ways to demonstrate learning, such as written reports, oral presentations, or video pitches. This accommodates diverse strengths and builds confidence. For instance, a shy student might prefer a written proposal, while an outgoing student opts for a presentation.
  - o **Individualized Goals:** Set personalized objectives, such as mastering 20 business terms for a beginner or improving pronunciation for an advanced learner. This fosters ownership and measurable progress.
  - o **Authentic Outputs:** Design assessments that mirror workplace tasks, such as drafting a contract or presenting a business plan, to bridge classroom learning and professional demands.
- **Technology Integration:**
  - o **Digital Tools:** Use language apps (e.g., Duolingo for Business) for vocabulary practice or virtual platforms (e.g., Microsoft Teams) for simulated negotiations, catering to tech-savvy learners and replicating remote work environments.
  - o **Interactive Platforms:** Tools like Kahoot or Padlet enable collaborative learning, with quizzes or discussion boards tailored to proficiency levels. For example, beginners might match terms to definitions, while advanced students create sentences.

- **Data-Driven Insights:** Leverage learning management systems to track progress and adjust instruction, ensuring differentiation remains responsive to student needs.
- **Teacher Role and Professional Development:**
  - **Facilitator Mindset:** Teachers act as facilitators, diagnosing learner needs through formative assessments (e.g., quizzes, observations) and adapting strategies dynamically.
  - **Training Needs:** Effective differentiation requires skills in curriculum design and cultural competence. Universities should invest in workshops on differentiated instruction and industry trends to equip instructors.

### 2.3. Benefits and Challenges

Differentiation offers significant benefits for Business English EFL classrooms:

- **Enhanced Engagement:** By addressing individual needs, differentiation boosts motivation and reduces disengagement, particularly for lower-proficiency learners.
- **Improved Outcomes:** Tailored instruction accelerates language acquisition, as evidenced by studies showing gains in vocabulary and fluency (Alavinia & Farhady, 2012).
- **Professional Readiness:** Career-focused content and authentic tasks prepare students for workplace demands, from cross-cultural communication to technical writing.
- **Inclusivity:** Differentiation ensures all learners, regardless of proficiency or background, feel valued and supported, fostering a positive classroom culture.

Challenges include:

- **Time Intensity:** Designing tiered materials and assessments requires significant planning, particularly for large classes.
- **Teacher Expertise:** Instructors may need training to implement differentiation effectively, especially in integrating technology or cultural elements.
- **Resource Constraints:** Limited access to authentic materials or digital tools can hinder implementation, particularly in under-resourced institutions.

To address these, universities can provide professional development, create shared resource banks (e.g., case study templates), and invest in affordable technologies like open-source platforms.

## 3. PROPOSED CASE STUDY: DIFFERENTIATION IN A BUSINESS ENGLISH COURSE FOR ENGINEERING MANAGEMENT STUDENTS

### 3.1. Context

This case study is designed for a future Business English course at the Technical Faculty in Bor, tailored for Engineering Management students at CEFR levels B1 to B2. The course prepares students for careers in Bor's copper industry, particularly with Serbia Zijin Copper, a subsidiary of China's Zijin Mining Group. Students are expected to collaborate with Chinese professionals in roles such as supply chain management, project coordination, or operations, requiring proficiency in industry-specific English and cross-cultural communication skills.

### 3.2. Objective

To implement a differentiated instructional unit titled “Drafting and Presenting a Project Proposal for Serbia Zijin Copper” that enhances student engagement, addresses varying proficiency levels, and aligns with career aspirations in engineering management. The unit leverages differentiation strategies to ensure inclusivity and practical relevance for future industry roles.

### 3.3. Differentiation Plan

#### - Content

- **Materials:** The unit focuses on preparing a project proposal for upgrading equipment at Serbia Zijin Copper’s Veliki Krivelj mine. B1 students receive a 1-page case study with simplified terminology (e.g., “equipment cost,” “project timeline”) and a glossary of 15 key terms. B2 students work with a 2-page case study incorporating advanced vocabulary (e.g., “capital expenditure,” “operational efficiency”) and insights into Chinese business practices, such as prioritizing long-term partnerships.
- **Career Relevance:** Content is tailored to engineering management roles, emphasizing project planning, budgeting, and technical communication. The case study includes real-world scenarios, such as proposing a conveyor system upgrade, to mirror workplace tasks.
- **Cultural Relevance:** The materials highlight Serbia-China business dynamics, such as Serbia’s focus on cost-effective solutions and Zijin’s emphasis on relationship-building, using excerpts from Zijin’s project management guidelines.

#### - Process

- **Grouping:** The unit begins with mixed-proficiency groups for brainstorming project ideas, and encouraging peer learning. Later, proficiency-based groups focus on targeted tasks: B1 students practice structured proposal outlines, while B2 students develop detailed proposals incorporating technical and cultural considerations.
- **Scaffolding:** B1 students receive templates for proposal sections (e.g., budget summary) and flashcards for technical terms. B2 students are guided to use formal, diplomatic language (e.g., “We propose a mutually beneficial solution”) to reflect Chinese business etiquette.
- **Technology:** Kahoot hosts vocabulary quizzes (basic for B1, advanced for B2), and Microsoft Teams simulates virtual project meetings, replicating Zijin’s remote collaboration practices. Interactive tools like Padlet allow students to share proposal drafts for peer feedback.

#### - Product

- **Assessments:** B1 students submit a 250-word written project proposal summary, using a provided template. B2 students deliver a 5-minute oral presentation pitching their proposal to Zijin’s management, addressing technical specifications and cultural factors.
- **Individualized Goals:** B1 students aim to master 15 technical terms, while B2 students focus on improving clarity and professionalism in spoken English.
- **Authentic Outputs:** Assessments mirror workplace tasks, such as drafting proposals or presenting to stakeholders, to bridge academic learning with professional demands.

### 3.4. Implementation Plan

The unit spans three 90-minute sessions:

- **Session 1:** Introduce the case study, build vocabulary through Kahoot quizzes, and brainstorm proposal ideas in mixed-proficiency groups.
- **Session 2:** Conduct proficiency-based tasks, including drafting proposal sections and practicing presentations, with a mock project meeting on Teams.
- **Session 3:** Host a final virtual presentation session and collect assessments (written summaries or oral pitches).

### 3.5. Expected Outcomes

- **Engagement:** Students are expected to show increased motivation, with B1 learners gaining confidence in technical writing and B2 learners appreciating the challenge of professional presentations.
- **Skill Development:** B1 students should improve technical vocabulary recognition by 20-25%, while B2 students enhance fluency and cross-cultural communication skills.
- **Professional Readiness:** The unit prepares students for interactions with Zijin, equipping them with skills for drafting proposals and presenting to international stakeholders.
- **Teacher Insights:** The instructor will assess the effectiveness of differentiation, noting areas for improvement, such as simplifying templates or expanding cultural content.

## 4. DISCUSSION POTENTIAL

The case study will be used to facilitate classroom discussions on how differentiated materials, grouping strategies, and assessments impacted learning. Students will reflect on how these approaches prepare them for engineering management roles with Serbia Zijin Copper, fostering awareness of their professional development.

### 4.1. Strategic Implications for Universities

The proposed case study highlights differentiation's role in aligning Business English instruction with industry needs. Universities can adopt this approach by:

- **Curriculum Design:** Integrate differentiation into EFL programs, emphasizing career-focused content and cross-cultural skills.
- **Faculty Development:** Offer training on differentiation, focusing on practical tools like tiered assessments and technology integration.
- **Industry Partnerships:** Collaborate with local employers (e.g., Zijin) to develop authentic case studies, ensuring relevance and employability.
- **Technology Investment:** Provide access to platforms like Teams or Kahoot to support interactive, differentiated learning.

By embedding differentiation, universities can position their Business English programs as strategic assets, producing graduates who are linguistically proficient and professionally competitive.

## 5. CONCLUSION

Differentiation is a transformative strategic tool for Business English EFL classrooms, enabling educators to address diverse learner needs while fostering professional competence. By customizing content, processes, and assessments, instructors can create engaging, inclusive environments that prepare students for global business contexts. The proposed case study for Technical Faculty in Bor illustrates how differentiation can be applied to a specific industry context, equipping students for careers with Serbia Zijin Copper. Universities should invest in teacher training, resource development, and industry partnerships to maximize differentiation's impact, ensuring EFL programs deliver unique value in an increasingly competitive educational landscape.

## REFERENCES

- Alavinia, P., & Farhady, S. (2012). Using differentiated instruction to teach vocabulary in mixed-ability classes. *Journal of Language Teaching and Research*, 3(4), 689-696.
- Gardner, H. (1983). *Frames of Mind: The Theory of Multiple Intelligences*. Basic Books.
- Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*. Free Press.
- Richards, J. C., & Rodgers, T. S. (2014). *Approaches and Methods in Language Teaching* (3rd ed.). Cambridge University Press.
- Santangelo, T., & Tomlinson, C. A. (2012). Teacher educators' perceptions and use of differentiated instruction practices. *Action in Teacher Education*, 34(4), 309-327. <https://doi.org/10.1080/01626620.2012.717032>
- Tomlinson, C. A. (2014). *The Differentiated Classroom: Responding to the Needs of All Learners* (2nd ed.). ASCD.
- Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.



## DIGITALIZATION THROUGH E-INVOICES IN MICRO AND SMALL ENTERPRISES – CROATIAN EXPERIENCES

Ivana Miklošević \*

*University of Slavonski Brod, Department of Social Sciences and Humanities, Croatia*

**Abstract:** The aim of this paper is to investigate practical experiences of micro and small entrepreneurs in the Republic of Croatia regarding the digitalization process, with a special emphasis on the implementation of e-invoices in their business operations. Qualitative methods were used within the scientific research conducted, specifically semi-structured interviews with 15 micro and small entrepreneurs operating in various sectors (trade, services, manufacturing, and construction). The scientific contribution of this paper lies in the exploration of both positive and negative aspects encountered by micro and small enterprises through the implementation of electronic invoices. Furthermore, the study identifies obstacles faced by entrepreneurs during their adaptation to new digital requirements in doing business with the public sector, as well as the level of institutional support provided. Results indicate uneven readiness for change among entrepreneurs from different sectors, with information scarcity and limited capacities identified as primary challenges. On the other hand, positive developments were observed in terms of business efficiency and administrative burden reduction for enterprises and their employees. This paper contributes to a better understanding of the real needs of micro and small entrepreneurs in adapting their business to digital transformation, and may serve as a basis for shaping support measures to facilitate their digital transition.

**Keywords:** Digitalization, e-invoices, micro and small enterprises, Republic of Croatia.

### 1. INTRODUCTION

In contemporary business, one of the key competitiveness factors for micro and small enterprises is their adaptation to increasingly demanding market and regulatory requirements related to business digitalization. The implementation of electronic invoices (e-invoices) in business operations represents one aspect of digitalization. Entrepreneurs are an essential component of any country's economy, and through their activities, they generate a significant share of each country's GDP. Cash flow and buying and selling transactions are critical activities for conducting economic operations worldwide, and with the application of

---

\* Corresponding author: [imiklosevic@unisb.hr](mailto:imiklosevic@unisb.hr)

Ivana Miklošević, ORCID: 0000-0002-5882-6409



digitalization and e-invoices in business, these economic activities become faster, more transparent, and more efficient.

The aim of this paper is to explore how micro and small entrepreneurs have adapted to the mandatory implementation of electronic invoices (e-invoices) in business transactions with the public sector, identify the obstacles encountered during this process, examine the ways they overcame these obstacles, and gather their suggestions for improving the implementation of e-invoicing in micro and small enterprises. These insights represent the primary scientific contribution of this paper.

Micro and small enterprises constitute a fundamental pillar of the economy in the European Union, including the Republic of Croatia, generating a substantial number of jobs and ensuring livelihood for numerous families. These enterprises play a crucial role in economic growth, employment expansion, investment generation, and fostering business innovations. Micro and small entrepreneurs frequently face rapid and unpredictable changes dictated by market dynamics, while simultaneously needing to comply with various legal regulations and governmental provisions imposed by national authorities, including those of the Republic of Croatia.

The ability to rapidly adapt to evolving market conditions, consumer demands and preferences, as well as regulatory requirements, is particularly characteristic of micro and small enterprises. According to data provided by the European Commission, micro and small enterprises employ nearly two-thirds of private-sector workers and generate over half of the total added economic value (European Commission, 2022). In the Republic of Croatia, micro and small enterprises hold specific importance, as their growth and development directly impact the economic prosperity and stability of each region, county, and city within the country. These enterprises frequently face financial difficulties and weaker negotiating positions compared to larger companies. Consequently, the digitalization of business operations and the implementation of electronic invoicing undoubtedly pose greater and unforeseen challenges for micro and small enterprises, but simultaneously offer significant opportunities for enhancing their business efficiency and overall competitiveness.

Given the significant role that micro and small enterprises play in the economy of the Republic of Croatia, it is crucial to better understand the experiences of these entrepreneurs regarding the digitalization process and the implementation of electronic invoices (e-invoices) in their business operations. A critical aspect of digitalization in Croatia is the mandatory introduction of electronic invoices for transactions with the public sector, regulated by the Act on Electronic Invoicing in Public Procurement (Official Gazette 94/2018) and Directive 2014/55/EU of the European Parliament and Council of the European Union. Although national regulations and European guidelines clearly emphasize the advantages of implementing e-invoices, such as accelerated business processes, enhanced transparency, and reduced operational costs (European Commission, 2022), the practical experience of micro and small enterprises in Croatia reveals a complex reality with numerous challenges for these entrepreneurs, which will be discussed in subsequent chapters of this paper. The following sections include a review of relevant literature, a description of the research methodology, analysis and discussion of the research results, conclusions, and recommendations aimed at enhancing the digitalization process in micro and small enterprises.

## **2. LITERATURE REVIEW**

In Croatia, the Act on Electronic Invoicing in Public Procurement (Official Gazette 94/2018) mandates that all public procurement entities are required to receive, and their

suppliers obliged to issue, electronic invoices, ensuring compliance with Directive 2014/55/EU of the European Parliament and Council of the European Union (Zakon.hr, 2014).

In addition to legal obligations, electronic invoicing (e-invoicing) offers numerous advantages, such as reducing administrative costs and enhancing business transparency (European Commission, 2022). However, in practice, Croatian micro and small enterprises frequently encounter various barriers in implementing e-invoices, including low digital literacy, high costs of software solutions, lack of support, and general resistance to change. According to the Government of the Republic of Croatia (2021), within the framework of the National Recovery and Resilience Plan 2021–2026, the established objective is the adaptation of institutions, resilience in crisis situations, and strengthening administrative capacities oriented towards the digital transition.

The first electronic invoice (e-invoice) system in the Republic of Croatia was developed by the Financial Agency, an institution of the Government of the Republic of Croatia. The Financial Agency plays a primary role in ensuring, managing, and maintaining a central platform for the exchange of e-invoices between invoice issuers and public procurement entities (Financial Agency, 2025). An appropriate software system, compliant with legislative standards and requiring adaptation of business processes and organizational structures, is essential for automated e-invoice exchange. For smaller enterprises, ready-made solutions are available, frequently cloud-based, whereby the service provider (information intermediary) takes responsibility for data security, archiving, and formatting. In Croatia, the Financial Agency is defined as the central information intermediary managing electronic invoice exchange within public procurement, while other service providers are obligated to connect to its central platform (Republic of Croatia, Ministry of Economy, 2025).

Chen et al. (2015) emphasize that the development of an integrated e-invoicing platform can significantly contribute to creating a smart public administration. The implementation of electronic invoices (e-invoices) holds a central position in the digital transition of micro, small, and medium-sized enterprises, representing a critical step towards the comprehensive digitalization of business processes, particularly in interactions with the public sector. Numerous studies confirm that introducing e-invoices yields substantial benefits for small businesses, including reduced operating costs, shorter invoice processing times, and enhanced transparency in financial transactions (European Commission, 2022).

According to a study conducted by the European Commission (2022), SMEs utilizing digital solutions such as e-invoicing can reduce their administrative costs by up to 20% and significantly accelerate their receivables collection process. Digital tools facilitate faster adaptation of enterprises to regulatory and economic changes, thus reducing business risks and enhancing long-term sustainability. Within the Croatian context, research indicates that the adoption of electronic invoicing in business practices is largely driven by the legislative framework, particularly the Act on Electronic Invoicing in Public Procurement (Official Gazette 94/2018), aligned with Directive 2014/55/EU of the European Parliament and the Council (European Parliament and Council, 2014). Research conducted in Vietnam revealed that perceived usefulness, ease of use, and system compatibility significantly influence the acceptance of e-invoices among enterprises (Nguyen et al., 2020). Moreover, implementing infrastructure for e-invoices can result in substantial savings in business transactions (Vanjak et al., 2008).

### **3. DATA AND METHODOLOGY**

The objective of this paper is to explore and analyze the experiences of micro and small enterprises in the Republic of Croatia concerning the implementation and everyday use of

electronic invoicing systems. Employing a qualitative methodology, specifically semi-structured interviews conducted with 15 entrepreneurs from various business sectors, the study identifies the challenges and benefits associated with implementing e-invoices in the operations of micro and small enterprises. The methodology of this research relies on a qualitative approach, justified by the relatively small number of respondents and the necessity for an in-depth exploration of their experiences, perceptions, and attitudes toward the implementation of electronic invoicing within their businesses.

The chosen method of semi-structured interviews enables a detailed examination of specific challenges, barriers, and benefits that micro and small entrepreneurs encounter in their everyday business operations, an analysis that a quantitative approach would not sufficiently capture, due to the limited sample size. Respondents were selected using purposeful sampling, aiming to encompass enterprises from various sectors (retail, services, manufacturing, and construction), as well as diverse levels of experience and stages of digitalization concerning e-invoice usage. Key criteria for respondent selection included company size (micro and small enterprises with up to 50 employees) active operation over the past two years, and compliance with the mandatory use of electronic invoices according to Croatian legislation (Official Gazette, 94/2018). All respondents voluntarily agreed to participate in the interviews, were informed of the purpose of the research, and were assured of the anonymity of their data.

The research includes selected representative quotations from respondents, highlighting the key findings of the conducted study. Interviews were conducted between January and March 2025, with each interview lasting approximately 30 to 45 minutes, depending on respondents' willingness and extent of experiences shared. Eight interviews were held in person with micro and small business owners, while seven were conducted online via telephone calls. Data collected were analyzed using thematic analysis, which enabled the identification of central themes related to the personal experiences of micro and small business owners regarding the implementation of electronic invoicing in their enterprises.

A limitation of this research is the relatively small sample size, implying that findings cannot be fully generalized to the entire population of micro and small enterprises in Croatia. However, the qualitative approach is justified precisely due to the opportunity it offers for detailed examination, allowing deeper insight into the posed research questions and providing valuable perspectives on real challenges encountered by micro and small entrepreneurs during the digitalization process and the implementation of electronic invoices into their business operations.

The conducted research aims to address the following research questions:

- RQ1: What approaches have micro and small enterprises in the Republic of Croatia employed to adapt to the legislative requirement of implementing electronic invoicing in business transactions with the public sector?
- RQ2: What key advantages and challenges do micro and small enterprises in Croatia identify regarding the implementation of electronic invoices in daily operations?
- RQ3: How do micro and small enterprises perceive institutional support during the digitalization process?

The research findings indicate positive developments in the optimization of business processes, but simultaneously confirm the need for stronger institutional and educational support for small entrepreneurs.

#### **4. RESULTS AND DISCUSSION**

Semi-structured interviews were designed based on a predefined set of questions covering the following thematic areas: basic information about the company (business sector,

number of employees, and duration of business operations), the degree of digitalization within business activities and experiences regarding the implementation and usage of electronic invoices, primary reasons and motivation for adopting e-invoicing, perceptions of benefits and challenges encountered during implementation and use of e-invoices, evaluation of institutional support and suggestions for its improvement, as well as future intentions regarding further digitalization of their business processes.

The collected data were analyzed using thematic analysis, through which key themes reflecting experiences, perceptions, as well as benefits and challenges faced by micro and small entrepreneurs in implementing electronic invoices into their business processes, were identified. The primary objective of employing this method was to determine common practices among entrepreneurs, differences in their approaches, and specific challenges related to the implementation of e-invoices within micro and small enterprises in the Republic of Croatia.

After collecting data through interviews, the obtained results were interpreted and utilized to formulate conclusions and recommendations presented in the subsequent sections of this paper. The conducted study has certain limitations, primarily due to the relatively small sample size. The limited number of interviews (15 micro and small entrepreneurs) facilitates an in-depth understanding of specific experiences and perceptions of the participants; however, it concurrently restricts the potential for broader generalization of the results. Moreover, due to the qualitative nature of the research, findings cannot be statistically representative, yet they provide deeper insight into the specific challenges and obstacles faced by micro and small enterprises during the process of digital transformation and implementation of e-invoicing in the Republic of Croatia. The qualitative method was specifically selected as it allows thorough exploration of perceptions, attitudes, and personal experiences of entrepreneurs, which is especially significant for understanding the complex process of digital transition in micro and small businesses. This method is optimal for identifying specific barriers, benefits, and challenges faced by entrepreneurs during the digitalization of their business processes, aspects that a quantitative approach could not analyze in sufficient detail. Qualitative content analysis of the conducted interviews provides detailed and authentic insights into the experiences and needs of micro and small entrepreneurs regarding the implementation of e-invoices into the operations of businesses they own and manage.

The entrepreneurs included in the research belong to the following sectors: trade (4 entrepreneurs), services (6 entrepreneurs, of whom 2 entrepreneurs are from the IT sector), manufacturing (3 entrepreneurs), and construction (2 entrepreneurs). All respondents are classified as micro or small entrepreneurs according to the criteria defined by the Accounting Act (Official Gazette 85/24, 145/24).

The following section presents the analysis of the conducted interviews, which revealed several key themes common to all respondents. The questions were organized into three main thematic groups:

- Experiences of implementing e-invoices in business operations across sectors,
- Barriers and challenges in the digitalization process of enterprises across sectors,
- Perceptions of benefits and advantages arising from digitalization of business.

Table 1 presents entrepreneurs' experiences with implementing e-invoices across various sectors. The numbers indicated in the table represent the count of entrepreneurs who provided each specific response. Entrepreneurs in the service sector reported the most positive experiences, with four out of six respondents describing the implementation process as straightforward and swift. In the retail sector, the majority of entrepreneurs encountered partial difficulties that were quickly resolved. Conversely, the manufacturing sector exhibited diverse experiences, ranging from straightforward implementations to notably complex ones. The

construction sector reported the fewest issues, largely due to fewer business partners and relatively simplified administrative processes specific to this sector.

*Table 1. Experiences with e-invoice implementation in enterprises by sector*

Experiences with e-invoice implementation	Trade (n=4)	Services (n=6)	Manufacturing (n=3)	Construction (n=2)
Simple and quick implementation	1	4	1	1
Partial difficulties, quickly resolved	2	1	1	1
Significant difficulties, complex implementation	1	1	1	0

The following selected quotations illustrate entrepreneurs' experiences regarding the implementation of e-invoices in their business operations, *"Regarding the manufacturing sector, the introduction of e-invoicing was not easy for us because we had to completely change the software solutions we had been using."* (Entrepreneur from the manufacturing sector) An entrepreneur from the service sector responded as follows, *"We did not encounter major problems or challenges; the implementation was relatively straightforward, and the software support was good."* Furthermore, an entrepreneur from the trade sector stated, *"At the beginning, we felt quite lost, as we did not have much information regarding our obligations or the procedure for implementing e-invoicing into our business operations. However, once we became accustomed to the new system, it turned out to be easier than we initially expected."*

An entrepreneur from the manufacturing sector stated, "The software solution we adopted was expensive, but later we realized that it significantly facilitated our business operations." An entrepreneur from the service sector noted, "We didn't have significant problems with the implementation of e-invoices, although occasionally we experienced difficulties connecting with some public institutions whose systems were not operational." Another entrepreneur from the service sector mentioned that their accountant was initially unfamiliar with the system, requiring additional training, but after a few months, they fully adapted to the new system. A second entrepreneur from the manufacturing sector stated that they implemented the e-invoice system primarily due to legal obligations, but later recognized its substantial benefits for their business processes. Entrepreneurs from both the trade and construction sectors indicated encountering suppliers who continued sending paper invoices because they had not yet implemented an e-invoicing system, causing delays in their business activities. All entrepreneurs agreed that adapting to new work procedures and training their employees in issuing and processing e-invoices took some time; nevertheless, they generally expressed satisfaction with the overall implementation of the e-invoice system in their enterprises.

Table 2 presents the next thematic category, outlining the barriers and challenges encountered in the digital transformation process of micro and small enterprises by sector.

*Table 2. Barriers and challenges in the digitalization process of enterprises by sector*

Barrier/Challenge	Trade (n=4)	Services (n=6)	Manufacturing (n=3)	Construction (n=2)
Insufficient digital literacy of employees	3	2	2	1
High software costs	2	3	2	1
Weak institutional support	1	3	2	1
Employee resistance to change	2	1	1	1

Table 2 clearly illustrates the extent to which barriers and challenges in the digital transformation of micro and small enterprises vary across different sectors. The trade sector particularly emphasizes the problem of insufficient digital literacy among employees, complicating the successful implementation of e-invoices within these enterprises. High

software costs related to issuing and receiving e-invoices represent the greatest challenge for the service sector, while this factor poses the least concern in the construction sector. The manufacturing sector stands out due to weak institutional support and high software costs, identified as the main barriers during digitalization. In the construction sector, insufficient digital literacy among employees is also highlighted as a critical obstacle, though this sector is represented by the smallest number of respondents in this research.

An entrepreneur from the service sector remarked, *"Initially, we experienced difficulties integrating the new e-invoice system."* A respondent from the construction sector stated, *"We resisted transitioning to digital business practices at first; however, later we realized that we spend less time on administrative tasks, our business processes are faster and more efficient, and we are now very satisfied with the digitalization process and the implementation of e-invoicing."* A trade sector entrepreneur noted, *"Our employees lacked adequate training and digital literacy. It was extremely challenging to train our staff for the new working methods, requiring significant amounts of time, energy, and additional costs, but we ultimately succeeded."*

Manufacturing sector entrepreneurs expressed their need for enhanced institutional support, explaining that instructions provided on the Tax Administration's website were excessively complicated, and when they had inquiries or uncertainties, they were redirected to multiple officials within various institutions, resulting in delayed responses. An entrepreneur from the manufacturing sector further emphasized, *"Sometimes, I believe regulations and rules regarding business digitalization are written by experts who lack sufficient understanding of the realities and daily unexpected situations of our operations."*

In the continuation of the paper, Table 3 presents entrepreneurs' perceptions of the benefits of business digitalization across different sectors.

Table 3. Sector-specific perceptions of the benefits and advantages of business digitalization

Perception of benefits and advantages	Trade (n=4)	Services (n=6)	Manufacturing (n=3)	Construction (n=2)
Lower administrative costs	3	5	2	1
Faster invoice processing	2	4	3	2
Higher level of transparency	2	4	2	1
Simplified communication with the public sector	2	3	2	1

Entrepreneurs from all four analyzed sectors report multiple benefits resulting from the digitalization of their business operations, including reduced administrative costs, faster processing of incoming and outgoing invoices, and increased transparency of business activities. The service sector particularly highlights the benefits of lower administrative expenses and expedited invoice processing within companies. Entrepreneurs in the manufacturing and construction sectors identify faster handling of incoming and outgoing invoices as the main advantage of digitalization. The trade sector entrepreneurs emphasize reduced administrative costs as the most significant benefit derived from digitalizing their business operations. For most micro and small enterprises, lower administrative costs represent the most important advantage gained through digitalization. An entrepreneur from the trade sector noted, *"By implementing e-invoicing, we managed to lower postal service costs and speed up invoice payments, significantly improving our revenue and overall business performance."*

*"We work faster, more transparently, and have lower costs related to paper consumption for printing and postal services, which significantly benefits our business operations. We are very satisfied with these outcomes,"* stated an entrepreneur from the service sector. An entrepreneur from the manufacturing sector explained, *"We've saved valuable time*

*previously required for invoice processing. With digitalization, it's easier and quicker to monitor all transactions. The time saved will be utilized for other business tasks, as time is always scarce. Thanks to digitalization and e-invoicing, we now have more available time."*

The following Table 4 provides a brief summary of the key challenges and primary benefits of implementing e-invoices by sector, as reported by micro and small entrepreneurs. This table consolidates the information previously presented in the preceding tables.

*Table 4. Key challenge and primary benefit of e-invoice implementation by sector*

Sector	Leading challenge	Leading benefit
Trade (n=4)	Insufficient digital literacy of employees	Lower administrative costs
Services (n=6)	High software costs	Lower administrative costs
Manufacturing (n=3)	Weak institutional support	Faster invoice processing
Construction (n=2)	Insufficient digital literacy of employees	Faster invoice processing

According to entrepreneurs from the trade sector, the primary challenge is insufficient digital literacy among employees, whereas the key benefit in the same sector is reduced administrative costs. For entrepreneurs operating in the service sector, the main issue is the high cost of software required for implementing e-invoicing, although they emphasize significant savings achieved through lower administrative expenses. Entrepreneurs in the manufacturing sector highlight weak institutional support as their biggest challenge, whereas they identify faster invoice processing as the greatest benefit. Similarly, entrepreneurs in the construction sector underline faster invoice processing as the primary advantage of e-invoicing implementation, with insufficient digital literacy among employees noted as the main disadvantage.

The findings of the conducted research clearly indicate differences among sectors regarding perceived challenges and benefits of e-invoice implementation. However, certain sectors share the same leading challenge, for example, insufficient digital literacy among employees is a predominant issue for both trade and construction sector entrepreneurs. Likewise, reduced administrative costs are the leading benefit identified by entrepreneurs in both trade and service sectors, whereas those in manufacturing and construction emphasize faster processing of all invoices, both received and issued.

In conclusion, the following statements from entrepreneurs across various sectors illustrate the key findings of the study. An entrepreneur from the service sector stated, *"Our business is now much clearer, it's easier to track invoice payments, and invoices are easier to locate."* A manufacturing sector entrepreneur emphasized, *"Business digitalization has made our enterprise more competitive, particularly when competing in tenders against larger companies."* Another entrepreneur from the manufacturing sector added, *"In the long term, the advantages of digitalization and the implementation of e-invoices outweigh the costs, particularly in terms of time efficiency, which is always in short supply for entrepreneurs."* An entrepreneur from the trade sector highlighted, *"With the implementation of e-invoices, we experience significantly fewer errors than before, as the software automatically verifies invoice accuracy."*

The findings presented in this study offer valuable guidelines for micro and small enterprises in other countries that have not yet mandated the implementation of electronic invoicing.

## 5. CONCLUSION

The results of the research conducted on a sample of 15 micro and small entrepreneurs in the Republic of Croatia regarding the digitalization process through the implementation of

e-invoices in their business indicate that entrepreneurs recognize the advantages and benefits provided by the integration of electronic invoicing into their operations. Entrepreneurs highlighted several benefits from the introduction of e-invoices: acceleration of business processes, substantial reduction of administrative burdens on their employees or accounting service providers, reduced administrative costs, and a higher level of business transparency. The leading challenges that micro and small enterprises encountered during the implementation of e-invoices included a low level of digital literacy among their employees, high initial implementation costs, and insufficient institutional support characterized by overly complicated guidelines and a lack of timely and accurate information provided by public sector representatives. Key areas for intervention and support to micro and small entrepreneurs in the Republic of Croatia should focus on organizing more professional training related to the implementation of e-invoices and providing precise and prompt responses by employees of public institutions responsible for e-invoice systems. Although the conducted study has limitations related to the relatively small sample of interviewed entrepreneurs, it provides detailed insights into the difficulties faced by micro and small enterprises during the transition to e-invoicing and may serve as a valuable guide for other entrepreneurs in recognizing the broad spectrum of advantages offered by digitalization through the adoption of electronic invoicing systems.

Future research in this area could include a quantitative analysis involving a larger sample of entrepreneurs or comparative studies with micro and small enterprises from other countries in the region.

## REFERENCES

- Chen, S. C., Wu, C. C. & Miao, S. (2015). Constructing an integrated e-invoice system: The Taiwan experience. *Transforming Government: People, Process and Policy*, 9(3), 370-383. <https://doi.org/10.1108/TG-09-2014-0043>
- Government of the Republic of Croatia (2021). *National Recovery and Resilience Plan 2021–2026*. Government of the Republic of Croatia. [https://commission.europa.eu/system/files/2021-07/recovery\\_and\\_resilience\\_plan\\_for\\_croatia\\_hr.pdf](https://commission.europa.eu/system/files/2021-07/recovery_and_resilience_plan_for_croatia_hr.pdf)
- European Parliament and Council of the European Union. (2014). *Directive 2014/55/EU on electronic invoicing in public procurement*. <https://eur-lex.europa.eu/eli/dir/2014/55/oj/eng>
- European Commission. (2022). *VAT in the Digital Age: E-invoicing and Digital Reporting*. [https://taxation-customs.ec.europa.eu/taxation/vat/vat-digital-age-vida\\_en](https://taxation-customs.ec.europa.eu/taxation/vat/vat-digital-age-vida_en)
- Financial Agency (2025). *E-invoice in Public Procurement*. <https://www.fina.hr/javne-usluge/e-racun-u-javnoj-nabavi>
- Nguyen, A. H., Nguyen, T. P., & Dang, G. T. T. (2020). Determinants of E-invoice Adoption: Empirical Evidence from Vietnam. *The Journal of Asian Finance, Economics and Business*, 7(7), 311–321. <https://doi.org/10.13106/jafeb.2020.vol7.no7.311>
- Official Gazette. (2018). *Act on Electronic Invoicing in Public Procurement (NN 94/2018)*. [https://narodne-novine.nn.hr/clanci/sluzbeni/2018\\_10\\_94\\_1817.html](https://narodne-novine.nn.hr/clanci/sluzbeni/2018_10_94_1817.html)
- Republic of Croatia, Ministry of Economy. (2025). *How to Get an E-Invoice*. <https://mingo.gov.hr/djelokrug/uprava-za-trgovinu-i-unutarnje-trziste/e-racuni-i-e-trgovina/e-racun-7014/kako-do-e-racuna/7016>
- Vanjak Z., Mornar V. & Magdalenić I.. (2008). Deployment of e-Invoice in Croatia. *ICSOF 2008 - Proceedings of the 3rd International Conference on Software and Data Technologies*. <https://dx.doi.org/10.5220/0001888903480354>



Zakon.hr (2024). Accounting Act (Official Gazette 85/24, 145/24).  
<https://www.zakon.hr/z/118/zakon-o-racunovodstvu>



## ANALYSIS OF INNOVATION IN BRICS COUNTRIES

Ivica Nikolić<sup>1\*</sup>, Lidija Krstić<sup>1</sup>, Anđelka Stojanović<sup>1</sup>, Denis Stojkanović<sup>2</sup>

<sup>1</sup>*University of Belgrade, Technical Faculty in Bor, Serbia*

<sup>2</sup>*The Higher School of Professional Studies for Management and Business Communication*

**Abstract:** The process of globalization creates intense competition in the global market, requiring the economies of all countries to gain a competitive advantage through the development of innovation. This paper analyzes the innovation capabilities of all ten BRICS member states, including both the founding countries (Brazil, Russia, India, China, and South Africa) and the new members (Egypt, Ethiopia, Indonesia, Iran, and the United Arab Emirates). The analysis is based on the values of the Global Innovation Index (GII), which contributes to the creation of an environment in which innovation factors are continuously assessed and enables a comprehensive evaluation of innovation policies. The aim of the paper is to group BRICS countries into a homogeneous cluster in order to better understand their innovation capacities based on data collected over a five-year period. The research results provide a more comprehensive insight into the position of each BRICS member, identifying both the countries that stand out as leaders in innovation and those that lag behind.

**Keywords:** Innovation, Global Innovation Index, BRICS, Cluster analysis.

### 1. INTRODUCTION

The current level of innovative development in many countries, particularly in developing and emerging economies, remains insufficient to achieve comprehensive structural and institutional modernization of their economic systems. This insufficiency is further exacerbated by the pressures of globalization, which continuously challenge national innovation systems and compel them to adapt to the evolving demands of the global market. Contemporary literature has already identified a positive correlation between economic, political, and social dimensions of globalization and the performance of technological innovation, suggesting that successful integration into the global system can enhance

---

\* Corresponding author: [inikolic@tfbor.bg.ac.rs](mailto:inikolic@tfbor.bg.ac.rs)

Ivica Nikolić, ORCID: 0000-0003-1986-4653

Lidija Krstić, ORCID: 0009-0009-6618-4723

Anđelka Stojanović, ORCID: 0000-0001-7254-4646

Denis Stojkanović, ORCID: 0009-0003-0686-7879

innovation capacity—provided that domestic systems are adequately prepared to respond (Petkovski, 2023).

In this context, it becomes clear that successful integration into the global system, while capable of enhancing innovation capacity, requires not only the adaptation of domestic innovation systems but also their substantial strengthening through coordinated integration and innovation processes. This is precisely where integration and innovation must act synergistically: innovation potential, although an integral part of integration potential, simultaneously influences its further deepening and development. In the case of countries such as BRICS members, the alignment of development policies and research programs, the expansion of financial resources, and the creation of a shared technological framework open up broader opportunities for innovation and enable deeper economic interconnectedness. A key factor in realizing this potential is the unification of national efforts toward integration with innovation-driven development trends, thereby forming a unified trajectory toward sustainable modernization and competitiveness within the global market (Sidorova, 2018).

The combination of the Global Innovation Index (GII) and cluster analysis provides deeper insights into the innovation performance of BRICS countries and enables the identification of key factors influencing their innovation capacity. The aim of this paper is to explore the application of GII and cluster analysis in studying innovation within BRICS nations. Cluster analysis is used to determine which BRICS countries lead in innovation and which are lagging, grouping them according to similarities in their innovation characteristics. This approach facilitates the identification of shared challenges and opens up opportunities for mutual cooperation aimed at fostering innovation-driven development (Nikolić et al., 2024).

The initial part of the paper presents a review of relevant literature on innovation, its importance for economic development, and methods for measuring innovation capacity. The paper then analyzes the positions of BRICS countries based on the GII, with a focus on their specific strengths and weaknesses. The next section outlines the research methodology, including a description of the Global Innovation Index and cluster analysis as tools for grouping countries according to innovation parameters. Based on the research results, key innovation factors in BRICS countries will be identified, along with their classification into homogeneous cluster groups.

In the final section, the paper discusses the implications of the findings and provides policy recommendations aimed at strengthening innovation capacity within the BRICS framework. It also offers suggestions for future research and specific actions that could contribute to the development of innovation and the promotion of sustainable economic growth in these countries. This study contributes to a better understanding of innovation processes within BRICS and provides a foundation for developing effective strategies to enhance competitiveness and technological advancement in this international partnership.

## **2. LITERATURE REVIEW**

Innovations are increasingly recognized as a key driver of economic development and global competitive advantage. In this context, states bear the responsibility to formulate and implement appropriate policies aimed at enhancing their national innovation capacities. A considerable body of literature has examined the innovation performance of BRICS countries; however, nearly all existing studies have focused exclusively on the original five members of the bloc: Brazil, Russia, India, China, and South Africa. To date, academic research has not included the newly admitted members — Egypt, Ethiopia, Indonesia, Iran, and the United Arab Emirates — which can be attributed to their relatively recent accession to the alliance.

One representative study in this field is by Petkovski (2023), in which the author aimed to construct a structural model of the innovation environment within BRICS countries, using indicators based on the Global Innovation Index (GII). The research covered only the founding BRICS members and revealed significant disparities in innovation capacity levels. The most notable progress was observed in China and India, while Brazil exhibited a decline in innovation potential, indicating the need for a revision of its national innovation policies.

Another highly relevant study investigating the determinants of national innovation system efficiency in BRICS countries is Yuezhou (2011). This research utilizes Data Envelopment Analysis (DEA) in conjunction with panel data analysis to evaluate performance over time. The findings reveal considerable disparities in efficiency: China, India, and Russia attain relatively high scores, while Brazil and South Africa lag behind, pointing to the necessity of structural reforms and policy improvements in these countries.

Although cluster analysis has most frequently been applied to innovation research within the European Union and other European nations, such methodological approaches provide a valuable foundation for analyzing BRICS countries as well. The work of Nikolić et al. (2024) serves as an illustrative example; through cluster analysis of innovation indicators, the authors grouped EU countries based on similarities derived from the Global Innovation Index. This approach enabled a clearer understanding of innovation capacities and contributed to the development of more effective policy measures. Given the diversity of innovation profiles among BRICS members, cluster analysis could prove to be a useful tool for identifying groups of countries with shared challenges and capabilities, thus facilitating the formulation of targeted innovation strategies.

A particularly noteworthy contribution to the literature is the study by Sidorova (2018), which analyzes BRICS countries' innovation capacities through hierarchical cluster analysis using data on the number of researchers, R&D investments, patent registrations, and technological exports. The author identified two clusters: one comprising China as the innovation leader, and the other including the remaining countries with lower and more fragmented innovation performance. Although China clearly stands out, its advantages are not absolute. Russia ranks highest on several key indices, including the Knowledge-Based Economy Index and the Global Modernization Index. In general, each BRICS country possesses distinct strengths in developing and deploying national innovation potential. Despite its structural limitations, South Africa demonstrates comparatively strong results in institutional development and market sophistication among BRICS members. The research emphasizes the importance of coordinated research programs and investment in education as critical factors for improving innovation systems within the BRICS framework.

While studies on BRICS remain limited in scope, existing research underscores the need for more extensive comparative analyses and a broader inclusion of newly admitted members. Such efforts would enhance the understanding of innovation dynamics within the BRICS alliance and support the creation of more targeted and effective innovation policies.

### **3. GLOBAL INNOVATION INDEX IN BRICS COUNTRIES**

The GII is one of the most relevant tools for measuring the innovation capabilities of countries worldwide and is therefore applicable to BRICS member states as well. This index combines a range of indicators related to the input dimensions of innovation—such as institutions, human capital, research, infrastructure, and market sophistication—as well as output indicators encompassing knowledge creation, technological products, and creative outputs. In the context of BRICS countries, the GII enables a comparative analysis of innovation potential among member states by identifying their strengths and weaknesses within national

innovation systems. Existing research reveals significant disparities among these countries: China and India demonstrate consistent growth and dominate across most innovation indicators, while Brazil and South Africa are frequently ranked lower due to limited investments in research and development and weaker institutional support. The inclusion of new members such as Egypt, Ethiopia, Indonesia, Iran, and the United Arab Emirates introduces additional challenges and underscores the need for expanded analyses to better understand their innovation positions within the BRICS framework. As a tool, the GII provides a solid foundation for designing innovation-stimulating policies, enabling decision-makers to identify trends, monitor progress, and align strategies with the demands of the global innovation landscape.

### 3.1. The BRICS group

The acronym BRIC was first introduced in 2001 by Goldman Sachs in its paper titled Building Better Global Economic BRICs, which presented growth projections for four leading emerging economies that are ethnically and geographically heterogeneous. The term was quickly adopted by the public, particularly in the media. The original group consisted of Brazil, Russia, India, and China. In 2010, a new acronym—BRICS—was introduced with the inclusion of South Africa into the initial BRIC group. This expansion extended the alliance to encompass over 40% of the global population and nearly 30% of the world's land mass (Rajput et al. 2012).

By early 2023, the five founding BRICS members had, in terms of Gross Domestic Product (GDP) measured by Purchasing Power Parity (PPP), surpassed the G7 countries, accounting for approximately 31.5% of global GDP. The G7 comprises the world's most industrialized nations and collectively represents around 58% of global net wealth. The Group of Seven was established in 1976, when Canada joined the original Group of Six (G6), which included France, Germany, Italy, Japan, the United Kingdom, and the United States (Statista, 2025). Figure 1 shows the geographical distribution of G7 and BRICS member countries (Statista, 2025; BRICS, 2025).



Figure 1. G7 and BRICS member countries (Statista, 2025)

On January 1, 2024, the BRICS group welcomed four new members: Egypt, Ethiopia, Iran, and the United Arab Emirates, followed by the accession of Indonesia on January 6, 2025.

The aim of this most recent expansion is to promote the creation of a multipolar world order that amplifies the previously marginalized voices of the Global South and seeks to reduce the dominance of the Global North, positioning BRICS member states at the center of the global agenda (BRICS, 2025).

### 3.2. The Global Innovation Index (GII)

The Global Innovation Index (GII) was established by the World Intellectual Property Organization (WIPO) with the aim of systematically monitoring and reporting on key global innovation trends, as well as ranking countries based on their innovation performance on an international scale. Since 2007, the index has been published annually through a collaboration between INSEAD, Cornell University, and WIPO. To facilitate a clearer understanding of the interrelationships between various dimensions of innovation, a graphical representation of the GII conceptual framework is used, as shown in Figure 2. Calculating the overall GII score is a complex process that encompasses numerous dimensions and components. Each GII component corresponds to a specific index developed by the World Bank, UNESCO, or other relevant institutions, and is expressed through quantitative, qualitative, or composite indicators (the latter being calculated as a weighted average of the respective components). In order to enable comparisons and ranking, all indicators are normalized on a scale from 0 to 100 using the min-max method. Rankings are published both for the overall GII and for each individual dimension and component (Nikolić et al., 2024, WIPO, 2025).

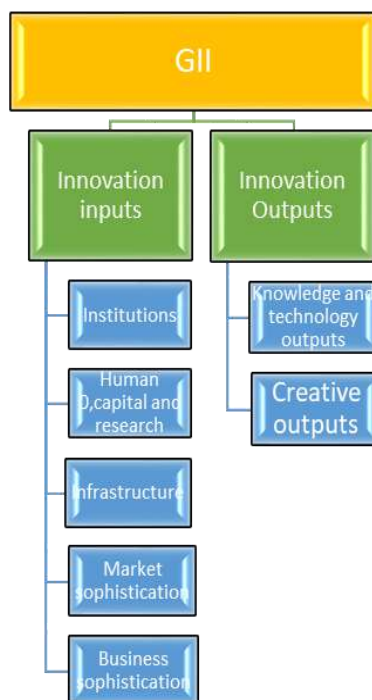


Figure 2. GII Dimensions (Nikolić et al., 2024)

The main objective of this research is to explore the innovation capabilities of BRICS countries. Accordingly, the study was conducted on a sample of BRICS member states, which now includes ten countries: Brazil, Russia, India, China, South Africa, Egypt, Ethiopia, the United Arab Emirates, Indonesia, and Iran. The BRICS framework represents a particularly intriguing area of research, as this alliance is now considered the fastest-growing market in the

world, encompassing nearly half of the global population. Therefore, its role in the field of innovation is highly significant. Some studies suggest that population growth trends are closely linked to intensive technological innovation, as in highly populated countries, demand is largely driven by population size (Coccia, 2014). Moreover, the population structure of BRICS countries shows a continuing increase across all member states (World Data Bank, 2023). This factor has thus emerged as a key reason for including BRICS data in the present research (Petkovski, 2023).

The Global Innovation Index (GII) for 2025 consists of seven key dimensions that offer a comprehensive overview of a country's innovation potential.

The *Institutional dimension* covers the political, regulatory, and business environment, all of which significantly influence innovation development.

*Human capital* and research evaluate educational resources, investments in education, and scientific activity.

*Infrastructure* includes access to ICT, general infrastructure (such as energy and logistics), and environmental sustainability. *Market sophistication* measures access to finance, trade flows, and the level of competition.

*Business sophistication* includes the number of skilled workers, collaboration between academia and industry, and firms' capacity to adopt new technologies.

*Knowledge and technology outputs* refer to the number of patents and scientific publications, the economic impact of knowledge, and its diffusion through technology and investment.

*Creative outputs* encompass intangible assets, cultural and digital content, including mobile apps and online presence.

This framework allows for accurate comparisons between countries and a better understanding of their innovation performance.

#### 4. DATA AND METHODOLOGY

The introduction of cluster analysis as a methodological approach in the study of innovation within BRICS member countries represents a significant step toward understanding the complex dynamics of their innovation systems. This method enables the identification of behavioral patterns and shared characteristics among BRICS nations, thus providing a basis for the formulation of innovation policies that reflect the current state of development. The application of cluster analysis facilitates the recognition of similarities and differences in institutional frameworks, human capital, infrastructure, and technological capacities among these countries, further contributing to their strategic positioning within the global economy.

Cluster analysis also allows for the identification of countries with high innovation potential, the mapping of regional specificities, and the diagnosis of barriers that hinder innovation development. It is particularly useful in the context of pronounced economic, cultural, and political differences that exist among BRICS members, as it supports the exploration of opportunities for collaboration and knowledge exchange. Rather than promoting a uniform model, this analysis highlights the need for flexible, tailored approaches that take into account local conditions and development priorities.

In this context, cluster analysis emerges as a valuable tool for improving both national and transnational innovation strategies, strengthening the competitiveness of BRICS countries, and creating sustainable pathways toward technological and economic progress.

In this study, cluster analysis was applied to the values of seven dimensions of the Global Innovation Index (GII) for BRICS member countries, including the five new members: Egypt, Ethiopia, Indonesia, Iran, and the United Arab Emirates. Table 1 presents the average

values for all innovation parameters over the period from 2020 to 2024. For each country, indicators such as human capital, research and development, infrastructure, market, business environment, knowledge creation, and technological outputs were analyzed. The aim was to identify similarities and differences in the innovation profiles of the countries and, based on the results, to propose tailored innovation policies.

In the application of cluster analysis, the exact number of groups into which the observation units will be classified is often not known in advance. Therefore, a two-step approach is commonly employed to determine the most appropriate cluster structure. In the first stage, hierarchical cluster analysis using Ward's method is applied to estimate the optimal number of clusters. Subsequently, in the second stage, the analysis is repeated with the predetermined number of clusters in order to allocate each observation unit to its respective group. The entire procedure is carried out using the SPSS statistical software package.

*Table 1. Average values for 10 countries in the time period from 2020 to 2024 (WIPO, 2025)*

Number	Country	Total GI	Institution	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technological results	Creativity
1	Brazil	69,40	91,40	62,40	74,20	75,60	54,20	64,80	73,20
2	Egypt	90,20	107,40	94,20	93,20	90,00	103,00	74,40	88,00
3	Ethiopia	125,00	115,00	129,80	121,40	124,20	125,20	84,60	121,80
4	India	42,60	57,40	51,20	78,00	24,20	55,20	26,80	55,20
5	Indonesia	72,40	79,80	89,60	70,40	45,40	94,20	71,40	75,80
6	Iran	61,00	127,80	54,60	81,20	47,40	113,80	51,80	44,40
7	South Africa	62,00	74,00	76,20	76,40	34,20	58,40	59,60	67,80
8	China	12,00	50,40	21,20	23,40	15,20	14,20	5,20	13,00
9	Russian Federation	49,80	92,69	30,20	66,60	55,40	45,40	51,00	54,00
10	United Arab Emirates	32,40	16,80	17,80	14,00	26,00	23,40	62,20	41,80

## 5. RESULTS AND DISCUSSION

Table 2 presents the agglomeration coefficients for each step of the hierarchical cluster analysis conducted on the sample of BRICS countries. The table outlines nine merging stages, illustrating the formation of clusters from ten down to one. The column containing the agglomeration coefficients enables the observation of similarity changes between country groups at each stage. Notably, stages 8 and 9 exhibit a sharp increase in coefficients, rising from 19123,673 to 40161,245, and subsequently to 75297,652. These values indicate that clusters merged at these stages are significantly less similar. Based on this observation, it can be concluded that the optimal number of clusters among the BRICS countries is *three*. Beyond this point, further merging results in a loss of homogeneity among country groups.



Table 2. Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	5	7	985,840	0	0	6
2	1	9	2280,220	0	0	3
3	1	4	5174,587	2	0	6
4	8	10	8138,967	0	0	8
5	2	3	11259,647	0	0	9
6	1	5	14391,268	3	1	7
7	1	6	19123,673	6	0	8
8	1	8	40161,245	7	4	9
9	1	2	75297,652	8	5	0

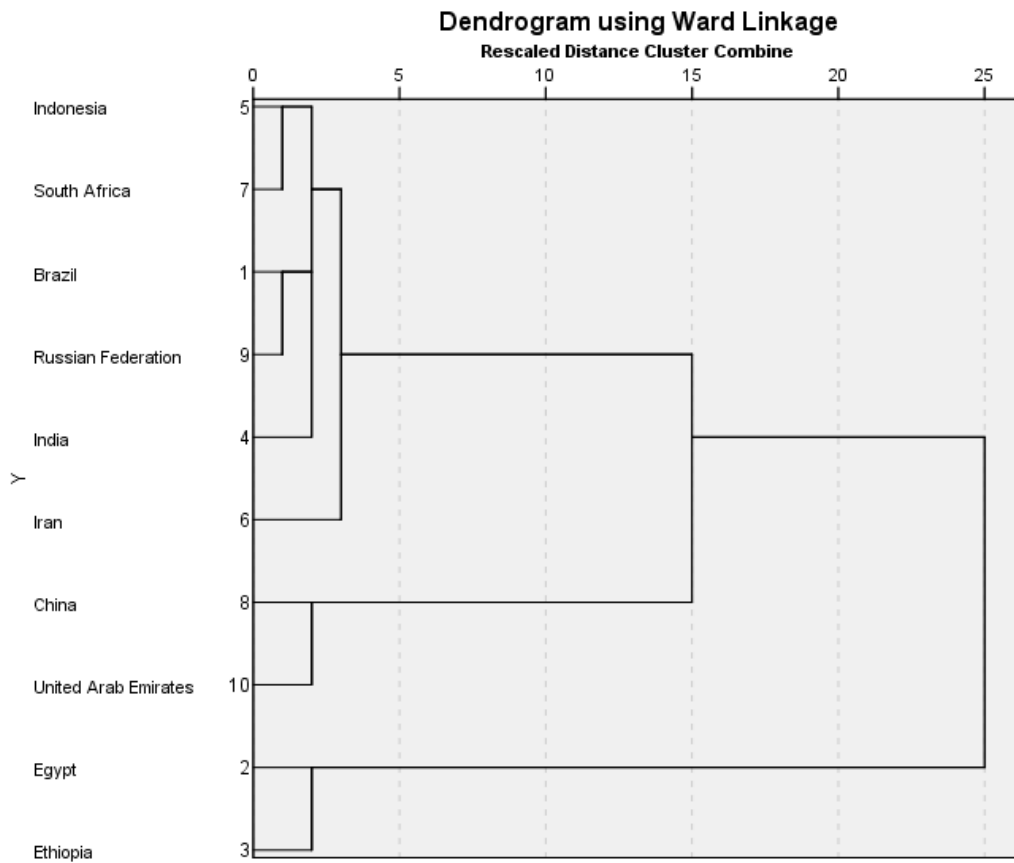


Figure 3. Dendrogram for determining the number of clusters

Figure 3 presents a dendrogram constructed using the hierarchical clustering method with Ward's linkage, analyzing the member states of the expanded BRICS alliance (commonly referred to as BRICS+). This designation includes ten countries: Brazil, Russia, India, China, South Africa, as well as newly affiliated members—Egypt, Ethiopia, Iran, the United Arab Emirates, and Indonesia.

The dendrogram reveals the formation of three clearly differentiated clusters:

*The first cluster*, comprising Brazil, Russia, India, Indonesia, Iran, and South Africa, is characterized by a moderate level of innovation development. These countries are grouped at a relatively low level of rescaled distance, indicating a high degree of similarity in their innovation-related characteristics. The countries within this cluster exhibit moderate innovation performance, along with potential for further progress through enhanced infrastructure and research capacity.

*The second cluster* includes China and the United Arab Emirates, which demonstrate a high degree of mutual similarity, yet merge with the previous group at a higher hierarchical level. These countries lead in terms of innovativeness within the BRICS+ group. This can be attributed to strong investments in technology, education, and research and development (R&D), as well as the presence of effective institutional frameworks that support innovation.

*The third cluster*, consisting of Egypt and Ethiopia, stands out as the most distinct pairing and the most distant from other member states, indicating significant differences in innovation capacity compared to the rest of the BRICS+ countries. This cluster represents the countries with the lowest innovation capabilities within the analyzed group. Their limited innovation output is largely due to insufficient investment in research infrastructure, education, and technological advancement.

## 6. CONCLUSION

Based on the analysis of the innovation capacities of the expanded BRICS alliance using cluster analysis, it can be concluded that this method represents an effective tool for understanding the complex relationships among countries in terms of innovation. Cluster analysis enabled the identification of behavioral patterns, institutional similarities and differences, as well as technological capacities across member states, thus laying the foundation for the formulation of tailored innovation policies. The formation of three distinct clusters indicates the existence of significant differences in levels of innovation development: the first cluster includes countries with moderate innovation capacities, the second consists of innovation leaders, while the third encompasses countries with limited potential. Notably, the analysis does not promote a one-size-fits-all development model, but rather emphasizes the importance of flexible approaches that account for local conditions and development priorities.

The identification of China and the UAE as innovation leaders confirms the effectiveness of their institutional frameworks and sustained investments in education and research, whereas Egypt and Ethiopia highlight the need for substantial improvements in infrastructure and technological advancement. This classification allows more strategic positioning of BRICS countries within the global economy and opens up opportunities for mutual cooperation and knowledge exchange. Furthermore, the use of cluster analysis provides a basis for designing national and transnational innovation strategies aimed at enhancing competitiveness and fostering sustainable technological progress. Overall, the findings suggest that despite economic and political differences, BRICS+ countries possess potential for mutual learning and collective strengthening of their innovation systems.

## ACKNOWLEDGMENT

The research presented in this paper was done with the financial support of the Ministry of Science, Technological development and Innovation of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-137/2025-03/ 200131.

## REFERENCES

- BRICS 2025: <https://infobrics.org/>
- Coccia, M. (2014). Driving forces of technological change: the relation between population growth and technological innovation: analysis of the optimal interaction across countries. *Technological Forecasting and Social Change*, 82, 52-65. <https://doi.org/10.1016/j.techfore.2013.06.001>
- Nikolić, I., Stojanović, A., Radić, A., Đorđević, P., (2024), Analysis of Innovation in EU Countries. *International May Conference on Strategic Management – IMCSM24*, May 2024, Bor, Republic of Serbia, Volume XX, Issue (2), 180-190.
- Petkovski, I. (2023), Structural PCA-MLR Model of the Innovation Environment in BRICS Countries. *Serbian Journal of Management*, 18(1), 1 – 26. <https://doi.org/10.5937/sjm18-32136>
- Rajput, N., Khanna, A., Oberoi, S. (2012), Global Innovation Index and its Impact on GDP of BRICS Nations-Innovation Linkages with Economic Growth: An Empirical Study. *Global Journal of Enterprise Information System*, 4(3), 35-44. DOI:10.15595/GJEIS/2012/V4I2/33611
- Sidorova, E. (2018), The Innovation Development of the BRICS Countries: Preconditions and Prospects for Cooperation. *International Organisations Research Journal*, 13(1), 34-50. DOI:10.17323/1996-7845-2018-01-02
- Statista, 2025: <https://www.statista.com/chart/30672/brics-expansion-map/>
- WIPO 2025: <https://www.wipo.int/portal/en/index.html>
- World data bank (2023). Population database: <https://data.worldbank.org/indicator/SP.POP.TOTL>
- Yuezhou, C. (2011), Factors affecting the efficiency of the BRICSs' national innovation systems: A comparative study based on DEA and Panel Data Analysis. *Kiel Institute for the World Economy, Economics Discussion Paper No. 2011-52*. <http://dx.doi.org/10.2139/ssrn.1974368>



## A COMPARISON OF DIFFERENT LEADERSHIP APPROACHES IN THE HOTELS INDUSTRY AND THEIR IMPACT ON EMPLOYEE PERFORMANCE

Jovan Momirski\*

*Singidunum University, Belgrade, Serbia*

**Abstract:** Leadership in the hotels industry plays a key role in shaping organizational culture, employee motivation, and overall hotel performance. Due to the dynamic nature of this industry, different leadership styles directly influence service quality, team productivity, and employee satisfaction. This paper explores the impact of different leadership styles, including transformational, transactional, servant, authoritarian, democratic, empowering, participative, and charismatic, on hotel operations, through the analysis of concrete examples and relevant theoretical models. Implementing different leadership styles can contribute to creating a more productive work environment and increasing guest satisfaction. The aim of the research is to determine the ways in which different leadership styles shape the working atmosphere, the efficiency of employees and their commitment to work. The methodological framework includes a comparative analysis of research and examples from well-known hotel chains, in order to clearly the strengths and potential disadvantages of different leadership styles. The results provide practical insights for improving leadership in hotel industry and more efficient employee management within the industry.

**Keywords:** Leadership, hotels, employee performance.

### 1. INTRODUCTION

In contemporary hospitality management, leadership is emphasized as a key factor in enhancing service quality and achieving organizational success. According to research by Lončar (2023), leaders who apply appropriate leadership styles can significantly influence employee motivation, which directly contributes to the improvement of service quality in hotels.

The influence of different types of leadership fosters innovation in the hotel industry. Transformational leadership, in particular, plays a significant role in this process. In order to increase hotel competitiveness and improve service quality, it is necessary to encourage

---

\* Corresponding author: [jovan.momirski.21@singimail.rs](mailto:jovan.momirski.21@singimail.rs)

employee creativity and initiative. Leaders have a key influence on these processes (Jovičić Vuković et al., 2018).

Leadership is defined as the influence on others in terms of directing them toward the achievement of goals. It is a complex process that depends on the leader's traits and the circumstances under which leaders exert influence on others (Bavik & Koseoglu, 2022).

There are various leadership styles, and they are adapted to the specific characteristics of the hotel industry. The importance of this adaptation is examined and analyzed in contemporary research. Special emphasis is placed on employee motivation and satisfaction, as these are key factors for improving service quality and achieving sustainable competitive advantage. According to Grudić Kvasić (2018), leadership characterized by authenticity and transparency enhances employee satisfaction, which in turn leads to improved operational efficiency in hotels.

The aim of this paper is to analyze different leadership approaches within hotel organizations, with a particular focus on their impact on employee performance. The paper provides an analysis of various leadership styles in the hospitality industry. Furthermore, it demonstrates how different leadership approaches influence employee engagement and performance in the hotel sector. Taking into account key case studies and theoretical analysis, the study will identify patterns and key factors that affect team effectiveness.

## **2. LITERATURE REVIEW**

Employee satisfaction is an integral part of work quality in any organization. Through their work, employees use and develop their knowledge and talents, while also growing personally. A leader's knowledge should include the awareness that employees have a need to fully develop through their professional activities, which highlights the leader's role in this process. Motivation is a crucial element, and without it, leadership cannot be successful. There are numerous reasons for this. It can thus be concluded that employee commitment within an organization is directly linked to motivation.

Effective motivation involves enabling employees to express their ideas and opinions, making them active, rather than passive, members of the team. In this way, they gain a better understanding of their role within the organization, which contributes to greater role stability. If motivation is lacking, the workforce will not be stable. Naturally, an unsatisfied employee tends to leave the organization. Employee turnover leads not only to financial costs but also to a series of disruptions in the functioning of the organization.

Leaders have a significant influence on employee commitment and motivation. Committed employees are motivated to direct their energy toward the quality execution of their tasks. Rabiul & Yean (2021) found in their research that motivational language inspires employees and creates an emotional connection with the organization. This form of communication provides direction from leaders, establishes balance, reduces uncertainty, and clarifies tasks. In addition, it demonstrates concern for the emotional well-being of employees, which increases their organizational commitment.

The following leadership styles are identified: transformational, transactional, servant leadership, authoritarian leadership, democratic leadership, among others.

Leadership in the hospitality industry represents a key factor influencing work efficiency, employee satisfaction, and the overall performance of the organization. Different leadership approaches shape the ways in which managers motivate, guide, and develop their teams. The literature particularly highlights four dominant leadership styles: transformational,

transactional, servant, and traditional forms such as authoritarian and democratic leadership (Bass & Riggio, 2006).

Transformational leadership promotes innovation, a visionary approach, and inspirational employee motivation. In the hospitality industry, this approach is especially important due to the need for constant adaptation to market changes and a high level of employee engagement (Fahlevi et al., 2022). Transformational leaders contribute to motivating employees to improve performance. Transformational leadership has the capacity to change and transform an enterprise, enabling the achievement of exceptional results. Such leaders have the ability to initiate change and transformation, and to realize the strategic goals and vision of the organization (Vlahović, 2008).

Research on transformational leadership and its impact on employees, particularly in relation to problem-solving, was conducted by Luo et al. (2019). They concluded that it is necessary to invest additional emotional effort in order to regulate emotions and increase the level of polite communication with customers. Customer dissatisfaction with service creates a range of problems, and the key role of employees is to demonstrate a positive attitude, care, and empathy, thereby fostering customer loyalty. In this process, leaders play an important role by supporting and empowering employees to respond appropriately when handling customer complaints (Luo et al., 2019).

Transactional leadership is characterized by a clear system of rewards and punishments. This leadership style motivates employees through explicitly defined goals and structures. As a result, it contributes to increased efficiency in everyday work processes (Al Khajeh, 2018).

Recent studies indicate that transactional leadership can have varying effects on employee performance in the hospitality industry. Although it possesses a number of positive characteristics, excessive reliance on this leadership style may lead to limitations in employee creativity and initiative. Therefore, it is recommended to combine transactional leadership with transformational approaches in order to achieve a balance between operational efficiency and innovation in the hotel environment (Stefanović, 2017).

Servant leadership is oriented toward a supportive set of activities, in which the role of the leader is not perceived as direct or dominating, but rather as supportive. This concept is distinctive in that a leader earns their role by offering support and assistance to team members. Servant leaders strive to create a sense of belonging within the organization by encouraging employees to engage beyond their formal job roles. In doing so, they foster personal and professional development, as well as continuous learning (Kreitner & Kinicki, 2012).

"The only authority that should be accepted is the one earned by offering help. The only leaders who deserve to be followed are those who have proven themselves as helpers—those willing to serve first, and only then to lead" (Greenleaf, 1998, p. 25).

Leaders fulfill their role through various forms of action based on their power. Authoritarian leadership involves the exercise of authority, which is a type of power that arises from the demonstrated ability to act within the defined limits of one's role. This leadership style is entirely characterized by a focus on results and efficiency. The leader makes decisions independently or with the involvement of a small group of associates. Employees are expected to perform only the tasks assigned to them, without participating in decision-making.

The authoritarian leadership style is appropriate in organizations where strict guidelines are required, and where a high degree of supervision is necessary—especially when employees have limited experience. However, a significant drawback of autocratic leadership is its tendency to suppress individual creativity.

Democratic leadership is a style in which employees are fully involved in business processes and decision-making. Employees are highly motivated, and the leader places

complete trust in them when it comes to making decisions. The application of this style in hotel enterprises fosters interpersonal relationships.

Lewin et al. (1939) described a democratic leader as someone who encourages freedom among team members through guidance and influence, thereby instilling trust. Bhatti et al. (2012) argue that there are significant differences between democratic and authoritarian leadership styles, primarily due to the greater focus on people. A democratic leader is more a part of the group than a separate individual.

The core component of charismatic leadership lies in the personal traits of the leader. A charismatic leader possesses a wide range of skills, including interpersonal, strategic, business, and cognitive abilities (Stavrinoudis & Chrysanthopoulou, 2015). Charismatic leadership effectively influences subordinates and represents an interaction between the leader and followers. As a result, followers achieve self-affirmation through the realization of a mission defined by the leader. They are positioned in such a way that working toward organizational goals takes precedence over personal goals and interests.

Charismatic leadership is characterized by strong motivation, leader trust, and communication delivered in a uniquely engaging manner. There is an emotional connection between the leader and the employee, in the sense that the leader's actions are so inspiring that employees are driven to identify with them (Lončar, 2023). A positive aspect of this leadership style is the emphasis on two-way communication, which facilitates the building of trust, the development of self-confidence, and a greater willingness to act toward the achievement of defined goals.

Empowering leadership involves granting employees authority and encouraging their independence, decision-making, and expression of opinions. In the hotel industry, this approach can yield positive results and is therefore both recommended and desirable. Its influence on employee behavior contributes to increased job satisfaction and loyalty. The focus is on trust and the belief that employees possess the competence and responsibility to make decisions independently (Lin et al., 2019).

In a study conducted by Su et al. (2022), employee self-management in the hospitality sector was analyzed. The study concluded that self-management positively affects not only employees but also guest satisfaction and loyalty. Self-management serves as a mechanism that fosters self-motivation, which should be supported by hotel leaders in a way that enables employees to feel a sense of autonomy. This, in turn, leads to greater job satisfaction and enhanced motivation.

Participative leadership refers to the direct involvement of employees in decision-making processes. It entails the delegation of authority to subordinates by the leader and their inclusion in solving leadership-related tasks. This includes strategy development and decision-making. Participative leadership is value-based and team-centered. This style encourages employee engagement and recognizes their contribution to decision-making. Furthermore, it leads to increased employee energy, resulting in greater motivation toward work and a heightened sense of care for hotel guests (Hu & Liden, 2011).

### **3. METHODOLOGY**

The selection of case studies is aligned with existing research. The choice of sources includes relevant analyses of leadership in the hospitality industry. The research methodology involves a comparative analysis of case studies that examined various leadership styles. The aim is to identify key factors that influence employee engagement. The methods used include analysis of existing data and theoretical interpretation of results.

Through the analysis of available literature and case studies, trends have been identified in the application of different leadership styles in the hotel sector and their impact on employee performance. Research confirms that leadership style plays a crucial role in increasing work efficiency, employee satisfaction, and hotel competitiveness. The reviewed studies focus on leadership in the hospitality industry and examine the impact of specific leadership styles on employees.

In a study conducted by Petrović (2024) in hotels in the Republic of Serbia, it was observed that servant leadership has a positive effect on employees. This leadership style increases employee engagement, reduces negative job-related impacts such as burnout, and contributes to overall job satisfaction.

#### **4. RESULTS AND ANALYSIS**

A case study conducted within the Intercontinental Hotels Group revealed that the implementation of quality management principles contributes to greater employee loyalty, as it is based on employee care. The outcome of such practices is improved service quality (Petrović, 2013).

The analysis of the impact of different leadership styles leads to the conclusion that there are significant differences in their effects on employee performance in the hospitality industry. Numerous studies indicate that leadership can directly influence employee well-being, engagement, and job satisfaction, all of which contribute to the business success of hospitality establishments.

The results of the study (Kara et al., 2013) show that the transformational leadership style has a positive impact on the quality of work life among employees in five-star hotels. This approach helps reduce stress, increases job satisfaction, and strengthens the sense of belonging to the company. On the other hand, the transactional leadership style demonstrates fewer positive effects on employees, while the autocratic leadership style may result in heightened anxiety and job dissatisfaction.

The study of Llorens Montes et al., (2019) highlights the importance of leadership that directly enhances psychological strength and employee engagement. The findings suggest that leaders who delegate responsibility and promote employee autonomy achieve better job performance and lower staff turnover rates. Paradoxically, although servant leadership promotes care for employees, it did not produce the expected results in terms of increasing engagement.

In the paper Fouad (2019), the author emphasizes that both transformational and transactional leadership styles positively correlate with job satisfaction, whereas the laissez-faire style shows no significant effect. Transformational leaders foster creativity and innovation among employees, while transactional leaders provide clear structure and rewards, which can enhance motivation in certain organizational contexts.

According to Rabiul et al. (2021), the role of a leader's communication competence is emphasized as a key factor for employee engagement. Servant leadership, when combined with strong communication skills, can significantly enhance employee motivation. In contrast, transactional leaders, despite clearly defined goals, show weaker results in terms of employees' emotional connection to the organization.

Similarly, the study of Ozturk et al. (2021) indicates that servant leadership has a more pronounced impact on work engagement, fostering responsibility and a collegial atmosphere, than on overall job satisfaction. However, in dynamic environments that require quick and decisive managerial interventions, this type of leadership demonstrates lower effectiveness.



According to Stanojević (2012), leadership at the Hyatt Regency Belgrade is a crucial factor that contributes to achieving high service standards and enhancing employee engagement. Managers at this hotel apply various leadership styles, including transformational, transactional, and servant leadership. Each of these styles influences employee motivation, innovation, and service quality in different ways. Transformational leadership is frequently practiced at Hyatt and contributes to higher job satisfaction, greater loyalty, and reduced employee turnover. On the other hand, the autocratic leadership style shows negative effects, as it reduces motivation and employee engagement.

Maintaining high productivity remains a challenge for managers. To sustain a high level of productivity and employee motivation, continuous managerial development and adaptation of leadership styles to the specific needs of the hotel and the market is recommended.

Ji et al. (2022) studied the impact of participative leadership on hotel employees in China and concluded that this style has a strong influence on employee enthusiasm for work, as well as their behavior in direct service delivery. In contrast, enthusiasm is less evident under traditional leadership. These findings suggest that the application of appropriate leadership styles can contribute to improving hotel operations and employee satisfaction, as well as enhancing the customer experience and the hotel's competitiveness in the market.

## 5. CONCLUSION

Based on the analyzed studies on leadership in the hospitality industry, it can be concluded that there is no universal leadership model that can be applied across all hotel organizations. Different leadership styles bring various benefits and levels of efficiency in operations, as well as increased employee satisfaction. The research process is dynamic and should be continuous, as there is a constant pursuit of new findings aimed at overall business improvement and development.

Future research should focus on analyzing combined leadership styles, as the integration of different approaches may contribute to greater long-term sustainability and competitiveness in the hotel industry. Research efforts should also aim to improve the adaptation of leadership styles to the specific characteristics of hotels in various geographic and cultural contexts.

A key conclusion is that empowering leadership holds significant practical relevance in the hospitality industry. Employees on the front lines of guest interaction, when given decision-making autonomy, can improve service quality and contribute to the overall enhancement of business operations. Moreover, the autonomy delegated by leaders has a positive effect on employees' work enthusiasm, which in turn enhances the hotel's reputation.

Overall, it can be concluded that, for successful operations in the hospitality sector, it is essential to implement leadership styles that promote employee autonomy and thus contribute to improved service quality and market competitiveness.

## REFERENCES

- Al Khajeh, E. H. (2018). Impact of leadership styles on organizational performance. *Journal of human resources management research*, 1-10.
- Bass, B. M., & Riggio, R. E. (2006). *Transformational leadership* (2<sup>nd</sup> ed.). Psychology Press.
- Bavik, A., & Koseoglu, M. A. (2022). Intellectual structure of leadership studies in hospitality and tourism. *International Journal of Contemporary Hospitality Management*, 34(12), 4562–4591. <https://doi.org/10.1108/IJCHM-10-2021-1264>

- Bhatti, N., Maitlo, G. M., Shaikh, N., Hashmi, M. A., & Shaikh, F. M. (2012). The impact of autocratic and democratic leadership style on job satisfaction. *International Business Research*, 5(2), 192.
- Fahlevi, M., Aljuaid, M., & Saniuk, S. (2022). Leadership style and hospital performance: Empirical evidence from Indonesia. *Frontiers in Psychology*, 13, 911640. <https://doi.org/10.3389/fpsyg.2022.911640>
- Fouad, M. (2019). Impact of leadership style on employee job satisfaction in the hospitality industry. *International Journal of Heritage, Tourism and Hospitality*, 13, 1–12. <https://doi.org/10.21608/ijhth.2019.35101>
- Greenleaf, R. (1998). Servant leadership. In L. C. Spears (Ed.), *Insights on leadership* (pp. 55–74). John Wiley & Sons.
- Grudić Kvasić, S. (2018). The influence of leadership on organizational success in the hotel industry (Dissertation). University of Rijeka, Faculty of Economics. (in Croatian). <https://urn.nsk.hr/urn:nbn:hr:192:771498>
- Hu, J., & Liden, R. C. (2011). Antecedents of team potency and team effectiveness: An examination of goal and process clarity and servant leadership. *Journal of Applied Psychology*, 96(4), 851–862. <https://doi.org/10.1037/a0022465>
- Ji, L., Ye, Y., & Deng, X. (2022). From shared leadership to proactive customer service performance: A multilevel investigation. *International Journal of Contemporary Hospitality Management*, 34(11), 3944–3961. <https://doi.org/10.1108/IJCHM-11-2021-1237>
- Jovičić Vuković, A., Damnjanović, J., Papić-Blagojević, N., Jošanov-Vrgović, I., & Gagić, S. (2018). Impact of leadership on innovation: Evidence from the hotel industry. *Management: Journal of Sustainable Business and Management Solutions in Emerging Economies*, 23(3), 57–66. <https://doi.org/10.7595/management.fon.2018.0008>
- Kara, D., Uysal, M., Sirgy, M., & Lee, G. (2013). The effects of leadership style on employee well-being in hospitality. *International Journal of Hospitality Management*, 34, 9–18. <https://doi.org/10.1016/j.ijhm.2013.02.001>
- Kreitner, R., & Kinicki, A. (2012). *Organizational behavior*. McGraw-Hill Education.
- Lewin, K., Lippitt, R., & White, R. K. (1939). Patterns of aggressive behavior in experimentally created social climates. *Journal of Social Psychology*, 10, 271–301.
- Lin, M., Ling, Q., Luo, Z., & Wu, X. (2019). Why does empowering leadership occur and matter? A multilevel study of Chinese hotels. *Tourism Management Perspectives*, 32, 100556. <https://doi.org/10.1016/j.tmp.2019.100556>
- Llorens Montes, F., Huertas, I., & Rojo, A. (2019). Effects of different leadership styles on hospitality workers. *Tourism Management*, 71, 402–420. <https://doi.org/10.1016/j.tourman.2018.10.027>
- Lončar, J. (2023). Leadership in the function of improving the quality of services in the hotel industry (Doctoral dissertation). Singidunum University, Belgrade. (in Serbian).
- Luo, A., Guchait, P., Lee, L., & Madera, J. M. (2019). Transformational leadership and service recovery performance: The mediating effect of emotional labor and the influence of culture. *International Journal of Hospitality Management*, 77, 31–39. <https://doi.org/10.1016/j.ijhm.2018.06.004>
- Ozturk, A., Karatepe, O. M., & Okumus, F. (2021). The effect of servant leadership on hotel employees' behavioral consequences: Work engagement versus job satisfaction. *International Journal of Hospitality Management*, 97, 102994. <https://doi.org/10.1016/j.ijhm.2021.102994>

- Petrović, M. (2013). Caring for employees as a principle of quality management: A case study of the hotel chain Intercontinental Hotels Group. *Ekonomski signali*, 8, 1–17. (in Serbian).
- Petrović, M. (2024). Servant leadership and its impact on employees' psychological capital. *CORE*. (in Serbian).
- Rabiul, M. K., & Yean, T. F. (2021). Leadership styles, motivating language, and work engagement: An empirical investigation of the hotel industry. *International Journal of Hospitality Management*, 92, 102712. <https://doi.org/10.1016/j.ijhm.2020.102712>
- Stanojević, I. (2012). Leadership and hotel management in Belgrade on the example of the Hyatt Regency hotel (Master's thesis). Singidunum University, Belgrade. (in Serbian).
- Stavrinoudis, T., & Chrysanthopoulou, D. (2015). The role of leadership in building and managing corporate reputation of 4 and 5 star hotels. *Tourism and Hospitality Research*, 17. <https://doi.org/10.1177/1467358415613392>
- Stefanović, V. (2017). The influence of transformational leadership on the motivation of employees in tourism. Monograph, Faculty of Science and Mathematics, Niš. (in Serbian).
- Su, L., Houghton, J. D., Chen, S., & Zou, W. (2022). Does organizational empowerment promote self-leadership in hotel management? *Journal of Hospitality and Tourism Management*, 53(1), 165-175. <https://doi.org/10.1016/j.jhtm.2022.10.003>
- Vlahović, S. (2008). Leadership in modern organizations. *CID*. (in Serbian)



## CONFLICT MANAGEMENT STYLES IN PROJECT-BASED ORGANISATIONS: RELATION TO DEMOGRAPHIC FACTORS

Aleksandra Radić \*, Nenad Milijić

*University of Belgrade, Technical faculty in Bor, Serbia*

**Abstract:** During the project realization, disagreements arise and cannot be avoided. Project complexity, various participants, stakeholders' interests, task requirements, and tight project deadlines create an environment for conflict issues. Every individual engaged in the project responds to conflict differently and has a distinct conflict management strategy. Therefore, this research aims to get deeper insights into conflict management styles' differences in specific demographic characteristics. Empirical research was conducted to obtain this study's objective. A total sample of 114 employees from project-based organizations operating in the Republic of Serbia was collected. The findings of the ANOVA test revealed that participants' responses differed in terms of age, work experience, and project type. Findings provide valuable insights by examining differences in conflict management styles and identifying behavioral patterns and variations based on demographic factors.

**Keywords:** Conflict management styles, projects, ANOVA.

### 1. INTRODUCTION

Caused of uncertainty, the high degree of people diversity, different goals and motivations, conflicts have been considered an inevitable part of organizational life (İslamoğlu et al., 2008). Conflicts in the organization can be explained as interactive processes between social entities often followed by disagreements and dissonance (Afzalur Rahim, 2002).

In project-based organizations, that operate to satisfy specific customer requirements with high quality, on time, and within the budget, conflicts cannot be omitted (Prieto-Remón et al., 2015). Especially, if the project is realized in undetermined conditions, with low communication and feedback levels, poor contract management, and opposed motivations between project stakeholders, conflicts will arise (Khosravi et al., 2020). Tabassi et al. (2017) stated that conflict is not always considered unfavourable, but incredibly beneficial for problem-solving and generating new ideas.

Examination of conflicts in project management is a common research topic. Although studies emphasized the importance of different conflict management styles in the context of projects, less attention has been paid to the comparison of conflict styles between different roles

---

\* Corresponding author: aradic@tfbor.bg.ac.rs

Aleksandra Radić, ORCID: 0000-0003-4253-8004  
Nenad Milijić, ORCID: 0000-0001-8741-3892

within the project team, such as project managers and team members, as well as the influence of specific project-based organization characteristics on the conflict style.

This points to the need for a deeper understanding of how context and role in a team shape conflict management styles, which is the basis for further research within this paper. In light of increasing interest in management of conflicts in projects, it is important to explore the influence of demographic factors. Therefore the paper objective is to get deeper insights about how conflict management styles differs in relation to demographic specificities.

The paper is organized as follows. Literature Review focuses attention on conflict management theory and conflict management styles. Research Methodology describes methodology used for achieving study objectives. Results and Discussion present the main results and association with previous literature findings. Conclusion deals with summarization, study implications, limitations and future research directions.

## **2. THEORETICAL BACKGROUND**

Performances of project-based organizations often rely on project teams and project managers' expertise, tendency to competitiveness, and intergroup cohesive relations. Nevertheless, managing conflicts is also one of the key skills needed to finish the project successfully.

Many theories offer different theoretical models to define the individual's behavior in conflict and detect his/her conflict-handling approach. One of the most popular is the two-dimensional model proposed by Blake and Mouton in 1964. This model is also known as The Dual Concern Model and includes two dimensions - concern for self (low and high) and concern for others (low and high) (Rahim & Magner, 1995; De Dreu et al., 2001).

The dimension "concern for self" refers to the extent to which an individual tries to satisfy personal needs or beliefs. Similarly, the dimension "concern for others" refers to respecting the needs of others. In combination, these two dimensions indicate five different styles of managing interpersonal conflict (Figure 1).

The Avoiding style, also known as the ignorance style, is related to low concern for self and low concern for others, too. This style can be described by withdrawal behavior, no confrontation with others (Shabani et al., 2022), and a tendency to minimize addressing the conflict, either ignoring it (Montes et al., 2012). Although this style can be seen as the most unsuitable for an organizational environment, sometimes it is a wise choice when conflict by itself is unimportant and can be set aside (Wilmot & Hocker, 2017).

The Dominating style involves high concern for self and low concern for others. This style is also ineffective and inappropriate for social relationships, but it has been found useful for goal-related organizations such as project-based organizations (Gross & Guerrero, 2000). An individual with this dominant style might use authority strategies and social pressure to accomplish a project goal.

Compromising style refers to a moderate concern for self and others. This conflict management approach suggests that both parties should "give something" to "take something" (Shabani et al., 2022). This style tends to an intermediate position and splits the differences between conflict parties (Gross & Guerrero, 2000).

Individuals who use the Obliging style have a greater concern for others than for themselves. They usually appreciate other's needs more than their own interests. Obliging is associated with tendency to please the other side, passively accepting the others beliefs (Rahim & Magner, 1995). In disagreements of two sides, where one is on the higher hierarchy, obliging can be reasonable style for managing the conflict (Wilmot & Hocker, 2017).

The Integrating style is related to high concern for self and high concern for others. It is one of the most appropriate styles that focus on problem-solving collaboratively by searching for new and creative solutions to satisfy the needs of all parties (Gross & Guerrero, 2000). Nevertheless, it is a high-energy style and sometimes can be seen as manipulative (Wilmot & Hocker, 2017).

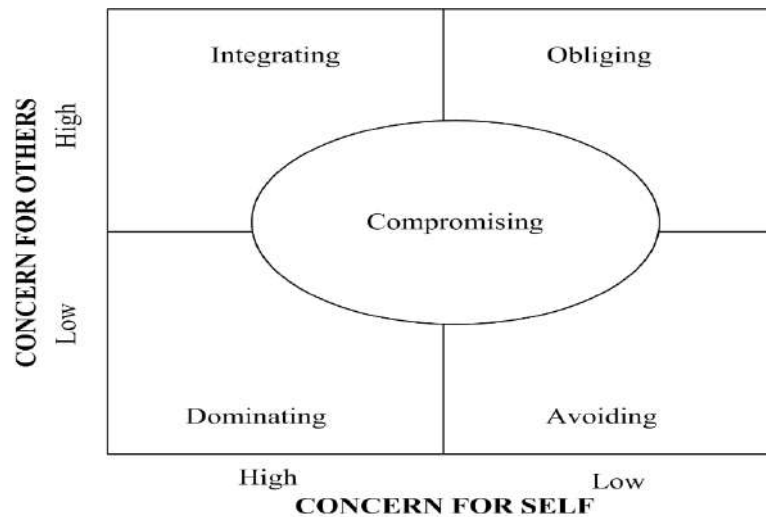


Figure 1. The Dual Concern Model (Rahim & Magner, 1995)

The study conducted by Mohammed et al. (2008) identified significant connections between Hofstede's cultural dimensions and the tendency of project managers to adopt a certain style of conflict management. For instance, the study showed that avoidance of uncertainty is correlated with a project manager's tendency to use an Avoiding style. On the other hand, Prieto-Remón et al. (2015) research study showed that project managers adopt Dominating and Compromising styles in most cases. Kowszyk et al. (2023) explored five conflict management styles within the mining sector by conducting interviews with managers from four mines in Latin America and examining differences between preferred styles.

Wang & Liu (2021) assessed cooperative conflict management styles as a mediator among political skills and relationship quality. The research confirmed a significant and positively associated relationship with the domination of integrating and compromising styles as the most frequently applied styles in construction projects.

Zhang et al. (2015) investigated the relationship between emotional intelligence, conflict management styles, and innovation performance in the construction industry. Integrating style is the most preferred one, followed by compromising and dominating styles. Tabassi et al. (2019) evaluated the impact of team leaders' conflict management styles on team performance, with the mediating role of team coordination in the construction industry. This study highlighted that team leaders most frequently choose avoidance and cooperative approaches to manage conflicts.

Wu et al. (2018) analyzed the relationship between contractual flexibility and project success of megaprojects and found that contractual flexibility was positively associated with project success. When adding conflict types as a mediator, the relationship was significantly weakened.

As above mentioned studies have demonstrated that Rahim and Magner's (1995) concept can be applied from psychology to project management, this study aims to examine different conflict management styles in project.

### 3. RESEARCH METHODOLOGY

This study employed sampling and survey techniques. To identify the conflict management styles among project managers and members of project teams, an anonymous survey was completed in 2023. Participant were informed that their answers would be used for preparing scientific research. Paper questionnaires were distributed directly to organizations, while an online version was sent through the LinkedIn network. In both cases, the survey employed a five-point Likert scale to assess respondents' agreement with the statements provided in the questionnaire, where 1 represents the least agreement and 5 indicates the greatest agreement.

Participants in the face-to-face survey were asked to indicate the extent of their agreement with various statements by circling a number on a five-point Likert scale. For the online survey, a questionnaire was created using Google Forms.

The questionnaire items are adapted from existing literature on conflict management styles (Rahim & Magner, 1995; Wilmot & Hocker, 2017), and consists of two parts. The first part includes demographic questions such as gender, age, project position, educational level, years of work experience, company size, and type of project. The second part of the questionnaire comprises 25 questions, corresponding to the five conflict management styles.

The reliability of the measuring instrument was determined by evaluating the internal consistency coefficients of the questionnaire through the Cronbach alpha test. According to the results, for all five groups of questions, regarding five conflict management styles, Cronbach's alpha coefficients exceed the minimum recommended value of 0.70 (Nunnally & Bernstein, 1994).

Furthermore, to explore the influence of demographic factors on preferred conflict management styles, an Analysis of variance (ANOVA) test was utilized. ANOVA was performed in the IBM SPSS v. 25 software package.

### 4. RESULTS AND DISCUSSION

Out of a total of 128 respondents in the research, 69 preferred a Compromise style, 45 preferred an Integrative style, and the rest 14 chose an Avoidance, Dominating, or Obliging style. Due to the pronounced unevenness in the distribution of preferred styles of conflict management among respondents, which can affect the validity of statistical processing and group comparisons, the analysis was restricted to styles with a sufficient number of cases, namely Compromising and Integrating which is 114.

The study involved more females than males, the most of them are 26-45 year old. Also, study involved more team members than project managers. The most of the respondents have high school degree and previous work experience of 6-10 years, work in small and medium project-based organizations mostly related to industrial projects. For more details, see Table 1.

*Table 1.* Demographic characteristics of the research sample (N = 114)

Variables	Category	N	Percentage %
Gender	Male	45	39,5
	Female	69	60,5
Age	Less than 25 years	7	6,1
	26 – 35 years	43	37,7
	36 – 45 years	19	34,2
	46 – 55 years	18	15,8
	Above 56 years	7	6,1
Project position	Project manager	27	23,7
	Team member	87	76,3

Table 1. (continued)

Variables	Category	N	Percentage %
Education	Elementary school	5	4,4
	High school	65	57,0
	Higher education	14	12,3
	University	30	26,3
Work experience	Less than 5 years	26	22,8
	6 – 10 years	41	36,0
	11 – 20 years	25	21,9
	21 – 30 years	17	14,9
	Above 31 years	5	4,4
Company size	Less than 10 employees	1	0,9
	11 – 50 employees	16	14,0
	51 – 250 employees	92	80,7
	Above 251 employees	5	4,4
Project type	Construction projects	14	12,3
	Industrial projects	87	76,3
	IT projects	6	5,3
	Event organizing projects	7	6,1

Table 2 presents the mean values of participant responses on compromising and integrating questions regarding demographic variables and its categories.

Table 2. Compromising and Integrating styles mean values

Variables	Category	Compromising (mean value)	Integrating (mean value)
Gender	Male	4.07	3.80
	Female	4.22	4.08
Age	Less than 25 years	4.26	4.09
	26 – 35 years	4.39	4.09
	36 – 45 years	4.05	3.99
	46 – 55 years	3.77	3.69
	Above 56 years	4.31	3.63
Project position	Manager	4.10	4.14
	Team member	4.18	3.91
Education	Elementary school	3.88	3.92
	High school	4.11	3.89
	Higher education	4.36	4.03
	University	4.22	4.12
Work experience	Less than 5 years	4.54	4.35
	6 – 10 years	4.18	3.83
	11 – 20 years	4.04	4.08
	21 – 30 years	3.91	3.76
	Above 31 years	3.52	3.24
Company size	Less than 10 employees	3.80	4.60
	11 – 50 employees	4.09	4.01
	51 – 250 employees	4.17	3.91
	Above 251 employees	4.32	4.68
Project type	Construction projects	3.54	3.03
	Industrial projects	4.29	4.08
	IT projects	4.25	4.75
	Event organizing projects	3.66	3.86

ANOVA testing was conducted to examine how demographic factors influence preferred conflict management styles. The results are presented in Table 3.



Table 3. ANOVA test results

Demographic characteristics	Conflict management style	Significance		Remark
		F	p	
Gender	Compromising	1.055	0.307	n.s.
	Integrating	2.996	0.086	n.s.
Age	Compromising	2.609	0.039	**
	Integrating	1.074	0.373	n.s.
Project position	Compromising	0.203	0.653	n.s.
	Integrating	1.535	0.218	n.s.
Education	Compromising	0.680	0.566	n.s.
	Integrating	0.559	0.643	n.s.
Work experience	Compromising	3.422	0.011	**
	Integrating	3.132	0.018	**
Company size	Compromising	0.199	0.897	n.s.
	Integrating	1.564	0.202	n.s.
Project type	Compromising	4.345	0.003	*
	Integrating	7.087	0.000	*

Notes: n.s. non-significance; \* statistically significant at 0.01 level; \*\* statistically significant at 0.05 level.

According to the results (Table 3), participants' responses were found not to be different regarding gender. Previous literature (Havenga, 2006) states that it was found that women are more integrated than men. However, results presented in Table 2 indicate that mean values of integrating style are higher for women (4.08) than men (3.80), but this difference is not statistically significant.

Participants' responses were found different regarding age in the case of compromising style. The integrating style means value somehow declines with age, but this is not the case with compromising style. To detect the main difference in compromising style regarding age, an additional ANOVA post-hoc test was performed. Results showed that between 26-35 and 46-55-year-old participants exists a statistically significant difference (mean difference = 0.619; Sig. = 0.028).

Furthermore, participants' responses were found not to be different regarding project position. However, previous findings concerning the relationship between conflict styles and hierarchical levels show that employees on higher levels prefer dominating and compromising styles the most, while employees on lower levels usually prefer avoiding styles (Brewer et al., 2002). Additionally, Slabbert (2004) examined traditional organizations and found that managers utilize low cooperation styles, while on the other hand, their subordinates prefer high cooperation styles. However, this study examines employees of project-based organizations that are particularly different from traditional hierarchy and rigid organizational structure (Mitrev et al., 2017).

The difference in education levels was not found to be statistically significant based on the ANOVA test. Mean values for both considered conflict styles increase with the respondents' level of education. This finding aligns with the research conducted by İslamoğlu et al. (2008), which indicates that employees with higher education levels (BSc degree and above) tend to use an integrating style more than high school graduates.

Additionally, the results of this study indicate that the mean values for both conflict styles decline as employees gain more work experience. These results are contrary to the findings of Drory and Ritov (1997) which emphasized that integrating and compromising styles are chosen more often by experienced employees than by inexperienced ones. Differences observed in this study are statistically significant for both styles. Post-hoc test results revealed significant differences between participants with less than 5 years of work experience and those

with 21-30 years of experience (mean difference = -0.633; Sig. = 0.048), as well as between participants with less than 5 years of experience and those with over 31 years (mean difference = -1.018; Sig. = 0.039). This can be explained by the statement that integrating style involves a high level of cooperation, the search for win-win solutions, which can seem idealistic, requires a lot of energy, and by the fact that experienced employees are more likely to take a position of authority.

The participant's responses were found not to be different regarding company size. These findings can be supported by statements that conflict management styles, including Integrating and Compromising, depend more on personal skills, values, and attitudes than on organizational factors (Rahim & Magner, 1995). Additionally, participants' responses were found to be different regarding project type and this difference is statistically significant for both styles. When analyzing the Compromising style, post-hoc test results indicated significant differences between participants engaged in construction projects and those in industrial projects (mean difference = - 0.745; Sig. = 0.004).

Furthermore, when analyzing Integrating style, post-hoc test results show significant differences between participants engaged in construction projects and those in industrial projects (mean difference = - 1.051; Sig. = 0.000), and between participants engaged in construction projects and those in IT projects (mean difference = -1.721; Sig. = 0.001).

Construction projects typically require a more authoritarian hierarchy and careful monitoring of deadlines and budgets, leaving little space for compromise (Lawani et al., 2024). In contrast, industrial projects can be managed more collaboratively, with greater interdependence among sectors such as production, engineering, and logistics. On the other hand, since IT projects utilize the agile concept (Crawford et al., 2014), employees involved in these projects have a greater need for integrative solutions and flexibility.

## 5. CONCLUSION

It is important to have comprehensive knowledge about conflict styles to manage and solve interpersonal conflicts. Furthermore, it is valuable to recognize their main relation to demographic factors. Therefore, this study employed an ANOVA test to analyze the influence of demographic characteristics on conflict styles.

The study results provide certain implications. Although no statistically significant difference was found in conflict style preferences according to gender, position in the project, education, and company size, certain tendencies were observed. For instance, females are more inclined to an Integrating style, while a higher level of education means a more pronounced use of both Integrative and Compromising styles.

On the other hand, factors like age, work experience, and project type showed a statistically significant impact. As younger and less experienced employees prefer cooperative styles, this may indicate changes in attitudes and energy needed to resolve conflicts as employees gain experience and assume more responsible positions. Additionally, employees on construction projects prefer less cooperative styles, while integrative and compromising styles are more often applied in IT and industrial projects. These findings indicate that the project context and organizational structure may shape conflict resolution.

Besides theoretical and practical implications, this study has some limitations. The observed sample size is not sufficient and reliable for generalizing the results. In this study, the influence of demographic characteristics is analyzed for only two of five conflict management styles. To overcome this limitation, future research should be directed to a comprehensive analysis of all conflict management styles based on a larger sample.

## ACKNOWLEDGEMENT

The research presented in this paper was carried out with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia within the framework of financing scientific research work at the University of Belgrade, Technical Faculty in Bor, in accordance with the contract with registration number 451-03-137/2025-03/ 200131.

## REFERENCES

- Afzalur Rahim, M. (2002). Toward a theory of managing organizational conflict. *International journal of conflict management*, 13(3), 206-235. <https://doi.org/10.1108/eb022874>
- Brewer, N., Mitchell, P., & Weber, N. (2002). Gender role, organizational status, and conflict management styles. *International Journal of Conflict Management*, 13(1), 78-94. <https://doi.org/10.1108/eb022868>
- Crawford, B., Soto, R., de la Barra, C. L., Crawford, K., & Olguín, E. (2014). Agile software teams can use conflict to create a better products. In *HCI International 2014-Posters' Extended Abstracts: International Conference, HCI International 2014, Heraklion, Crete, Greece, June 22-27, 2014. Proceedings, Part I 16* (pp. 24-29). Springer International Publishing. [https://doi.org/10.1007/978-3-319-07857-1\\_5](https://doi.org/10.1007/978-3-319-07857-1_5)
- Davaei, M., Gunkel, M., Veglio, V., & Taras, V. (2022). The influence of cultural intelligence and emotional intelligence on conflict occurrence and performance in global virtual teams. *Journal of International Management*, 28(4), 100969. <https://doi.org/10.1016/j.intman.2022.100969>
- De Dreu, C. K., Evers, A., Beersma, B., Kluwer, E. S., & Nauta, A. (2001). A theory-based measure of conflict management strategies in the workplace. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior*, 22(6), 645-668. <https://doi.org/10.1002/job.107>
- Drory, A., & Ritov, I. (1997). Effects of work experience and opponent's power on conflict management styles. *International Journal of Conflict Management*, 8(2), 148-161. <https://doi.org/10.1108/eb022794>
- Gross, M. A., & Guerrero, L. K. (2000). Managing conflict appropriately and effectively: An application of the competence model to Rahim's organizational conflict styles. *International Journal of Conflict Management*, 11(3), 200-226. <https://doi.org/10.1108/eb022840>
- Havenga, W. (2008). Gender and age differences in conflict management within small businesses. *SA Journal of human resource management*, 6(1), 22-28. <http://dx.doi.org/10.4102/sajhrm.v6i1.143>
- İslamoğlu, G., Börü, D., & Birsal, M. (2008). Conflict management styles in relation to demographics. *Boğaziçi Journal*, 22(1-2), 107-140. <http://dx.doi.org/10.21773/boun.22.1.7>
- Khosravi, P., Rezvani, A., & Ashkanasy, N. M. (2020). Emotional intelligence: A preventive strategy to manage destructive influence of conflict in large scale projects. *International Journal of Project Management*, 38(1), 36-46. <https://doi.org/10.1016/j.jiproman.2019.11.001>
- Kowszyk, Y., Vanclay, F., & Maher, R. (2023). Conflict management in the extractive industries: A comparison of four mining projects in Latin America. *The Extractive Industries and Society*, 13, 101161. <https://doi.org/10.1016/j.exis.2022.101161>

- Lawani, K., Arias Abad, L. A., Craig, N., Hare, B., & Cameron, I. (2024). Exploring emotional intelligence and conflict management styles in Dominican Republic construction industry. *Journal of Engineering, Design and Technology*, 22(1), 89-119. <https://doi.org/10.1108/JEDT-09-2021-0485>
- Miterev, M., Mancini, M., & Turner, R. (2017). Towards a design for the project-based organization. *International Journal of Project Management*, 35(3), 479-491. <https://doi.org/10.1016/j.ijproman.2016.12.007>
- Mohammed, U. K., Prabhakar, G. P., & White, G. (2008). Culture and conflict management style of international project managers. *International Journal of Business Management*, 3(5), 3-11. <http://dx.doi.org/10.5539/ijbm.v3n5p3>
- Montes, C., Rodríguez, D., & Serrano, G. (2012). Affective choice of conflict management styles. *International Journal of Conflict Management*, 23(1), 6-18. <https://doi.org/10.1108/10444061211199304>
- Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric theory 3rd ed., New York.
- Prieto-Remón, T. C., Cobo-Benita, J. R., Ortiz-Marcos, I., & Uruburu, A. (2015). Conflict resolution to project performance. *Procedia-Social and Behavioral Sciences*, 194, 155-164. <https://doi.org/10.1016/j.sbspro.2015.06.129>
- Rahim, M. A., & Magner, N. R. (1995). Confirmatory factor analysis of the styles of handling interpersonal conflict: First-order factor model and its invariance across groups. *Journal of Applied Psychology*, 80 (1), 122–132. <https://psycnet.apa.org/doi/10.1037/0021-9010.80.1.122>
- Shabani, G., Behluli, A., & Qerimi, F. (2022). The impact of conflict management styles on organizational performance: A comparative analysis. *Emerging Science Journal*, 6(4), 758-775. <http://dx.doi.org/10.28991/ESJ-2022-06-04-07>
- Slabbert, A. D. (2004). Conflict management styles in traditional organisations. *The Social Science Journal*, 41(1), 83-92. <https://doi.org/10.1016/j.sosci.2003.10.007>
- Tabassi, A. A., Abdullah, A., & Bryde, D. J. (2019). Conflict management, team coordination, and performance within multicultural temporary projects: Evidence from the construction industry. *Project Management Journal*, 50(1), 101-114. <https://doi.org/10.1177/8756972818818257>
- Tabassi, A. A., Bryde, D. J., Abdullah, A., & Argyropoulou, M. (2017). Conflict management style of team leaders in multi-cultural work environment in the construction industry. *Procedia Computer Science*, 121(2), 41-46. <http://dx.doi.org/10.1016/j.procs.2017.11.007>
- Wang, D., & Liu, Y. (2021). The effect of political skill on relationship quality in construction projects: The mediating effect of cooperative conflict management styles. *Project Management Journal*, 52(6), 563-576. <https://doi.org/10.1177/87569728211037503>
- Wilmot, W., & Hocker, J. L. (2017). Interpersonal conflict, 10th edition. McGraw-Hill Education. <https://doi.org/10.1177/87569728211037503>
- Wu, G., Zhao, X., Zuo, J., & Zillante, G. (2018). Effects of contractual flexibility on conflict and project success in megaprojects. *International Journal of Conflict Management*, 29(2), 253-278. <https://doi.org/10.1108/IJCMA-06-2017-0051>
- Zhang, S. J., Chen, Y. Q., & Sun, H. (2015). Emotional intelligence, conflict management styles, and innovation performance: An empirical study of Chinese employees. *International Journal of Conflict Management*, 26(4), 450-478. <https://doi.org/10.1108/IJCMA-06-2014-0039>



## DYNAMIC TRAFFIC LANES STRATEGY MANAGEMENT IN SMART CITY

Amit Vujic<sup>1</sup>\*, Vladimir Tomasevic<sup>2</sup>, Vladica Ristic<sup>3</sup>, Marija Maksin<sup>1</sup>

<sup>1</sup> International Research Academy of Science and Art, Belgrade, Serbia

<sup>2</sup> School of Engineering Management, Union University "Nikola Tesla", Belgrade, Serbia

<sup>3</sup> Faculty of Applied Ecology "Futura", Metropolitan University, Belgrade, Serbia

**Abstract:** Integrated domains, urban mobility, information and communication technologies (ICT), advanced parking solutions, and the shared economy drive the evolution of smart city ecosystems. This paper explores the strategic management of digitized urban street lanes as a transformative tool to improve traffic efficiency and overall city security. Traditional lane configurations are typically static, denoted as (n+n), where (n) lanes are permanently assigned to each direction. This assumes symmetric traffic distribution, which fails for real-time directional imbalances. Our approach defines two dynamic directional lane vectors {A} and {B} representing the active lane allocations, with (i+j=2n), the total number of available lanes. This allows real-time reallocation based on sensed traffic asymmetry. Our methodology transcends mere technological deployment, targeting infrastructure redesign for improved adaptability, security, and resilience. The proposed model enables streets to respond fluidly to dynamic demand, mitigating congestion, reducing fuel consumption and emissions, and reclaiming valuable urban time otherwise lost in traffic. A real-life case study illustrates the methodology's feasibility. We further validate our concept using a modified Nagel–Schreckenberg cellular automaton simulation enriched with game theory principles. This methodology provides a scalable path toward safer, more sustainable, and strategically managed urban infrastructure.

**Keywords:** Smart City, Floating Car Data, Cell Automata, Strategy Management, Security Systems.

---

\* Corresponding author: [avujic@eplus.systems](mailto:avujic@eplus.systems)

Amit Vujic, ORCID: 0009-0007-4901-8112

Vladimir Tomasevic, ORCID: 0000-0001-9845-2950

Vladica Ristic, ORCID: 0000-0002-8605-1698

Marija Maksin, ORCID: 0000-0002-3695-5824

## 1. INTRODUCTION

Considering the smart city ecosystem, several key domains are foundational: urban mobility, information and communication technologies (ICT), advanced parking solutions, strategic security management, and the shared economy. These domains jointly accelerate the transformation of cities toward higher intelligence, efficiency, and resilience.

Conventional infrastructure relies on static traffic lane configurations as commonly symmetric, denoted as  $n + n$  street lanes permanently allocated to each direction, irrespective of fluctuating traffic demand. This configurations usually lead to significant congestion and high inefficiency in peak hours.

In contrast, we propose a dynamic model for lane reallocation, guided by sensor inputs, FCD inputs and simulation models.

We define real-time lane allocation as directional vectors:

$$\text{vec}\{A\} = [a_1, a_2, \dots, a_i], \text{vec}\{B\} = [b_1, b_2, \dots, b_j], \text{with } i + j = 2n \quad (1)$$

Here,  $\text{vec}\{A\}$  and  $\text{vec}\{B\}$  represent the current lane assignments for each traffic direction, while  $a_k, b_k$  represent operational states or capacity metrics of each lane segment. This representation enables responsive urban traffic optimization, enhancing throughput and safety in dynamically congested areas.

Our approach is not solely techno-centric but includes the redesign and strategic management of infrastructure in support of urban intelligence and security systems (Runyoro & Ko, 2013).

While techno-centric methods dominate smart city literature, they often conflict with sustainability goals when implemented without contextual constraints. (Munhoz et al., 2020)

A wide body of research addresses intelligent mobility through high-investment projects: solar-powered roads, piezoelectric surfaces, inductive charging lanes, musical and weigh-in-motion roads, and smart intersections utilizing V2X and VANET technologies. (Umedu, 2010; Atici et al., 2011; Toh, 2020).

However, the real-world scalability of these technologies often remains limited.

Despite multiple approaches to intelligent urban mobility, there is no universal consensus on optimal methodology.

Many proposed systems rely on brute-force deployment of technology without integration into shared economy models or behavioral infrastructure adaptation.

End user interaction is often minimal, with limited open data usage and negligible adaptability to existing infrastructure norms.

Shared economy concepts such as ride-sharing, vehicle pooling, high-occupancy vehicle lanes (HOV), and floating parking units (FPU) (Vujic, 2014) are essential but underdeveloped in major smart city deployments.

For example, bicycle sharing, scooter fleets, and car-sharing models have proven beneficial but remain marginal in terms of systemic integration.

Alternative transportation and sustainable transit methods - like Hyperloop systems (Cohn, 2021) - offer promise but require complementing structural reforms in urban layouts. Technological innovation continues to drive discussions about mobility intelligence (Soriano et al., 2018), but smarter traffic flow requires more than innovation: it requires predictive responsiveness.

Integrating smart infrastructure with responsive building and street networks can vastly improve both urban and rural ecosystems. Selective lane restrictions based on traffic types or

schedules, when managed dynamically, can encourage non-traditional transit adoption and help reduce private car dependency.

Redefining transport infrastructure involves not only technological advancement but also the optimization of existing assets through dynamic reconfiguration. As mobility becomes more intelligent, it increases its capacity to integrate simulations results, sensor data, and socioeconomic modeling systems.

Empirical efforts, such as sociology-technical test-beds for smart urban mobility (Fryszman et al., 2019), illustrate the potential of simulation-based design and participatory governance.

This paper builds on those findings by developing its own simulation framework using Python (Lutz, 2013), C++ (Stroustrup, 2000), and Monte Carlo techniques (Rubinstein & Kroese, 2008) to analyze lane digitization scenarios.

Our proposed methodology, grounded in theory and tested through simulation, demonstrates how cities can apply vector-based lane optimization to improve real-time flow, reduce emissions, and enhance strategic security responsiveness.

## 2. LITERATURE REVIEW

In the context of techno-centric smart city development, this paper highlights selected key approaches relevant to mobility and infrastructure management. A comprehensive review is beyond this paper's scope; however, the following notable models serve as foundational references for advancing smart mobility and lane management systems.

**Multi-modal Integration:** This approach emphasizes the unification of different transport modes - private vehicles, metro, buses, and shared mobility services - into a cohesive system for optimized movement of people and goods (Bagloee, 2019). While multi-modal systems significantly improve transport intelligence and urban sustainability, they typically require large-scale infrastructure investments and policy coordination.

**Vehicle Quota System (VQS):** This strategy is designed for cities with limited spatial capacity, such as Singapore. It controls the vehicle population through a certificate of entitlement (COE) scheme that regulates ownership based on vehicle type and engine capacity. VQS ensures a balanced load on urban roads and supports long-term traffic and environmental stability (Manasa, 2018).

**Floating Car Data (FCD):** FCD uses timestamped GPS and velocity data from participating vehicles to describe vehicle movement in a Lagrangian frame, unlike stationary traffic monitors that provide Eulerian views. FCD transforms vehicles into mobile sensors and enables real-time adaptive traffic management, making it an enabler for both efficiency and surveillance-supportive strategies (Runyoro & Ko, 2013).

Despite these advances, traffic lanes in both urban and rural environments are still largely treated as static infrastructure, with fixed directional configurations ( $n+n$  lanes). Urban planners tend to assume these parameters are constant in simulations and design, rarely addressing dynamic reallocation.

When recurring congestion arises, traditional remedies include costly street reconstruction, re-timing traffic lights, or introducing HOV and yellow lanes. However, such interventions do not optimize existing lane usage or account for directional imbalance-where one side of a ( $n+n$ ) street may be heavily congested while the other remains underused.

In modern smart cities, the concept of Digitally Structured Lanes (DSL) addresses directional traffic imbalance by enabling real-time reconfiguration of lane assignments.

Given a total of  $2n$  available lanes, the system dynamically redistributes them into directional allocations represented by vectors:

$$\text{vec}\{A\} \text{ and } \text{vec}\{B\}, \text{ where } |\text{vec}\{A\}| = i, |\text{vec}\{B\}| = j, \text{ and } i + j = 2n \quad (2)$$

The goal is to achieve temporal equilibrium by adjusting  $i$  and  $j$  based on traffic flow asymmetry. Typical reconfiguration scenarios include allocations such as:

$$(i, j) \in \{(0, 6), (1, 5), (2, 4), (4, 2), (5, 1), (6, 0)\} \quad (3)$$

for  $n = 3$ .

These dynamic lane states replace traditional static models like (3, 3), which assume symmetric flow, and omit configurations like (1, 1), (2, 2), (4, 4), which are not effective for congestion mitigation and are excluded for scope and clarity.

The DSL concept is intended to provoke city planners to rethink traffic architecture as adaptive and programmable infrastructure. This model not only increases throughput and reduces congestion but also introduces mechanisms for emergency lane control, prioritized security routing, and adaptive lock-down enforcement in crisis scenarios.

The objective is to elevate urban intelligence by embedding real-time street flow optimization as a core stage in infrastructure development.

As part of this, our methodology integrates cellular automata modeling, specifically a modified Nagel–Schreckenberg model to simulate directional lane transformation and flow stability (Aubert et al., 2017; Nagel, 2016).

A pilot application of this DSL methodology was tested in the eastern segment of Mihajlo Pupin Boulevard in Belgrade, Serbia. This case study demonstrates how urban segments can be evaluated for dynamic lane eligibility and digitization readiness.

Figure 1 illustrates a 1,100-meter stretch of Mihajlo Pupin Boulevard where the proposed DSL simulation was conducted.

This street section was evaluated for dynamic lane transformation feasibility based on real-time directional traffic flow analysis and infrastructure adaptability

### 3. DATA AND METHODOLOGY

The process of implementing Digitally Structured Lanes (DSL) begins with a detailed assessment of existing street conditions-referred to as "Stage 1" in Table 1. The goal is to determine whether specific segments are eligible for digitization, considering not only technical feasibility but also their potential to enhance overall smart city intelligence.

The methodology is explicitly designed to balance cost-efficiency, infrastructure sustainability, and strategic urban priorities. Streets identified as candidates for DSL implementation are expected to return value through: - Increased mobility intelligence, - Reduced traffic congestion and travel time, and greater resilience during high-density or emergency events.

Moreover, the redesign aligns with broader "security-centric urban planning". By digitising lanes, cities will gain adaptive capabilities that can support real-time emergency routing, dynamic lock-downs, and prioritised transit flows in response to security threats or disruptions.



Table 1. Proposed steps for DSL analysis and eligibility evaluation

Stage	Description
1	Identification of urban traffic hot spots where mobility efficiency and security responsiveness can be enhanced through DSL;
2	Analysis of current street dynamics based on the on the field observations and modified Nagel–Schreckenberg cellular automata model supported by Monte Carlo simulations;
3	Estimation of economic and temporal losses due to congestion in the existing (static) lane configuration, derived from simulation outputs;
4	Estimation of projected savings and performance improvements using simulated DSL reconfiguration;
5	Creation of a multi-criteria decision-support matrix to assess feasibility, return on investment, and security performance trade-offs

### 3.1. Hot areas identification and modified Nagel–Schreckenberg model

To monitor and simulate traffic behaviour in high traffic street lanes, this study employs a modified "Nagel–Schreckenberg cellular automaton model" (Wolfram, 2002). The selected street segment is divided into uniform spatial units called "smartCells", each 8 meters in length. This cell size reflects the average footprint of a passenger vehicle, including a safe following distance, as validated in previous works (Nagel, 2016).

Each vehicle occupying a smartCell operates with a speed between  $V_0$  and  $V_{max}$ , with stopped vehicles assumed to have a speed of  $V_0$ . The maximum number of vehicles in a lane is calculated as  $MaxVehicles = LaneLength/8$

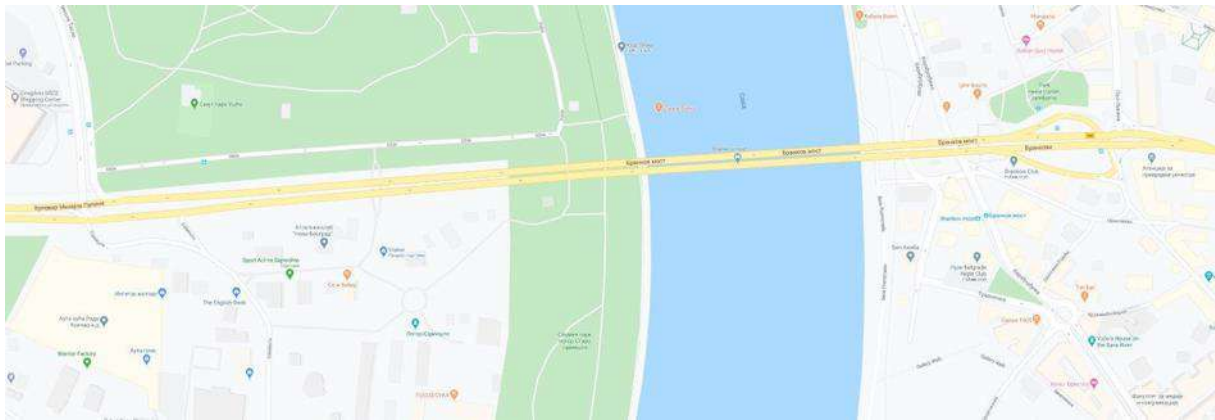


Figure 1. Segment of Mihajlo Pupin Boulevard (1,100 meters) in Belgrade, Serbia, selected for application of the DSL (Digitally Structured Lanes) simulation. (Google Maps, 2025)

A standard street lane segmentation according to modified Nagel–Schreckenberg model is illustrated in Figure 2.

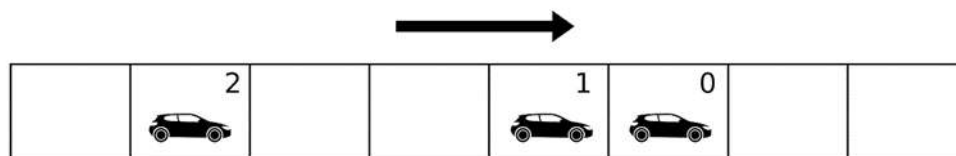


Figure 2. Street lane segmentation according to modified Nagel–Schreckenberg model

(Maksin & Ristić & Vujić, 2018)

Based on this framework, the following assumptions and structural inputs are defined for the Mihajlo Pupin Boulevard test case:

Focus is on observed "peak hour periods": 08:00–10:00, 13:00–14:00, and 17:00–19:00.

Each input point (Ai1, Ai2, Bi1, Bi2) is linked to a random generator that creates 1 vehicle every 4 to 8 seconds. During morning peaks, east to west or "North Vector" (vec {A}) experiences increased pressure. In such cases, output points (Bo1, Bo2) release vehicles randomly every 60 to 80 seconds, simulating typical congestion bottlenecks.

These inputs allow us to model "congestion dynamics, directional imbalance", and energy losses. The simulation also estimates "emissions and productivity loss" based on fuel types and average passenger density.

This model is not only a mobility optimiser but also supports "strategic simulation" for emergency lane activation, rerouting during security threats, and predictive congestion monitoring.

The framework was implemented in Python using the 'pyspy' symbolic computing package (Meurer, 2021), with performance-critical components written in C++.

### 3.2. Existing Street State Analysis

The current state of the monitored street segment was analysed by estimating traffic volume and congestion patterns across a one-month period, focusing on four daily peak hours.

In the analysed urban area, rush hour periods are observed in the morning (08:00–10:00) and afternoon (13:00–14:00 and 17:00–18:00).

While this analysis is based on empirical observation, more precise congestion estimates could be obtained through field data collection or by leveraging Floating Car Data (FCD) techniques (Runyoro & Ko, 2013).

During congestion, an asymmetrical load distribution is observed. In morning peak hours, the "North Vector" reaches 100% capacity, while the west to east or "South Vector" (vec {B}) operates at under 50% capacity. This imbalance is mirrored in the afternoon, when the South Vector becomes saturated.

On average, this leads to 120 hours of traffic congestion per month (30 days  $\times$  4 hours/day), with only three lanes actively congested while the opposing three lanes are underutilised.

The following direct consequences of congestion are analysed in this section:

- Estimated gasoline consumed by idling vehicles;
- Productivity loss from wasted working hours;
- CO2 emissions generated.

Indirect effects such as driver stress, reduced cognitive focus, and social fatigue are outside the scope of this paper but may offer avenues for future research.

#### A) Estimated Gasoline Consumption

The EU has set mandatory CO2 emission reduction targets for new vehicles-130 g/km in 2015 and 95 g/km in 2021. However, real-world emissions are often higher. According to NRDC, under congested conditions at speeds below 20 km/h, emission rates rise to 544 g/mile (0.340 kg/km). This value is used for simulation estimates.

Serbian Statistical Office data from 2017 indicates 65% of vehicles are diesel and 35% gasoline-powered. According to IEA and Eurostat reports, fuel consumption in Europe worsened in 2017–2018, with average usage at 5.1 L/100 km.

Additionally, MERN estimates that an idling 3.5L engine consumes over 2 liters/hour.

As of 2022, Serbia had one of the lowest electric vehicle penetration rates in Europe (0.04%);

#### B) Productivity Loss Due to Wasted Work Hours

According to Eurostat, the average hourly labor cost across EU member states is EUR 27.7. Although this figure varies significantly by country, we apply this rate for simulation consistency. Based on daily congestion patterns, the cumulative lost productivity in Belgrade's Mihajlo Pupin Boulevard segment is substantial.

#### C) CO<sub>2</sub> Emissions Summary

Assuming two passengers per vehicle, total daily congestion results in over 16,768.8 kg of CO<sub>2</sub> emissions per month, and significant energy waste all stemming from an existing lane configuration (3+3).

### 3.3. Digitised street state analysis

Street lane digitisation within the Smart City framework enables dynamic reallocation of traffic capacity during rush hours. When applicable, the platform shifts one or two lanes toward the more congested direction - "North Vector" or "South Vector" - transforming the default (A3+B3) lane configuration into options such as (A2+B4), (A4+B2), or (A5+B1).

This analysis focuses on quantifying improvements in vehicular throughput under various lane adjustments. Congestion is averaged over four peak hours per day (two morning, two afternoon). Morning congestion typically results in a fully saturated "North Vector", while "South Vector" remains underutilised - mirrored during evening rush hours.

The strategic goal of lane reallocation is to reduce congestion to fewer than four daily hours by dynamically adjusting the street's lane configuration based on real-time demand.

To generalise, the dynamic lane configuration logic can be expressed as:

$$A_i + B_j, \text{ where } i + j = 6, \text{ and } i, j \in \{0, 1, \dots, 6\} \quad (4)$$

This strategy allows for dynamic congestion pattern recognition and adaptive lane modelling.

### 3.4. Simulation model

The core simulation is built upon a modified "Nagel–Schreckenberg cellular automaton", integrated with principles from "Wolfram's cellular automata framework" (Wolfram, 2002), and enhanced through "Monte Carlo randomization" for stochastic traffic event modeling.

Key characteristics of the model:

- Each lane is divided into 8-meter smartCells to represent individual vehicle occupancy.

- Vehicles operate with discrete speed states between  $V_0$  and  $V_{max}$ .
- Lane capacity is dynamically adjusted via lane reallocation policies simulated in configurations (A3+B3), (A4+B2), and (A5+B1).
- Simulation time frames span 2–8 hours, capturing transitions between congestion and equilibrium.

The simulation was implemented in the "Python 3.8", running on a "Linux Ubuntu" environment. The built-in bash random number generator (RANDOM) was used for Monte Carlo trials to simulate vehicle arrival intervals and output queue delays.

#### 4. RESULTS AND DISCUSSIONS

This component of the research aims to quantify the economic and environmental impact of persistent congestion in static versus digitized lane configurations.

Data parameters included:

- Average hourly labor cost per worker in Europe: EUR 27.7 [EUR6],
- Fuel consumption and CO<sub>2</sub> emission levels at low speeds: 0.340 kg/km ,
- Distribution of fuel types: 65% diesel, 35% gasoline-powered vehicles,
- Estimated idle fuel consumption rate: 0.6 L/h per liter of engine displacement.

The model computes:

- Total vehicle-hours spent/lost/vasted during congestion,
- CO<sub>2</sub> emissions based on idle duration,
- Economic value lost due to delayed labor output (EUR/vehicle × hours).

This analytical approach provides a replaceable and adaptable framework for evaluating Smart City strategies based on "digitized traffic lane management", with support for real-time integration via Smart Infrastructure Platforms (SIP).

Number of smartCell's in single lane counts 137, while total initial  $vec\{A\}$  and  $vec\{B\}$  capacity is 411 vehicles.

Assuming two passengers per vehicle, total daily congestion results in over "91,000 EUR in lost value", "16,768.8 kg of CO<sub>2</sub> emissions" per month, and significant energy waste-all stemming from an existing static lane configuration (3+3).

For the Mihajlo Pupin Boulevard segment in Belgrade, the estimated annual economic loss based only on idle work hours and fuel waste and it is approximately EUR 32,787,936.00, signalling urgent need for policy and technological intervention.

Additional tables, images and code listings from simulation performed are available upon request since due the limitation of this paper had to be omitted.

#### 5. CONCLUSION

This paper highlights urban traffic congestion as a critical barrier to sustainable mobility and quality of life in smart cities. Prolonged delays, increased fuel consumption, and elevated CO<sub>2</sub> emissions represent direct costs, while psychological stress and opportunity loss constitute hidden burdens on the community.

Due to limited access to live sensor arrays and IoT datasets, the research was conducted using street segment observations and a custom simulation model grounded in cellular automata, specifically a modified Nagel–Schreckenberg algorithm. While constrained in scope, the model effectively quantifies the scale of inefficiencies and supports a proof-of-concept for lane digitisation strategies.

The study demonstrates that even partial lane reallocation, as part of a dynamic and responsive smart infrastructure, can significantly mitigate peak-hour congestion and improve traffic throughput.

Future research should prioritise:

- Deployment of real-time traffic sensors and Floating Car Data(FCD) platforms,
- Development of adaptive traffic flow equilibrium algorithms using extended cellular automata models,
- Validation of simulation outputs with real-world telemetry,
- Integration of strategic security considerations, including emergency lane switching and evacuation protocols.

The authors propose that Smart City governance bodies treat adaptive lane management as a core component of urban mobility intelligence, strategic security and resilience framework.

## ACKNOWLEDGMENT

This research has been supported by ePlus Systems Ltd, Belgrade, Serbia.

## REFERENCES

- Aubert, J., et al. (2017). Smart-X: an Adaptive Multi-Agent Platform for Smart Topics. *Procedia Computer Science*, 109, 943–948. <https://doi.org/10.1016/j.procs.2017.05.438>
- Atici, C., Ozcebe, T., & Lukkien, J. J. (2011). Exploring user-centered intelligent road lighting design. *IEEE Transactions on Consumer Electronics*, 57(2), 788–793. <https://doi.org/10.1109/TCE.2011.5955223>
- Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2019). Is it time to go for no-car zone policies? Braess Paradox detection. *Transportation Research Part A: Policy and Practice*, 121, 251–264. <https://doi.org/10.1016/j.tra.2019.01.021>
- Cohn, S. A. (2021). Hyperloop. USA. ISBN: 978-0-9725955-0-6.
- Fryszman, F., Carstens, D. D. D. S., & Da Cunha, S. K. (2019). Smart mobility transition: A socio-technical analysis in Curitiba. *Int. Journal of Urban Sustainable Development*, 11(2), 141–153. <https://doi.org/10.1080/19463138.2019.1630414>
- Runyoro, A. A. K., & Ko, J. (2013). Real-time road traffic management using floating car data. *International Journal of Fuzzy Logic and Intelligent Systems*, 13(4), 269–276. <https://doi.org/10.5391/IJFIS.2013.13.4.269>
- Knuth, D. E. (1998). *The Art of Computer Programming* (3rd ed., Vol. 1). Addison-Wesley.
- Lutz, M. (2013). *Learning Python* (5th ed.). O'Reilly Media.
- Manasa, P. (2018). Singapore model of smart city: A solution to growing urbanisation. *International Journal of Research in Social Sciences*, 8(1). <http://www.ijmra.us>
- Maksin, M., Ristić, V., & Vujić, A. (2018). Application of the IoT smart city technology in transport security improvement. In *Proceedings of the 17th International Conference – International University Travnik* (Vol. 1). Travnik, Bosnia and Herzegovina.
- Meurer, A., et al. (2021). SymPy: Symbolic computing in Python. <https://doi.org/10.7717/peerj-cs.103>
- Maldonado Silveira Alonso Munhoz, P. A., da Costa Dias, F., Kowal Chinelli, C., Azevedo Guedes, A. L., Neves dos Santos, J. A., da Silveira e Silva, W., & Pereira Soares, C. A. (2020). Smart mobility: The main drivers for increasing the intelligence of urban mobility. *Sustainability*, 12(24), 10675. <http://dx.doi.org/10.3390/su122410675>

- Nagel, K., & Schreckenberg, M. (1992). A cellular automaton model for freeway traffic. *Journal de Physique I*, 2. [http://www.ptt.uni-  
duisburg.de/fileadmin/docs/paper/1992/origca.pdf](http://www.ptt.uni-duisburg.de/fileadmin/docs/paper/1992/origca.pdf)
- Nagel, K., & Schreckenberg, M. (2016, January 15). North Rhine-Westphalia's OLSIM traffic forecasting system. Autobahn NRW. <http://www.autobahn.nrw.de/>
- Rubinstein, R. Y., & Kroese, D. P. (2008). *Simulation and the Monte Carlo Method* (2nd ed.). Wiley.
- Soriano, F. R., Samper-Zapater, J. J., Martinez-Dura, J. J., Cirilo-Gimeno, R. V., & Plume, J. M. (2018). Smart mobility trends: Open data and other tools. *IEEE Intelligent Transportation Systems Magazine*, 10(2), 6-16. <https://doi.org/10.1109/MITS.2017.2743203>
- Stroustrup, B. (2000). *The C++ Programming Language* (3rd ed.). Addison-Wesley.
- Toh, C. K., Cano, J., & Manzoni, P. (2020). Advances in smart roads for future smart cities. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 476(2233), 20190439. <https://doi.org/10.1098/rspa.2019.0439>
- Umedu, T., et al. (2010). An intervehicular-communication protocol for distributed detection of dangerous vehicles. *IEEE Transactions on Vehicular Technology*, 59(2), 627–637. <https://doi.org/10.1109/TVT.2009.2035041>
- Vujic, A. (2014). Smart parking in smart city. In *Proceedings of the ICAIIT 2014 – International Conference on Applied Internet and Information Technologies* (p. 292). Zrenjanin, Serbia. [https://aiitconference.org/archive/Proceedings\\_AIIT2014.pdf](https://aiitconference.org/archive/Proceedings_AIIT2014.pdf)
- Wolfram, S. (2002). *A new kind of science*. Wolfram Media.



## HOW NEWCOMERS INFLUENCE GROUP MICROCLIMATE?

Rita Remeikienė<sup>1 \*</sup>, Beatričė Rūškienė<sup>2</sup>

<sup>1</sup> *Mykolas Romeris university, Public Safety Academy, Lithuania*

<sup>2</sup> *Mykolas Romeris university, Institute of Psychology, Lithuania*

**Abstract:** This paper explores the multifaceted role of group composition and the influence of newcomers on group performance and dynamics. Group composition - including diversity in skills, traits, and backgrounds - significantly affects group processes such as cohesion, communication, and decision-making. While stability fosters trust and shared memory systems, controlled turnover can inject valuable perspectives and increase adaptability. Newcomers exert both unconscious and conscious influence. Unconsciously, their arrival can reshape group norms even before formal integration, while conscious influence depends on their motivation and the group's openness to change. Newcomers can positively stimulate creativity and group reflection, yet they may also disrupt harmony and demand increased resources for integration. The outcome of their influence is largely shaped by how well existing members manage receptivity and adapt to change. Thus, strategically managing group composition and supporting newcomer integration is essential to optimizing team functionality

**Keywords:** newcomers, group, members, team functionality, microclimate.

### 1. INTRODUCTION

Many previous studies focus on the process of newcomers' adaptation, socialization, and adjustment to the group they have joined (Houghton, 2014; Lee, 2024; Yu et al., 2025, etc.), but the changes in a group caused by newcomers are analysed less commonly. Meanwhile, this topic is becoming extremely relevant in the modern world, when various activities are increasingly being organised in the form of projects, and relatively small work groups are prevalent even in larger organisations.

Project and/or work groups are created to achieve greater efficiency than individuals can achieve. Consisting of a few or more individuals, work groups accumulate more resources (e.g. knowledge and skills) and can use these resources productively (e.g. group members can

---

\* Corresponding author: [rita.remeikiene@mruni.eu](mailto:rita.remeikiene@mruni.eu)

Rita Remeikienė, ORCID: 0000-0002-3369-485X  
Beatričė Rūškienė, ORCID: 0009-0005-6884-3383

exchange information, coordinate their actions, motivate each other). Group members have a common goal and are dependent on each other both in terms of the actions that need to be taken to achieve the goal and the results (whether positive or negative) (Larson, 2010).

However, the problems of inefficiency can arise if group members are not sufficiently cohesive, if they are unable to adapt quickly and creatively to changing circumstances. In this case, new group members can become a potentially valuable resource since they can influence the cognition and behaviour of the existing group members both directly and indirectly.

**The major purpose** of this article is to analyse what influence newcomers can have on the group microclimate. The research is based on the method of *comparative literature analysis*.

## 2. LITERATURE REVIEW

### 2.1. Group composition and membership changes

The term “group composition” refers to the characteristics of a certain group in terms of the group members’ abilities, achievement levels, opinions, personal traits, age, gender, ethnicity, etc. In other words, group composition is defined as a combination of the number of individuals in a group and their personal characteristics (Levine et al., 2019). Group composition is important because it shows how the characteristics of individual group members can affect group cohesion and compatibility (Fern, 2011). The diversity of group members can positively or negatively influence the processes in the group and the results achieved through cooperation, coordination of actions, cohesion, quality of decisions, etc. For instance, Fern (2011) found that the amount and quality of personally relevant information which tends to be disclosed in the group is directly affected by the number of male and female in this group. A higher degree of disclosure of personal information correlates with the degree of acquaintanceship among group members (Fern, 2011), and with a higher degree of acquaintanceship, one can expect greater predictability of group members' behaviour/actions.

Levine et al. (2019) and Hackman & Katz (2010) provide evidence that group stability is beneficial to group performance. According to Hackman & Katz (2010), the belief that a group without change cannot survive for long is a myth; on the contrary, stable groups tend to have healthier dynamics than those with constant newcomers since stability contributes to creating transactive memory systems within the group, as well as a sufficiently high degree of trust among group members.

Nevertheless, a group is not a static body. Any group is characterised by membership changes, which, according to Levine et al. (2019), are stimulated by the qualitative change of existing group members due to the experience they acquire, and the arrival of new members. Thus, membership turnover may bring benefits that outweigh the benefits of group stability.

Group composition and membership changes are important factors that significantly influence group performance and functioning. Research shows that group composition - which includes members’ skills, achievements, opinions, personal traits, age, gender, ethnicity, and more - can have both positive and negative effects on group dynamics and outcomes. For instance, Li (2021) found that increasing group diversity can help reduce performance decline in complex task environments by promoting better information processing and group adaptability. However, Rink & Ellemers (2015) emphasize that unstable group composition can cause self-evaluation issues, reduce the acceptance of new members, and hinder group performance. Additionally, Bedwell (2019) discusses that the impact of membership changes depends on how quickly a group can adapt and develop shared knowledge structures, known as team mental models (TMMs), which are crucial for effective adjustment and group



performance. Therefore, managing group composition and membership turnover requires carefully balancing the benefits of diversity with the potential challenges in order to optimize group functioning and achieve the best possible outcomes

## 2.2. Unconscious and conscious influence of newcomers

Levine et al. (2019) confirm that newcomers have the potential to consciously or unconsciously influence a group's microclimate and performance.

In the case of *unconscious influence*, the very arrival and presence of a newcomer in the group causes certain changes without the newcomer having any prior intention to initiate these changes. The changes in the group are largely determined by how existing group members relate to the newcomer or to each other. Unconscious influence can occur even before the newcomer actually appears in the group, since the old members of the group may have certain expectations regarding the newcomer. For example, the old members of the group usually expect that they will have and will be able to pass on the group's values, customs, etc. to the newcomer. In the process of transferring the values, it may turn out that some of the group's values are unstable, but the old members did not notice this before. This can encourage the old members to change the previous group culture. If the values in the group are stable, the previous socialization methods may change in the process of transferring them to the newcomer, especially if it turns out that transferring the values and knowledge in the customary ways is difficult. Also, it can become important to demonstrate that one actually believes what is being said, that the information conveyed to the newcomer reflects the content of the message as accurately as possible. Furthermore, the motivation of group veterans to socialize a group newcomer can enhance their own socialization abilities, especially if they have not had such experience before.

The group's adaptation to a newcomer also means monitoring the newcomer and encouraging his/her contribution to the group activities. If not one but several newcomers come to the group, then the more newcomers are there, the more efforts and investment the group's old-timers need to monitor newcomers' activities, adjust them, and direct them in the desired direction. Both individual and institutional tactics can be used for this purpose. It is noteworthy that if a newcomer is able to properly perform one's role, fulfil the obligations assigned, and adjust the behaviour/work to the guidelines provided by the group's old-timers, this newcomer will need less supervision. Conversely, newcomers who cannot cope with tasks and obligations will require more resources for monitoring, which may result in old-timers having less time to perform their duties. Here, the similarities in the demographic, personal and other characteristics of newcomer(s) to the analogous characteristics of old-timers play a significant role: more similarities mean greater motivation for integration on both sides.

Newcomers can also unconsciously change the relationships between group members. For example, if the attitude toward a newcomer in the group is negative (let us say, the newcomer is very active in trying to change the established traditions), this can raise the cohesion between the group old-timers. In the groups characterised by division, a newcomer can increase the power of one segment of the group over another segment, thereby increasing the likelihood of conflict and reducing group cohesion.

In order to *consciously* influence the group, newcomers introduce new ideas that aim to improve the processes in the group and/or achieve better results. Levine et al. (2019) examine small work/task groups and discuss the factors related to both newcomers, veterans, and the group as a whole, since these factors can influence the perceived opportunities/threats of the ideas communicated by a newcomer from the perspective of the veterans, which will determine whether these ideas will be accepted or rejected. The authors argue that the major factor of

conscious influence is a newcomer's motivation to propose new ideas, and this motivation must be consistent with the readiness of the group's veterans to listen to and accept these ideas.

Newcomers can intentionally shape group dynamics and performance by introducing new ideas and perspectives. Levine & Choi (2004) highlight that such conscious influence arises when newcomers actively seek to alter the group's structure, dynamics, or performance. This process involves a negotiation between newcomers and established members, where innovation occurs if newcomers present new ideas for improving team performance and old-timers accept and implement these ideas. The success of this influence depends on factors such as the newcomer's motivation to introduce new ideas, their ability to generate such ideas, and their success in convincing old-timers to adopt them.

Research by Hornsey et al. (2007) further explores how newcomers' criticisms and suggestions are received by established group members. Their studies reveal that groups often resist change proposed by newcomers, viewing their criticisms as less constructive and their suggestions as less agreeable compared to those from long-standing members. However, this resistance can be mitigated if newcomers demonstrate commitment to the group, such as distancing themselves from previous affiliations, thereby increasing the perceived legitimacy of their suggestions.

Additionally, the manner in which newcomers present their ideas can influence their acceptance. Using inclusive language that emphasizes group identity, such as plural pronouns ("we," "our"), can enhance the likelihood of their ideas being embraced by the group. In contrast, focusing on personal identity with singular pronouns ("I," "my") may hinder acceptance, as it can be perceived as highlighting differences rather than fostering group cohesion (Levine & Choi, 2011).

These findings underscore the importance of both the newcomer's approach and the group's receptiveness in determining the impact of conscious influence on group dynamics. Effective integration and acceptance of newcomers' contributions require strategic communication, alignment with group values, and a willingness from established members to embrace change.

### **3. POSITIVE AND NEGATIVE INFLUENCE OF NEWCOMERS ON GROUPS**

Newcomers can significantly impact group dynamics, both positively and negatively. Their presence often leads to increased creativity and reflection within the group, but can also introduce challenges that may affect group cohesion and performance.

Choi & Thompson (2005) found that groups that have experienced changes in their members are better at generating ideas. Furthermore, the creativity of newcomers can stimulate the creativity of the entire group. Rink et al. (2013) analyse team receptivity to newcomers, i.e. they focus on how teams adapt to newcomers. The authors review previous empirical studies which examine the changes in three components of team receptivity - team reflection, team knowledge utilization, and newcomer acceptance - when a newcomer joins a team. To identify the relationship between these three components of team receptivity and the characteristics of old-timers and newcomers in a group, they present a conceptual multilevel model that highlights which characteristics contribute to improving team receptivity. After conducting the empirical research, the authors found that team receptivity to newcomers can have a positive effect on sustained team performance, but only if team reflection and team knowledge utilization coincide with the newcomer acceptance process.

Hackman & Katz (2010) confirm that stable groups are not open to new perspectives, and that changes in existing habits and routines in response to new circumstances may entail higher transformation costs. Thus, the arrival of newcomers creates favourable circumstances for the insight and acceptance of new perspectives, and can reduce the costs of transformations required to complete group tasks.

Research indicates that groups experiencing changes in membership, such as the introduction of newcomers, tend to generate more original ideas. For instance, Choi & Thompson (2005) found that groups with new members were more creative, as the newcomers' fresh perspectives prompted existing members to reconsider established ideas and practices. Similarly, Wu et al. (2022) suggest that the uncertainty and disruption caused by membership changes can trigger reflection among group members, leading to increased epistemic motivation and the generation of both incremental and radical new ideas.

Despite the potential benefits, newcomers can also pose challenges to group dynamics. Hackman & Katz (2010) argue that stable groups may become resistant to new perspectives, and the introduction of newcomers can disrupt established routines and increase transformation costs. This resistance can hinder the group's ability to adapt to new circumstances and may lead to conflicts or decreased cohesion.

Furthermore, the integration of newcomers requires significant effort from existing members to monitor and guide the new entrants. If newcomers struggle to meet expectations or adapt to group norms, the additional resources required for their integration can detract from the group's overall performance. The degree of similarity between newcomers and existing members can influence this process; greater similarities may facilitate smoother integration, while differences can pose challenges.

In summary, while newcomers can bring valuable perspectives and stimulate innovation within groups, their integration must be managed carefully. Ensuring alignment between team reflection, knowledge utilization, and newcomer acceptance is crucial for harnessing the positive potential of newcomers and mitigating the risks associated with their integration.

#### **4. CONCLUSION**

Group composition, which includes the individual characteristics and diversity of members, plays a critical role in shaping group cohesion, communication, and decision-making outcomes. While stability within groups fosters trust and the development of transactive memory systems that support efficient collaboration, strategic membership turnover can introduce fresh perspectives that enhance adaptability and innovation. However, to fully leverage the benefits of diversity and new ideas, it is essential to manage group composition carefully - balancing the opportunities brought by change with the potential challenges of integration and maintaining group cohesion.

Newcomers can begin to unconsciously influence group dynamics even before their formal entry, as their anticipated presence may prompt shifts in group norms and values based on existing members' expectations. When newcomers attempt to exert conscious influence, their impact is most effective when their ideas align with the group's identity and are communicated in an inclusive, collaborative manner. Ultimately, the success of a newcomer's influence depends on both the openness of veteran group members and the newcomer's strategy for integration, as these factors jointly determine whether their contributions will be accepted or met with resistance.

Newcomers can boost group creativity and innovation by challenging existing routines, but their successful integration relies on team receptivity, which is influenced by shared reflection, effective knowledge exchange, and mutual acceptance.

## REFERENCES

- Bedwell, W. L. (2019). Team adaptation and resiliency: Toward a dynamic model of team interaction. *Frontiers in Psychology*, 10, 1306. <https://doi.org/10.3389/fpsyg.2019.01306>
- Choi, H. S., Thompson, L. (2005). Old wine in a new bottle: Impact of membership change on group creativity. *Organizational Behavior and Human Decision Processes*, 98(2), pp. 121–132. doi: <https://doi.org/10.1016/j.obhdp.2005.06.003>
- Fern, E. F. (2011). *Group Composition, Individual Characteristics, and Cohesion*. Advanced Focus Group Research. Retrieved from: <https://methods.sagepub.com/book/mono/advanced-focus-group-research/chpt/group-composition-individual-characteristics-cohesion>
- Hackman, J. R., Katz, N. (2010). *Group behavior and performance*. In: S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.), *Handbook of social psychology* (5th ed., pp. 1208–1251). John Wiley & Sons, Inc. doi: <https://doi.org/10.1002/9780470561119.socpsy002032>
- Hornsey, M. J., Grice, T., Jetten, J., Paulsen, N., & Callan, V. J. (2007). Group-directed criticisms and recommendations for change: Why newcomers arouse more resistance than old-timers. *Personality and Social Psychology Bulletin*, 33(7), 1036–1048. <https://doi.org/10.1177/0146167207301029>
- Houghton, C. E. (2014). 'Newcomer adaptation': a lens through which to understand how nursing students fit in with the real world of practice. *Journal of Clinical Nursing*, Jan 24;23(15-16), pp. 2367–2375. doi: [10.1111/jocn.12451](https://doi.org/10.1111/jocn.12451)
- Yu, L., Ren, H., Singh, R. (2025). Newcomers' organizational socialization: A systemic literature review. *International Journal of Management, Economics and Social Sciences (IJMESS)*, ISSN 2304-1366, IJMESS International Publishers, Jersey City, NJ, Vol. 14, Iss. 1/2, pp. 23-53, <https://doi.org/10.32327/IJMESS/14.1-2.2025.2>
- Larson, J. R. (2010). *In search of synergy in small group performance*. APA PsychNet. Retrieved from: <https://psycnet.apa.org/record/2009-22685-000>
- Lee, A. S. (2024). "Supervisors' roles for newcomer adjustment: review of supervisors' impact on newcomer organizational socialization outcomes. *European Journal of Training and Development*, 48(5/6), pp. 521-539. doi: <https://doi.org/10.1108/EJTD-10-2022-0107>
- Levine, J. M., & Choi, V. K. (2004). Minority influence in work teams: The impact of newcomers. *Journal of Experimental Social Psychology*, 40(3), 273–280. <https://doi.org/10.1016/j.jesp.2003.09.001>
- Levine, J. M., & Choi, V. K. (2011). How newcomers influence group utilization of their knowledge: Integrating versus differentiating strategies. *Group Processes & Intergroup Relations*, 14(3), 335–350. <https://doi.org/10.1177/1368430210384455>
- Levine, J. M., Choi, H.-S., Moreland, R. L. (2019). *Newcomer influence and creativity in work groups*. In: Paul B. Paulus, Bernard A. Nijstad (eds.), *The Oxford Handbook of Group Creativity and Innovation*. Oxford: Oxford University Press.
- Li, J. (2021). Does diversity benefit or hinder team performance? The role of task complexity and information processing. *Journal of Organizational Behavior*, 42(1), 34–51. <https://doi.org/10.1002/job.2498>
- Rink, F., Kane, A. A., Ellemers, N., van der Vegt, G. (2013). Team Receptivity to Newcomers: Five Decades of Evidence and Future Research Themes. *Academy of Management Annals*, 7(1). doi: <https://doi.org/10.5465/19416520.2013.766405>

- Rink, F., & Ellemers, N. (2015). Benefiting from value-in-diversity: The importance of knowing and believing in diversity. *Group Processes & Intergroup Relations*, 18(4), 447–460. <https://doi.org/10.1177/1368430214550339>
- Wu, S., Nijstad, B. A., & Yuan, Y. (2022). Membership change, idea generation, and group creativity: A motivated information processing perspective. *Group Processes & Intergroup Relations*, 25(3), 477 - 497. <https://doi.org/10.1177/1368430221999457>



## EXAMINING USE OF UNCONDITIONAL CASH TRANSFERS TO ENCOURAGE ENTREPRENEURSHIP EMANCIPATION: A SYSTEMATIC LITERATURE AND RESEARCH AGENDA

Kenneth Jerry Onyango<sup>1\*</sup>, Nathaniel Boso<sup>2</sup>, Hellen Otieno<sup>3</sup>

<sup>1</sup> *Strathmore Business School, Kenya*

<sup>2</sup> *Kwame Nkrumah University of Science and Technology, Ghana*

<sup>3</sup> *Strathmore University, Kenya*

**Abstract:** This theoretical paper looks at the use of unconditional cash transfers (UCT) to encourage emancipation through adoption of entrepreneurship in marginalized areas. Using an overview of existing frameworks, the paper explains how UCT could help individuals in these communities launch and grow their own enterprises. By investigating potential consequences on economic agency, resilience, and community development, it attempts to throw light on the theoretical underpinnings that link UCT to the growth of entrepreneurship. The review uses empowerment theory to analyse how UCT might promote a sense of autonomy and self-confidence, inspiring people to undertake entrepreneurial endeavors. Understanding how UCTs can support the growth of entrepreneurship in underserved areas is made easier by the framework provided by the empowerment theory. According to this theoretical analysis, UCTs can encourage economic empowerment and enhance welfare of households in disadvantaged communities, even though their efficacy may vary depending on the particular environment and implementation. The findings add to the discussion about how to use cash transfers to support economic empowerment in marginalized and conflict-prone communities.

**Keywords:** Unconditional Cash Transfer, Entrepreneurial Emancipation, Empowerment Theory, Social Protection, Marginalized.

### 1. INTRODUCTION

The evaluation of cash transfer in South America, which makes use of both unconditional and conditional cash transfers, demonstrates efficacy in increasing household spending, extending healthcare access, and increasing school enrollment rates. Research on the possible use of cash transfers to enhance welfare of households (Baird et al., 2013). Crost et al.

---

\* Corresponding author: [kenneth.onyango@strathmore.edu](mailto:kenneth.onyango@strathmore.edu)

Kenneth Jerry Onyango, ORCID: 0009-0007-7783-9030

Nathaniel Boso, ORCID: 0000-0001-7043-4793

Hellen Otieno, ORCID: 0000-0003-0190-491X

(2015) found that CCT reduced the amount of disputes that happened in treatment villages compared to control villages. Cash transfers are recognized by Holmes (2007) as a prevalent form of social protection programs for families in Nepal that are at risk after the eleven-year conflict concluded in 2006. In Nepal, the emphasis was on the need to place cash transfer programs in the context of the nation's major priorities, which include fostering equitable growth, giving the poor access to jobs, and advancing peace (Holmes & Uphadya, 2009). The struggle over pastures in drought-prone Northern Kenya between pastoralist groups is the source of conflict. With the help of a cash transfer program, pastoral households were able to change from their traditional way of life to a non-pastoral one, according to Hurrell & Sebates-Wheeler (2013).

In the arid northern regions of Kenya, where pastoralism is the main source of income for most households, UCT is widely used. Having a large number of animals that graze on the natural vegetation is a sign of being a pastoralist, and there are limited options to pursue other careers such as business or agriculture. The lives of pastoralists are made more difficult by the scarcity of water because agriculture is not an option. During dry seasons, families raise a lot of animals to live. This is the way of life for almost a million Kenyans who live in the north of the nation and for sixteen percent of people in the Sahel (Rachel, 2003). Livestock is an important source of nutrition and revenue for pastoralist people. Therefore, during dry seasons when there is competition for limited pastures, conflicts typically emerge.

Colier (2004) argued that the primary driver of conflict is competition for resources. Poor living conditions, characterized by low levels of educational attainment and a lack of work opportunities, are also prevalent in conflict-prone communities. Poverty is also prevalent at a high level. Participating in livestock raids guarantees that there will be animals to sell and maintain the family, providing an alternative source of income. The money from cattle raids is vital for homes with little educational opportunities and no chances for a successful profession. UCT can help emancipate entrepreneurship by providing communities with an alternative source of income and by making it simpler for enterprises to start (Nathaniel et al., 2014).

UCT is identified in the literature as a development enabler, particularly since it offers opportunities for capacity development and the development of targeted business skills. In marginalized areas, the generation of jobs through entrepreneurship is crucial for resolving conflicts (Rachel, 2003). This gives households the ability to start and run businesses, giving them alternatives to violent cattle raids as a means of making a better living. The cash transfer offers the chance to enroll in a microenterprise training program, which makes it easier to start enterprises employing UCT, such as kiosks, lodging, and honey production. Cash transfers therefore provide households with the opportunity to transition to a stable source of income through other means of subsistence. The documented cash transfer programs—such as Progreso/Oportunidades in Mexico and the Child Support Grant program in South Africa—improved understanding of the UCT. In a survey of 25 cash transfer programs, Fiszbein & Schady (2009) discovered that the recipients had a range of social repercussions, including a decline in poverty, an increase in household expenditure, an increase in school enrollment, and an increase in women's negotiating power. It has been demonstrated that the application of UCT leads to a rise in the number of higher-income households and a fall in the number of homes living in poverty (Arnold et al., 2011). The guarantee of steady future revenue from other sources of sustenance, according to Bianchi and Bobba (2012), encourages entrepreneurship emancipation and deters participation in conflict activities.

The theoretical review highlights how UCT can be used to encourage the adoption of alternate livelihood sources, especially through entrepreneurship emancipation, which is crucial for lowering resource-based conflict. The theoretical analysis thus seeks to bridge the information gap on the use of UCT for entrepreneurial development, explore avenues for policy

effect, and guide the establishment of a framework for its use to strengthen underprivileged communities. In order to desensitize households in conflict-prone areas to participating in violence, this will empower them to make educated options and opt to use UCT to pursue entrepreneurship as a substitute source of income.

## 2. LITERATURE REVIEW

Cash transfers are positively correlated with reducing poverty, as demonstrated by Ombogo's (2017) research in Turkana West." The monetary transfer that the recipient households received facilitated their capital accumulation. According to the analysis, as capital accumulation increased in the investigated area, the prevalence of poverty declined. Okoth (2022) found that the shift in livelihood brought about by Unconditional Cash Transfer is influenced by the educational attainment, religious beliefs, and cultural values of the cash beneficiaries. Furthermore, Turkana recipients of unconditional cash transfers were found to largely use their transfer money to meet their basic consumption needs (Ulrichs, 2019). With only 14% of Turkana County residents engaged in agro-pastoralism, Ulrichs (2019) conjectures that the bulk of households rely on market purchases for their food security. This is evidenced by the fact that household spending increased by USD 2.40 per adult each month after receiving the cash transfer. The money was used exclusively for food during the drought, but it was also used for non-food expenses during the remainder of the year.

The majority of households in marginalized regions suffer from both rising food prices as a result of poor harvests brought on by climate change and famine brought on by violence. Food shortages can also result from natural calamities and a lack of funds. Developing countries are using unconditional cash transfers more often to fight poverty and strengthen their resilience to natural catastrophes (Garcia & Moore, 2012). The medium- to longer-term policy outcome of cash transfer interventions is indicated by the FAO (2015), which suggests that in order to support the development of coping mechanisms and reduce the need for emergency support during times of climate change-induced vulnerability, vulnerable households require a predictable, regular income stream (Garcia & Moore, 2012). Since the poor are disproportionately affected by climate change-related disasters that can affect their livelihoods and fuel conflict due to competition for scarce resources, the program's unconditional cash transfer should prioritize meeting the needs of the poorest people (Peppiatt et al., 2001).

Climate change has serious effects on livelihood. Huho (2023) provides an illustration of this by pointing out that Northern Kenya, especially Turkana, has significant cattle losses, total crop failures, and higher levels of hunger and starvation during droughts brought on by climate change. The result is the loss of revenue streams that are mostly reliant on pastoralism. Huho (2023) found that pastoralist households can develop drought-adaptive living strategies with the assistance of unconditional cash transfers, which provide a source of income. Furthermore, the funds assist in addressing social and economic needs that pastoralism cannot fulfill during a drought. Therefore, unconditional cash transfers can assist households in Turkana and other marginalized regions of Northern Kenya in strengthening their resistance to climate shocks. This was proven by Matata (2022), whose analysis of Kenya's Hunger Safety Net Program—a large-scale, unconditional cash transfer program—showed that cash transfers positively and significantly influence families to adopt alternate sources of income, increasing their resilience to climate shocks. It was determined that regular and predictable cash transfers to low-income and vulnerable households are required to support families in their efforts to adjust to shocks associated with climate change. Investing the money received guarantees sustainability and increases household resilience to meeting basic needs even in the event of climate-related disasters. Developing one's talents is crucial to having the ability to make wise



investment choices that provide households with a steady stream of income. Giving UCT grantees access to microentrepreneurial training gives them this crucial capability, enabling them to use the extra funds they receive to assist the establishment of microbusinesses and satisfy their basic needs, such as paying their rent and tuition. The training is crucial because of the cash transfer beneficiaries' low educational attainment. Matata et al. (2023) discovered that 89.7% of the beneficiaries of the unconditional cash transfer scheme in Turkana West Sub County did not hold official academic degrees. The high prevalence of household illiteracy emphasizes how important it is to give beneficiaries micro-entrepreneurship training to improve their ability to apply basic business skills and to encourage using cash transfers to start a business and create jobs. According to Oxfam (2006), in order to increase profits, generate new company ideas, and foster creative thinking, unconditional cash transfers need to include business management. The success and creation of jobs that provide alternative income sources for others depends on the ability of skilled cash transfer recipients to manage their businesses.

Provided the beneficiaries accept the monetary transfer, the household income can increase. Sometimes local leaders are against cash transfer programs and prefer the government and other development agencies' food rations. Turkana, which experiences drought frequently, was one place where this was observed. Food help was given there instead of money. The move from food assistance to cash transfers was strongly opposed by community leaders, according to Bakari (2019). Using the financial transfer that the community members had received to purchase food proved to be challenging, as the leaders brought up. In order to enable people to use the money to access marketplaces and purchase necessities of life, the leaders play a critical role in convincing the community to accept the cash transfer and in putting down the necessary infrastructure for effective coordination of the cash transfer process. Participation in coordination organizations such as the Cash Working Group (KCWG, 2017) by community leaders facilitates greater communication between actors and recipients of unconditional transfer schemes. The Cash Working group leaders are in charge of providing technical and strategic guidance to the program's intended beneficiaries (Smith, 2015). Incorporating community leaders offers the benefit of stimulating creativity by implementing a cash transfer technique that considers cultural norms and values. It also encourages the adoption of best practices and the identification of structural capacity gaps that require correction in order to ensure the efficacy of the cash transfer program.

Women who receive cash transfers have more purchasing power, which reduces inequality. Inequality is addressed by providing women with an unconditional cash transfer. If inequality persists, it can exacerbate tension and conflict in both politics and society (Ikiara, 2009). Women who benefit from the program receive higher incomes, which encourages them to participate in the labor market. This is because impoverished individuals who receive cash transfers are more likely than those who do not to search for and find gainful employment. Progressive policies that encourage women's empowerment are required to accelerate efforts to alleviate poverty in developing countries (Gama, 2021). The policy of unconditional cash transfers for households is one way that women's empowerment is progressing. This is exemplified in Turkana West, where a participant in a focus group is reported by Matata et al. (2023) to have commended the cash transfers for enabling some local women to start merry-go-round and table banking enterprises, which have contributed to their economic empowerment.

The cash recipients' ability to take advantage of current business opportunities influences the actions taken to start an enterprise in a marginalized area prone to conflict utilizing the unconditional cash transfer. Exploiting entrepreneurial opportunities involves two steps: creation and discovery (Wu et al., 2021). A business owner must see a gap in the market that has to be filled with a novel good or service in order to fully capitalize on the opportunity

(Companys & McMullen, 2007). A chance can be transformed into a profitable endeavor for capital accumulation by securing resources like money, human talent, and technology. According to John et al. (2023), an enterprise is considered feasible if it is novel, stands out in the market, and gives it a competitive edge over other companies in the same industry. Conducting thorough market research to comprehend consumer needs, industry trends, and the characteristics of rivals enables risk detection and helps the business idea be refined (Edelman & Yli-Renko, 2010). Utilizing the opportunity allows the business owner to find emerging markets with potential for the introduction of a cutting-edge good or service, as well as to gain from ongoing learning and trend monitoring to guarantee the venture's sustainability (Kamran et al., 2022).

Entrepreneurship discovery is an exogenous process that necessitates a person to actively watch the business environment in order to spot trends, detect unmet requirements that may be satisfied by a business, and find possible opportunities (Edelman & Yli-Renko, 2010). The creative entrepreneur can investigate novel concepts and approach current issues and obstacles in a novel way because of this curiosity. Based on market research to understand customer behavior, market trends, and possible innovation areas, new ideas are put into action. Additionally, it aids in locating issues or inefficiencies in the market that could be resolved by novel goods or services. Understanding new technologies and their potential to open doors for new business initiatives that address recognized client demands is necessary before introducing an innovative product (Rosário & Raimundo, 2021). Therefore, in order to find possible chances for new businesses, entrepreneurship discovery entails a dynamic and iterative process of analysis, invention, and investigation.

By meeting urgent financial requirements and creating an atmosphere that encourages entrepreneurial activity, the unconditional cash transfer might be extremely helpful in promoting the discovery of entrepreneurship in marginalized communities that are prone to violence (King'ong'o, 2022). For those in conflict-prone areas who want to start their own business, the cash transfer offers startup money. Small firms or entrepreneurial endeavors might be launched with the help of this first funding. Unconditional cash transfers can function as a type of risk mitigation, offering a financial cushion that enables businesses to negotiate the uncertainties and losses connected with the war. war-prone areas are generally associated with increased risks for entrepreneurs. Additionally, it gives business owners access to resources like equipment, tools, and raw materials—all of which are critical for launching or growing their enterprises. One of the potential would be to use the financial transfer to help entrepreneurs in areas prone to conflict build or strengthen market links. This may entail setting them up with channels to reach wider customers or developing venues on which they can exhibit and offer their goods (Grawert et al., 2017). Through the judicious application of cash transfers in these methods, it becomes possible to stimulate entrepreneurship in marginalized regions prone to conflict, so promoting community development and economic resilience.

Entrepreneurship creation is an endogenous process in which a person uses brainstorming, creative thinking, and problem-solving to come up with original and feasible business ideas. Putting together a talented and varied team to provide complementary talents and views to the project is necessary for the delivery of the product or service that needs to be developed. The entrepreneur makes use of strategic alliances by forming connections with other companies or groups in order to expand their market reach, improve their capabilities, or gain access to more resources. Thus, by turning an idea into a real, sustainable business and taking care of everything from product development to team building and strategic planning, the recipient of the unconditional cash transfer opens up opportunities for entrepreneurship. The unconditional cash transfer is essential in fostering the development of business in marginalized communities prone to conflict, since it offers a stable financial basis and tackles particular

obstacles seen in these settings (Kelly, 2020). For people who want to launch their own businesses, the cash transfer acts as seed money. Initial beginning expenses including workspace, equipment, and inventory can be partially covered by this money. According to Blattman & Ralston (2015), the entrepreneur can use the money they receive to designate a percentage of their cash transfers to training and educational initiatives centered around startup culture. This equips the businessperson with the abilities and know-how required to launch and run profitable venture. Furthermore, according to Twigg and Calderone (2019), the unconditional cash transfer offers entrepreneurs a flexible funding method that enables them to adjust their firms to changing circumstances.

### **3. DATA AND METHODOLOGY**

The theoretical study examined previous studies on cash transfer programs as well as current efforts by the Kenyan government and other financing organizations, including non-governmental ones, to support livelihood changes in Turkana County through cash transfer initiatives. The theoretical review examined theories connected to UCT that emerged from research on cash transfers that households in Turkana County, in northwest Kenya, received.

### **4. RESULTS AND DISCUSSION**

The use of UCT is becoming increasingly recognized as a potential tool for reducing poverty and promoting economic prosperity. While their effectiveness in reducing poverty is well known, little is known about how they affect entrepreneurship and the growth of businesses. Aceytuno-Pérez et al. (2023) provide evidence for this claim, suggesting that UCTs provide individuals with extra income to devote to their entrepreneurial pursuits. People can overcome financial hurdles and purchase the tools, commodities, or services they require to start or expand their businesses with the help of this quick cash infusion. Improved ability to make decisions and take risks is necessary for corporate projects to succeed. According to Gennetian (2021), UCTs can lessen risk aversion and assist people in making better financial decisions. The potential for UCT to increase demand and consumption and hence increase economic activity is another factor demonstrating the significance of UCT. Haushofer & Shapiro (2013) assert that UCT grantees can increase business profitability and promote a more vibrant local economy by allocating funds to manufactured goods.

Given that having discretionary income enables people to make investments in their health, education, and skill development, it is clear that UCT may play a role in improving human capital and productivity. As a result, they might become more employable and productive, which would enable them to seize more commercial opportunities (Bastagli et al. (2015). As a safety net that can reduce a person's vulnerability to shocks and setbacks, the money received is vital (Beegle, 2018). Individuals might be encouraged to engage in business ventures and take chances without fear of falling into even deeper poverty as a result of this. UCT stands out for its potential to support greater female entrepreneurship and economic empowerment for women. Women who receive UCTs have the opportunity to seek entrepreneurial opportunities because they have direct financial control (Daidone, 2019). Furthermore, it is mentioned that UCT can support a community's broader efforts in innovation and entrepreneurship (Bastagli, 2016). This is due to the fact that UCTs, by providing individuals with the means to start their own businesses, can encourage an entrepreneurial mindset and the generation of fresh concepts and projects. Previous studies offer guidance on how UC can promote equitable economic development through establishing connections with individuals who may not have had access to conventional banking systems or employment opportunities (Farrington, 2005). Therefore, UCTs have the potential to make it possible for individuals of marginalized populations to participate in the entrepreneurial scene by offering

a transparent and unrestricted source of income. These assumptions form the foundation for a more in-depth analysis of the framework required to understand the potential impact of UCTs on entrepreneurship. Therefore, additional research is needed to fully understand the causal relationships and long-term effects of UCTs on entrepreneurial outcomes.

A deeper comprehension of UCT's function in promoting entrepreneurship emancipation in underprivileged areas prone to conflict can be gained by filling in the existing research gaps. Longitudinal studies can be utilized to conduct extended research across time to assess the long-term effects of financial transfers on the development of entrepreneurship (Baird, McIntosh & Özler, 2019). Contextual factors that influence the effectiveness of cash transfers can be identified using comparative analysis, which contrasts outcomes across a number of conflict-prone areas (Bozzoli et al., 2013). An in-depth understanding of the socioeconomic dynamics and challenges faced by entrepreneurs could be achieved through the use of mixed-methods research, which blends qualitative and quantitative methodologies. Furthermore, conducting in-depth case studies in certain conflict-prone areas would provide nuanced insights about impact of cash transfers on entrepreneurship (Oetzel, 2009).

## 5. CONCLUSION

A potential route toward stability and economic development is shown by research on UCT's ability to foster entrepreneurship in underprivileged, conflict prone neighborhoods (Diwakar, 2023). By providing financial resources and a steady income to households in marginalized communities, it can foster entrepreneurship and provide possibilities for long-term employment. This approach has the potential to break the cycle of poverty and address the root causes of conflict (Bebbington, 1999). In order to ensure enduring and positive impacts on the community, careful consideration of local dynamics, potential roadblocks, and long-term viability is necessary for effective implementation.

## REFERENCES

- Aceytuno-Pérez, M. T., de Paz-Báñez, M. A., & Sanchez-López, C. (2023). Assessing the Impact of the Implementation of Universal Basic Income on Entrepreneurship. *Basic Income Studies*, (0).
- Arnold, C., Conway, T., & Greenslade, M. (2011). Cash transfers evidence paper. London: Department for International Development.
- Baird, S., McIntosh, C., & Özler, B. (2019). When the money runs out: Do cash transfers have sustained effects on human capital accumulation? *Journal of Development Economics*, 140, 169-185.
- Bakari, A. (2019) The Standard: leaders Oppose the Cash Plan, pp 19, Monday September 9th , 2019: Nairobi, Kenya; Standard Group.
- Bastagli, F., Hagen-Zanker, J., Harman, L., Barca, V., Sturge, G., Schmidt, T., & Pellerano, L. (2016). Cash transfers: what does the evidence say. A rigorous review of programme impact and the role of design and implementation features. London: ODI, 1(7), 1.
- Bebbington, A. (1999). Capitals and capabilities: a framework for analyzing peasant viability, rural livelihoods and poverty. *World development*, 27(12), 2021-2044.
- Beegle, K., Honorati, M., & Monsalve, E. (2018). Reaching the poor and vulnerable in Africa through social safety nets. *Realizing the full potential of social safety nets in Africa*, 1, 49-86.
- Bianchi, M., & Bobba, M. (2012). Liquidity, risk, and occupational choices. *The Review of Economic Studies*, 129 (2): 697-752.

- Blattman, C., & Ralston, L. (2015). Generating employment in poor and fragile states: Evidence from labor market and entrepreneurship programs. Available at SSRN 2622220.
- Bozzoli, C., Brück, T., & Wald, N. (2013). Evaluating programmes in conflict-affected areas. A micro-level perspective on the dynamics of conflict, violence and development, 249-68.
- Collier, P. (2004). Greed and Grievance in Civil War. *Oxford Economic Papers* 56, 563-595.
- Comanys, Y. E., & McMullen, J. S. (2007). Strategic entrepreneurs at work: The nature, discovery, and exploitation of entrepreneurial opportunities. *Small Business Economics*, 28, 301-322.
- Crost, B., Felter, J., & Johnson, P. (2014). *Aid Under Fire: Development Projects and Civil Conflict*.
- Daidone, S., Davis, B., Handa, S., & Winters, P. (2019). The household and individual-level productive impacts of cash transfer programs in Sub-Saharan Africa. *American Journal of Agricultural Economics*, 101(5), 1401-1431.
- Diwakar, V. (2023). Ending extreme poverty amidst fragility, conflict, and violence.
- Edelman, L., & Yli-Renko, H. (2010). The impact of environment and entrepreneurial perceptions on venture-creation efforts: Bridging the discovery and creation views of entrepreneurship. *Entrepreneurship theory and practice*, 34(5), 833-856.
- FAO, 2015. *Nutrition and social protection*. Rome.
- Farrington, J., Harvey, P., & Slater, R. (2005). Cash transfers in the context of pro-poor growth. Hot Topic paper for OECD/DAC POVNET Risk and Vulnerability Task Team.
- Fiszbein, A., Schady, N. R., & Ferreira, F. H. (2009). *Conditional cash transfers: reducing present and future poverty*. World Bank Publications.
- Gama Gato, L., & Matyska, A. (2021). Gendered encounters in mobility: Women researching migrant construction workers. *Ethnography*, 14661381211038290.
- Garcia, M. and T. Moore. 2012. *The cash dividend: The rise of cash transfers programs in sub-Saharan Africa*. Washington DC: World Bank.
- Gennetian, L. A., Shafir, E., Aber, J. L., & De Hoop, J. (2021). Behavioral insights into cash transfers to families with children. *Behavioral Science & Policy*, 7(1), 71-92.
- Grawert, E., Hansohm, D., & Nusrat, R. (2017). Is conflict sensitivity applicable to employment? *Business in fragile and conflict-affected settings*.
- Haushofer, J., & Shapiro, J. (2013). Household response to income changes: Evidence from an unconditional cash transfer program in Kenya. *Massachusetts Institute of Technology*, 24(5), 1-57.
- Haushofer, J., & Shapiro, J. (2013). Household response to income changes: Evidence from an unconditional cash transfer program in Kenya. *Massachusetts Institute of Technology*, 24(5), 1-57.
- Holmes, A., & Harvey, R. (2007). *The Potential for Joint Programmes for Long Term Cash Transfers in Unstable Situations*. London: DfID: <https://resourcecentre.savethechildren.net/document/unconditional-cash-transfers-turkana/>.
- Holmes, R., & Uphadya, S. (2009). The role of cash transfers in post-conflict Nepal. *ODI Report*. London: ODI.
- Huho, J. M., Kioko, D., Maalim, A. A., Warsame, R., & Musa (2023): A. Adapting to Climate Change in the Semi-Arid Northern Kenya. *International Journal of Research and Innovation in Social Science*.
- Hurrell, A., & Sabates-Wheeler, R. (2013). *Kenya Hunger Safety Net Programme Monitoring and Evaluation Report*. Nairobi: Oxford Policy Management.
- Ikiara, G. K. (2009). Political economy of cash transfers in Kenya. *Overseas Development Institute*, 1-34.

- John William, A., Suresh, M., & Subramanian, N. (2023). Examining the causal relationships among factors influencing SMEs' competitive advantage: a TISM-neutrosophic MICMAC approach. *Benchmarking: An International Journal*.
- Kamran, S. M., Khaskhely, M. K., Nassani, A. A., Haffar, M., & Abro, M. M. Q. (2022). Social entrepreneurship opportunities via distant socialization and social value creation. *Sustainability*, 14(6), 3170.
- KCWG (2020), Calpnetwork: <https://www.calpnetwork.org/publication/kenya-cash-working-group-4-ws/>
- Kelly, L. (2020). Evidence on resilience approaches in fragile and conflict-affected states and protracted crises.
- King'ong'o, G. W. (2022). Indigenous Entrepreneurship, Post-Conflict Reconstruction And Globalization Dynamics On Economic Development: A Case Of The Micro And Small Livestock Enterprises In Turkana County, Kenya (Doctoral dissertation, University of Nairobi).
- Matata, M. (2022). Effects of Cash Transfers on Household Livelihoods and Resilience to Climate Shocks in the Arid and Semi-Arid Counties of Northern Kenya (Doctoral dissertation, Egerton University).
- Matata, M. J., Ngigi, M. W., & Bett, H. K. (2023). Effects of cash transfers on household resilience to climate shocks in the arid and semi arid counties of northern Kenya. *Development Studies Research*, 10(1), 2164031.
- Nathaniel D. Jensen, Christopher B. Barrett and Andrew G. Mude, August 2017. Index Insurance and Cash Transfers: A Comparative Analysis from Northern Kenya. <https://www.sciencedirect.com/science/article/pii/S0304387817300627>
- Oetzel, J., Westermann-Behaylo, M., Koerber, C., Fort, T. L., & Rivera, J. (2009). Business and peace: Sketching the terrain. *Journal of business ethics*, 89, 351-373.
- OKOTH, S. (2022). Influence of Socio-Cultural Factors on Performance of Donor-Funded Livelihood Projects, Lakezone Ward Turkana County, Kenya. Lakezone Ward Turkana County, Kenya (December 05, 2022).
- Ombogo, T. O., & Owuor, F. O. (2018). The influence of cash transfers instigated asset accumulation and retention on poverty reduction in Turkana West Sub-County, Kenya. *European Journal of Social Sciences Studies*.
- Oxfam, G. B. (2006). Cash-transfer programming in emergencies. Oxfam.
- Peppiatt, D., J. Mitchell, and P. Holzmann. 2001. Cash transfers in emergencies. London, England: Overseas Development Institute.
- Rachel Berger, March 2003. Conflict over natural resources among pastoralists in northern Kenya - A look at recent initiatives in conflict resolution. *Journal of International Development*, Published online in Wiley InterScience ([www.interscience.wiley.com](http://www.interscience.wiley.com)). DOI: 10.1002/jid.985
- Rosário, A., & Raimundo, R. (2021). Consumer marketing strategy and E-commerce in the last decade: a literature review. *Journal of theoretical and applied electronic commerce research*, 16(7), 3003-3024.
- Smith, G. (2015). Cash coordination in Philippines. Manila, Philippines, CaLP
- Twigg, J., & Calderone, M. (2019). Building livelihood and community resilience.
- Ulrichs, M., Slater, R., & Costella, C. (2019). Building resilience to climate risks through social protection: from individualised models to systemic transformation. *Disasters*, 43, S368-S387.
- Wu, A., Song, D., & Yang, Y. (2021). Untangling the effects of entrepreneurial opportunity on the performance of peasant entrepreneurship: the moderating roles of entrepreneurial

effort and regional poverty level. In *Business, Entrepreneurship and Innovation Toward Poverty Reduction* (pp. 112-133). Routledge.



## ASPECTS OF LEGAL REGULATION OF CO<sub>2</sub> EMISSIONS INTO THE ATMOSPHERE: A EUROPEAN UNION PERSPECTIVE

**Evaldas Raistenskis\*, Ligita Gasoarėnienė, Rita Remeikienė**

*Vilnius university, Faculty of Law, Lithuania*

**Abstract:** This article examines the legal regulation of CO<sub>2</sub> emissions in the European Union through a structured analysis of key legislative instruments and climate policy frameworks. Focusing on the emissions trading system, carbon capture, utilization and storage mechanisms, and sector-specific regulatory measures, the paper explores the effectiveness, consistency, and legal implications of recent developments. Drawing on academic research, strategic planning documents, and binding legal acts, the study highlights both the progress made and the limitations that remain within the current legal landscape. While the emissions trading system has demonstrated the potential to incentivise decarbonisation, questions persist regarding allocation fairness, transparency, and cross-border enforcement. In the field of carbon capture and utilisation, the lack of clear definitions and regulatory scope continues to generate uncertainty. Similarly, new legal instruments addressing the transport sector represent a step forward but also reveal tensions between legal ambition and technological readiness. The article concludes that further legal refinement is necessary to address fragmentation, improve coordination between legal layers and governance levels, and ensure alignment between long-term strategic goals and concrete legal obligations. Strengthening legal precision and coherence is essential to support the credibility and functionality of climate law across the European Union.

**Keywords:** Carbon capture and storage, CO<sub>2</sub> regulation, Emissions Trading System, European Union climate law, Legal coherence.

### 1. INTRODUCTION

The growing urgency of mitigating climate change has brought the regulation of carbon dioxide (hereinafter – CO<sub>2</sub>) emissions to the forefront of European Union (hereinafter – EU) legal and policy debates. As a key greenhouse gas, CO<sub>2</sub> is responsible for the majority of global warming effects, and its reduction is central to the EU's long-term strategic vision of achieving climate neutrality by 2050 (Bouckaert et al., 2021). The European Commission's 2050 long-

---

\* Corresponding author: [evaldas.raistenskis@tf.vu.lt](mailto:evaldas.raistenskis@tf.vu.lt)

Evaldas Raistenskis, ORCID: 0000-0003-3049-2926  
Ligita Gasparėnienė, ORCID: 0000-0002-5535-6552  
Rita Remeikienė, ORCID: 0000-0002-3369-485X



term strategy outlines ambitious targets that require a coherent legal framework addressing energy systems, industrial emissions, and carbon removal mechanisms (European Commission, n.d.).

Over the past three decades, the EU has developed an extensive body of climate legislation, including the Emissions Trading System (hereinafter – EU ETS), renewable energy directives, carbon border mechanisms, and sector-specific regulations (Dupont et al., 2023). Yet, the legal complexity of these instruments, differences in national implementation, and the evolving nature of carbon capture and utilization (hereinafter – CCU) technologies present persistent challenges (Jones & Piebalgs, 2022).

This paper aims to examine the legal regulation of CO<sub>2</sub> emissions in the EU, focusing on the structure, evolution, and effectiveness of relevant legal acts. The study applies classical methods of legal research, including logical-systematic interpretation, document analysis, and comparative legal review. Particular attention is given to regulatory instruments adopted or amended in the past five years, reflecting the EU's accelerated efforts under the European Green Deal and the Fit for 55 packages.

## **2. LITERATURE REVIEW**

The legal regulation of CO<sub>2</sub> emissions in the EU has evolved significantly over the past three decades, shaped by scientific consensus on climate change and the EU's commitment to international environmental standards. As noted by Dupont et al. (2023), EU climate policy has shifted from fragmented national initiatives to a comprehensive multi-level governance framework aimed at achieving climate neutrality.

A cornerstone of this framework is the EU ETS, introduced to internalize the cost of emissions and reduce industrial greenhouse gas outputs. Its legal structure, objectives, and effectiveness have been critically analysed in academic literature. Kotzampasakis and Woerdman (2024) provide a legal evaluation framework for assessing the normative foundations of the EU ETS, while Bayer and Aklin (2020) demonstrate its empirical success in reducing emissions, even during periods of low carbon prices. These insights are supported by Bianco et al. (2024), who use a decomposition and decoupling approach to trace CO<sub>2</sub> trends across EU member states.

Several studies have addressed the growing complexity of legal instruments related to renewable energy and emissions reduction. Frattini et al. (2024) provide a detailed overview of current regulatory frameworks for carbon capture, transport, and storage (hereinafter – CCS) across the European Economic Area. Their findings highlight the fragmented legal architecture and the need for clearer, harmonized provisions. Complementing this, Gabrielli et al. (2022) and Becattini et al. (2022) assess the infrastructure and supply chains necessary for CCS, emphasizing the role of legal predictability and system-level resilience.

More recently, attention has turned to CCU and carbon farming. Talus and Maddahi (2024) examine the legal status of CCU under EU law, with a particular focus on the permanence of CO<sub>2</sub> storage and the definitional boundaries between product-bound and atmospheric removal. Günther et al. (2024) critique the European Commission's Carbon Removal Certification Framework (CRCF), arguing that overestimated negative emissions and unverified claims may weaken the legal credibility of market-based land-use solutions.

The broader legal and policy direction is embedded in long-term strategic planning documents. Bouckaert et al. (2021) outline the EU's decarbonization pathway under the International Energy Agency, while the European Commission (2020) provides scenario-based projections of the EU energy system transformation. The 2050 long-term strategy reinforces

these trajectories, setting binding emission targets and emphasizing legal integration across sectors (European Commission, n.d.).

The role of sector-specific instruments is equally important. For instance, Regulation (EU) 2023/1805 and Regulation (EU) 2023/2405 set legal standards for low-carbon fuels in maritime and aviation transport, respectively. These are part of the broader Fit for 55 legislative package, aimed at aligning all sectors with the 2030 and 2050 climate goals. Furre et al. (2017) provide a case study of long-term monitoring of CO<sub>2</sub> injection at Sleipner, showcasing the practical implementation of CCS regulation.

To ensure legal consistency and adaptability, several updates have been introduced to existing frameworks. Directive (EU) 2023/959 revises the EU ETS, strengthening its governance structure and expanding its scope. Meanwhile, Directive (EU) 2023/2413 reinforces the promotion of renewable energy, supporting systemic integration with national policies. The Commission Implementing Decision (EU) 2025/792 introduces a new layer of transparency by publishing CO<sub>2</sub> data for heavy-duty vehicles (European Commission, 2025), and additional legal perspectives are offered by The National Law Review (2025) on the proposed flexibility mechanisms for emission targets in the transport sector.

Finally, the relationship between legal instruments and environmental outcomes has been explored through meta-analytical and comparative approaches. Thonemann et al. (2022) conduct a meta life cycle assessment on mineral carbonation, questioning the ecological gains of certain CCU applications. Jones and Piebalgs (2022) underline the strategic importance of carbon capture, utilization and storage (CCUS) in the EU's legal roadmap toward climate neutrality.

### **3. METHODOLOGY**

In conducting this research and drawing conclusions, classical methods of legal analysis were applied, as typically used in the study of environmental and regulatory law. These included the logical-systematic method, legal document and normative content analysis, the comparative method, and selected methods of legal interpretation. The application of these methods enabled a thorough examination of European Union legislation and climate policy instruments concerning CO<sub>2</sub> emissions. The methodology also allowed for the identification of structural legal principles and cross-country regulatory differences within the EU framework.

### **4. RESULTS AND DISCUSSION**

The legal regulation of CO<sub>2</sub> emissions in the EU reflects a multi-faceted system that combines market-based instruments, direct sectoral regulation, and long-term strategic commitments. While these elements appear coherent in principle, their interaction in practice reveals structural and interpretative inconsistencies. Many instruments operate in parallel, with overlapping scopes, divergent implementation mechanisms, and varying legal weight across Member States. As a result, the EU's legal climate governance is not only broad but also fragmented, requiring continuous coordination and review.

This section evaluates the effectiveness, coherence, and limitations of selected legal frameworks, with particular focus on recent legislative reforms and climate policy instruments. The aim is not only to assess their technical functioning but also to question their legal sufficiency in addressing systemic challenges posed by decarbonisation. In this regard, legal norms are analysed not merely as static texts but as instruments of policy that either enable or constrain climate action on the ground.

To ensure a structured and meaningful analysis, the discussion is divided into three thematic areas: the EU ETS, the regulation of CCUS, and sector-specific legal instruments in relation to the broader climate neutrality objective. These themes were selected due to their centrality in current EU legal and policy developments, as well as their representativeness of both horizontal and vertical regulatory challenges. Some of these instruments raise interpretative and implementation issues that merit critical reflection, especially as the EU strives to align legal design with ambitious environmental objectives. In particular, the tension between harmonised EU-level legislation and divergent national practices remains a persistent concern.

#### **4.1. The Functioning and Reform of the European Union Emissions Trading System**

The EU ETS has long been the cornerstone of the EU's climate policy. Introduced in 2005, it is designed as a market-based instrument to cap and reduce greenhouse gas emissions from energy-intensive sectors. Over time, it has evolved through several legislative phases to address both environmental objectives and economic feasibility.

From a legal perspective, the EU ETS represents a hybrid structure that combines supranational regulation with national implementation. According to Kotzampasakis and Woerdman (2024), the system's legal architecture reflects a balance between flexibility and enforceability, aiming to respect Member State autonomy while preserving the environmental integrity of the internal carbon market. However, such a structure also raises concerns about harmonisation, particularly in the interpretation and application of allocation rules, monitoring requirements, and sanctioning mechanisms.

Empirical evaluations show that the EU ETS has contributed to emissions reduction, even during phases marked by low carbon prices. Bayer and Aklin (2020) argue that the existence of a legally binding cap, regardless of fluctuating allowance values, creates a credible long-term signal for decarbonisation. This observation is echoed in the analysis by Bianco et al. (2024), who demonstrate a decoupling trend between CO<sub>2</sub> emissions and economic growth in several Member States.

Despite these achievements, important legal shortcomings remain. One issue is the uneven distribution of auction revenues and ongoing debates over the fairness of allocation methods. Directive (EU) 2023/959 addresses these gaps by amending the original 2003 Directive, reinforcing market stability mechanisms and expanding coverage to the maritime sector. While the reform enhances legal clarity, it also increases complexity and creates coordination challenges across sectors and Member States.

A critical reflection suggests that although the EU ETS has matured as a legal instrument, its capacity to drive structural transformation remains constrained. The principle of cost-effectiveness, while economically rational, may lead to suboptimal outcomes when the legal framework fails to integrate broader sustainability considerations. In this light, rethinking the EU ETS requires attention not only to emissions metrics but also to climate justice, sectoral equity, and intergenerational responsibility.

#### **4.2. Legal Challenges in the Regulation of Carbon Capture, Utilization and Storage**

The legal regulation of CCUS in the EU is fragmented, dynamic, and largely shaped by technological developments. While CCS is legally covered through Directive 2009/31/EC,

CCU remains significantly less defined. This asymmetry raises interpretative and implementation challenges across jurisdictions.

Directive 2009/31/EC provides the legal basis for geological storage of CO<sub>2</sub>, including permitting procedures, monitoring obligations, liability rules, and site closure conditions. Frattini et al. (2024) highlight that administrative complexity, limited cross-border coordination, and public acceptance hinder the development of CCS infrastructure. Furre et al. (2017) confirm that long-term monitoring, such as at the Sleipner site, is legally feasible but burdensome, particularly regarding post-injection liability.

CCU technologies, by contrast, are not explicitly addressed in current climate law. Talus and Maddahi (2024) point out that the legal differentiation between permanent and impermanent storage is insufficiently defined, leading to ambiguity about whether such applications constitute valid emission reductions. This may compromise environmental integrity if accounting systems fail to distinguish between reversible and irreversible outcomes.

Criticism has also been directed at the CRCF. Günther et al. (2024) argue that it overestimates the permanence of certain removal techniques, including carbon farming and mineral carbonation. Thonemann et al. (2022) support this through lifecycle assessments showing marginal climate benefits from some CCU applications.

Infrastructure and investment uncertainty also limit the legal potential of CCUS. Gabrielli et al. (2022) and Becattini et al. (2022) note that stable, long-term legal frameworks are essential for scaling and integrating CCUS supply chains. Without predictable regulation, developers face a disconnect between technological readiness and legal security.

This area exemplifies the broader dilemma of legislating ahead of innovation. While stricter definitions could support environmental integrity, premature regulation may stifle emerging technologies. The EU must strike a careful balance between enabling climate solutions and preventing regulatory arbitrage or greenwashing.

### **4.3. Sector-Specific Measures and Long-Term Legal Coherence**

Recent EU legislation has expanded climate-related obligations into sector-specific domains, notably maritime and aviation transport. These sectors, historically excluded from core emission reduction schemes, are now subject to tailored legal instruments designed to align with the EU's climate neutrality goals.

Regulation (EU) 2023/1805 introduces binding requirements for the use of low-carbon and renewable fuels in maritime transport. While the regulation represents a major step in integrating shipping into climate governance, its legal implementation relies heavily on fuel availability, port infrastructure, and monitoring capacity across Member States. The need for harmonised enforcement mechanisms is particularly pressing in a sector defined by cross-border operations and international legal overlaps. Similarly, Regulation (EU) 2023/2405 (ReFuelEU Aviation) mandates minimum shares of sustainable aviation fuels in airline fuel consumption. Although the regulation creates a clear legal obligation, its effectiveness will depend on market readiness and the avoidance of indirect emissions through land-use change. The regulation also illustrates a shift from market instruments to direct legal mandates, suggesting a broader change in legislative philosophy.

In the heavy-duty transport sector, the Commission Implementing Decision (EU) 2025/792 establishes transparency requirements for CO<sub>2</sub> emission data. This move is seen as a prelude to more targeted regulation. As noted in *The National Law Review* (2025), the Commission also proposed flexibility mechanisms for manufacturers to meet short-term climate targets, reflecting a pragmatic adaptation to industry capacity constraints.

These sectoral measures exist alongside the EU's broader climate roadmap. Bouckaert et al. (2021) outlines the strategic need for sectoral integration, while the Commission (2020, n.d.) emphasises systemic transformation across all economic areas. Yet, the legal coherence between long-term strategy and concrete instruments remains uneven. Jones and Piebalgs (2022) point out that carbon-intensive sectors still benefit from fragmented regulation, and Akerboom et al. (2021) note that implementation gaps undermine the consistency of national responses.

Taken together, the recent sector-specific instruments show legal progress but also raise questions about enforceability and strategic alignment. The coexistence of binding obligations, soft-law instruments, and national discretion generates a layered regulatory environment. Without improved vertical coordination and cross-sectoral legal integration, the full potential of EU climate legislation may remain unrealised.

## 5. CONCLUSION

The analysis of legal regulation related to CO<sub>2</sub> emissions in the EU reveals a complex, multilayered, and evolving system that combines market-based mechanisms, targeted sectoral mandates, and strategic planning instruments. While the EU has established a robust legislative framework to support its climate neutrality objectives, several normative and structural tensions continue to challenge its coherence and effectiveness.

The EU ETS remains the central legal instrument for reducing emissions in energy-intensive sectors. It has demonstrated measurable success in incentivising decarbonisation, particularly following recent reforms such as Directive (EU) 2023/959. However, legal concerns persist regarding the fairness of allocation methods, the balance between market efficiency and environmental ambition, and the consistency of implementation across Member States.

In the field of CCUS, regulatory developments are uneven. CCS is addressed by an established legal act, yet its practical application is limited by administrative burdens and liability concerns. Meanwhile, CCU operates without a clear legal framework, creating uncertainty around the recognition of impermanent carbon storage and its role in climate accounting. Although the introduction of certification tools like the CRCF reflects progress, more rigorous and transparent legal definitions are necessary to maintain regulatory integrity.

Sector-specific instruments – particularly in maritime, aviation, and heavy-duty transport – reflect the EU's effort to close legal gaps and extend climate obligations to all high-emission sectors. These initiatives mark a significant shift from market-based incentives to binding legal mandates. Yet, the implementation of such measures often encounters technological, infrastructural, and economic constraints. The alignment between long-term strategic planning and enforceable legal obligations therefore remains incomplete.

In summary, the EU has made substantial legal strides in regulating CO<sub>2</sub> emissions, but the system still lacks full integration. Addressing the disconnection between overlapping legal layers, improving vertical coordination, and enhancing the enforceability of obligations should be central to the next phase of EU climate law. The challenge lies not only in adopting new legal measures, but in refining the coherence, credibility, and legal precision of the existing regulatory framework.

## REFERENCES

- Akerboom, S., Waldmann, S., Mukherjee, A., Agaton, C., Sanders, M., & Kramer, G. J. (2021). Different this time? The prospects of CCS in the Netherlands in the 2020s. *Frontiers in Energy Research*, 9, 644796. <https://doi.org/10.3389/fenrg.2021.644796>.
- Bayer, P., & Aklin, M. (2020). The European Union Emissions Trading System reduced CO<sub>2</sub> emissions despite low prices. *Proceedings of the National Academy of Sciences*, 117(16), 8804–8812. <https://doi.org/10.1073/pnas.1918128117>.
- Becattini, V., Gabrielli, P., Antonini, C., Campos, J., Acquilino, A., Sansavini, G., & Mazzotti, M. (2022). Carbon dioxide capture, transport and storage supply chains: Optimal economic and environmental performance of infrastructure rollout. *International Journal of Greenhouse Gas Control*, 117, 103635. <https://doi.org/10.1016/j.ijggc.2022.103635>.
- Bianco, V., Cascetta, F., & Nardini, S. (2024). Analysis of the carbon emissions trend in European Union: A decomposition and decoupling approach. *Science of the Total Environment*, 909, 168528. <https://doi.org/10.1016/j.scitotenv.2023.168528>.
- Bouckaert, S., Fernandez Pales, A., McGlade, C., Remme, U., Wanner, B., Varro, L., D'Ambrosio, D., & Spencer, T. (2021). Net Zero by 2050: A roadmap for the global energy sector. *International Energy Agency*. <https://trid.trb.org/view/1856381>
- Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. *Official Journal of the European Union*, L 2023/2413, 31 October 2023.
- Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading system. *Official Journal of the European Union*, L 130, 16 May 2023, 134–202.
- Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006. *Official Journal of the European Union*, L 140, 5 June 2009, 114–135.
- Dupont, C., Moore, B., Boasson, E. L., Gravey, V., Jordan, A., Kivimaa, P., Turnheim, B., & von Homeyer, I. (2023). Three decades of EU climate policy: Racing toward climate neutrality? *WIREs Climate Change*, 15(1), e863. <https://doi.org/10.1002/wcc.863>.
- European Commission. (2020). Towards net-zero emissions in the EU energy system by 2050: Insights from scenarios in line with the 2030 and 2050 ambitions of the European Green Deal (Joint Research Centre Report). *Publications Office of the European Union*. <https://data.europa.eu/doi/10.2760/081488>.
- European Commission. (2025). Commission Implementing Decision (EU) 2025/792 of 24 April 2025 on the publication of data reported by Member States on the CO<sub>2</sub> emissions of new heavy-duty vehicles. *Official Journal of the European Union*, L 2025/792. [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AL\\_202500792](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AL_202500792).
- European Commission. (n.d.). 2050 long-term strategy. [https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy\\_en](https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en) (accessed 4 March 2025)

- Frattoni, E., Lukacova, K., & Rivas, S. (2024). Main current legal and regulatory frameworks for carbon dioxide capture, transport, and storage in the European Economic Area. *International Journal of Greenhouse Gas Control*, 131, 103962. <https://doi.org/10.1016/j.ijggc.2023.103962>.
- Furre, A. K., Eiken, O., Alnes, H., Vevatne, J. N., & Kiær, A. F. (2017). 20 years of monitoring CO<sub>2</sub>-injection at Sleipner. *Energy Procedia*, 114, 3916–3926. <https://doi.org/10.1016/j.egypro.2017.03.1523>.
- Gabrielli, P., Campos, J., Becattini, V., Mazzotti, M., & Sansavini, G. (2022). Optimization and assessment of carbon capture, transport and storage supply chains for industrial sectors: The cost of resilience. *International Journal of Greenhouse Gas Control*, 121, 103797. <https://doi.org/10.1016/j.ijggc.2022.103797>.
- Günther, K., Häyhä, T., & Jänicke, C. (2024). Carbon farming, overestimated negative emissions and the limits to emissions trading in land-use governance: The EU carbon removal certification proposal. *Environmental Science & Policy*, 149, 70–78. <https://doi.org/10.1016/j.envsci.2024.104354>.
- Jones, C., & Piebalgs, A. (2022). The role of CCUS on the EU road to climate neutrality (Policy Brief, European University Institute). <https://cadmus.eui.eu/handle/1814/73595>.
- Kotzampasakis, M., & Woerdman, E. (2024). The legal objectives of the EU emissions trading system: An evaluation framework. *Transnational Environmental Law*, 13(2), 312–336. <https://doi.org/10.1017/S2047102524000153>.
- Regulation (EU) 2023/1805 of the European Parliament and of the Council of 13 September 2023 on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC. *Official Journal of the European Union*, L 234, 22 September 2023.
- Regulation (EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023 on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation). *Official Journal of the European Union*, L 2023/2405, 31 October 2023.
- Talus, K., & Maddahi, R. (2024). Carbon capture and utilization under EU law: Impermanent storage of CO<sub>2</sub> in products and pre-combustion carbon capture. *Journal of World Energy Law and Business*, 17(5), 295–308. <https://doi.org/10.1093/jwelb/jwae009>.
- The National Law Review. (2025, April 16). Commission proposes to provide flexibility for manufacturers in meeting 2025 CO<sub>2</sub> emission targets. <https://natlawreview.com/article/commission-proposes-provide-flexibility-manufacturers-meeting-2025-co2-emission> (accessed 22 April 2025)
- Thonemann, N., Zacharopoulos, L., Fromme, F., & Nühlen, J. (2022). Environmental impacts of carbon capture and utilization by mineral carbonation: A systematic literature review and meta life cycle assessment. *Journal of Cleaner Production*, 332, 130067. <https://doi.org/10.1016/j.jclepro.2021.130067>.



## COMMUNICATION SATISFACTION AS A PREDICTOR OF ORGANIZATIONAL COMMITMENT

**Danijela Voza\*, Zorana Janković, Milovan Vuković**

*University of Belgrade, Technical faculty in Bor, Serbia*

**Abstract:** Effective internal communication plays a crucial role in fostering organizational commitment, which is essential for the long-term success and sustainability of any organization. This study investigates the relationship between communication satisfaction factors and organizational commitment, focusing on the influence of communication satisfaction in various organizational settings. A survey was conducted among 197 employees across different industries, utilizing the Communication Satisfaction Questionnaire (CSQ) and the Organizational Commitment Instrument (OCI) to measure key factors. The results of Correlation analysis indicate a significant positive correlation between overall communication satisfaction and organizational commitment, with communication climate, feedback, and media quality emerging as the most influential factors. The Stepwise Multiple Regression Analysis proved that horizontal communication and media quality are the strongest predictors of organizational commitment. These findings suggest that organizations can enhance employee engagement and retention by improving communication satisfaction, particularly through effective feedback mechanisms and fostering a supportive communication environment.

**Keywords:** communication satisfaction, organizational commitment, prediction, employee engagement

### 1. INTRODUCTION

In today's dynamic environment, marked by rapid shifts in business paradigms and strategies, human resources have emerged as a key factor in the sustainable development and success of organizations. Employees are increasingly expected to demonstrate efficiency, productivity, creativity, and high-quality performance, making internal communication a crucial element of effective business operations. The modern business landscape requires that information circulate within organizations faster and more efficiently than ever before.

---

\* Corresponding author: [dvoza@tfbor.bg.ac.rs](mailto:dvoza@tfbor.bg.ac.rs)

Danijela Voza, ORCID: 0000-0003-0895-731X  
Zorana Janković, ORCID: 0009-0008-6265-1454  
Milovan Vuković, ORCID: 0000-0003-1715-1078



Effective communication has become a fundamental prerequisite for achieving organizational goals, whether in the production of goods or the provision of services. Its primary function is to connect members of the organization in pursuit of common objectives. However, beyond its informational function, communication also has control, motivational, and emotional dimensions, all of which contribute to enhancing organizational cohesion and efficiency. Communication satisfaction is one of the key factors in understanding organizational dynamics and serves as an important mechanism for enhancing organizational effectiveness. High level of communication satisfaction leads to numerous positive outcomes, such as greater job satisfaction, improved performance, and increased overall organizational productivity.

A particularly significant aspect of human resource management is organizational commitment. Although it is often seen as an extension of job satisfaction, organizational commitment implies a deeper emotional connection between employees and the organization. It is a multidimensional construct encompassing employee loyalty and their willingness to remain with the organization over a longer period, even in situations where current working conditions are less than ideal. Organizations that foster organizational commitment create a work environment in which employees feel valued and recognized. When employees feel aligned with the values and goals of the organization, they exhibit higher levels of engagement and greater job satisfaction.

Employee communication and organizational commitment represent important areas of research, especially in developed countries. The findings from numerous studies highlight the critical role these factors play in improving organizational practices. The insights gained are used to develop strategies aimed at enhancing internal communication and strengthening employee commitment.

## **2. THEORETICAL FRAMEWORK**

### **2.1. Communication satisfaction**

Communication within an organization serves as the fundamental mechanism for connecting employees and directing activities toward the achievement of common goals. Effective internal communication becomes a key requirement for the successful functioning of modern organizations, especially under conditions of rapid change and increasing demands for efficiency and adaptability.

The concept of communication satisfaction refers to how satisfied employees feel with their overall communicative environment. Communication satisfaction encompasses various aspects of internal communication, particularly the two-way exchange of information between management and employees. The concept was developed by Downs and Hazen (1977), who operationalized communication satisfaction through several dimensions: communication climate, communication with superiors and subordinates, organizational integration, media quality, horizontal and informal communication, organizational perspective, and personal feedback.

*Communication climate* refers to the overall quality of communication processes within the organization at both the organizational and individual levels. *Communication with superiors* measures the willingness of managers to listen to employees, accept their ideas, and provide helpful guidance. *Subordinate communication* focuses on the flow of information from the top down and from the bottom up through the organizational structure. *Horizontal and informal communication* evaluates the quality and openness of information exchange among colleagues, including informal sources such as rumors. *Media quality* assesses the effectiveness of communication tools, meetings, written instructions, and organizational publications.

*Organizational integration* encompasses employee satisfaction with information related to the organization, their work tasks, and colleagues. *Organizational perspective* provides insight into broader information concerning the organization's strategy, goals, and finances. Finally, *personal feedback* addresses the employees' need to be informed about evaluations of their performance and their individual contributions to organizational objectives.

All these dimensions collectively form the foundation for understanding how communication processes impact employee satisfaction, engagement, and organizational commitment - representing a key focus of contemporary research in the field of organizational communication.

## **2.2. Organizational commitment**

Organizational commitment is defined as the level of identification and involvement an individual has within an organization (Lyndon & Rawat, 2015), as well as the degree to which an employee feels loyalty to their organization (Wee Siong & Ibrahim, 2023). The term commitment implies a stronger degree of emotional attachment employees feel toward the organization compared to mere job satisfaction. Organizational commitment represents a positive attitude of employees not toward their specific job roles, but toward the organization as a whole or its members. In this sense, employee commitment is often viewed as an emotional bond with the organization (Bucăța, Virca & Popescu, 2022). According to Lyndon and Rawat (2015), organizational commitment encompasses three key dimensions: belief in and acceptance of the organization's goals, willingness to exert extra effort, and the desire to remain a member of the organization.

A significant contribution to the development of organizational commitment theory was made by Meyer and Allen (1991) through their three-component model, which includes affective, continuance, and normative commitment:

- *Affective commitment* refers to an emotional attachment to and identification with the organization, where employees remain because they want to. This form of commitment primarily develops through positive work experiences, such as strong relationships with supervisors, organizational support, and role clarity.
- *Continuance commitment* is based on economic considerations and the perceived costs associated with leaving the organization. Employees stay because they have to, believing that leaving would be financially unfavorable or practically difficult.
- *Normative commitment* reflects a sense of obligation to remain with the organization, either due to prior social expectations (e.g., family pressure) or loyalty developed after joining the company.

Organizational commitment is also influenced by the degree of alignment between employees' personal characteristics and the attributes of the job, team, and organization itself. A better fit between the employee and the work environment contributes to higher job satisfaction, which in turn leads to stronger organizational commitment (Chhabra, 2015).

## **3. LITERATURE REVIEW**

The authors Putti et al. (1990) were among the first to demonstrate that satisfaction with communication relationships, particularly with top management, is strongly associated with organizational commitment. Field study conducted by Clampitt and Downs (1993) further examined how different dimensions of communication satisfaction influence employee

productivity and organizational commitment. These early studies laid the groundwork for subsequent research linking specific aspects of communication to organizational behavior.

In more recent literature, Raina and Roebuck (2016) highlighted that effective top-down communication - via clear instructions and timely feedback - significantly contributes to employee satisfaction, loyalty, and organizational commitment. In contrast, Buyukyilmaz and Kara (2024) showed that toxic leadership behavior negatively impacts job satisfaction, organizational identification, and employee commitment, while increasing their intention to leave the organization. Perceptions of fairness in organizational relationships have also been shown to be important. Lin (2014) found that a positive perception of organizational justice increases commitment and reduces employee turnover, whereas perceived unfair treatment has the opposite effect. Gautam et al. (2004) stressed that organizational identification and commitment are related but conceptually distinct, with affective commitment showing the strongest link to identification. Magdalena and Tanuwijaya (2022) demonstrated that job satisfaction and supervisor support positively affect organizational identification, which in turn enhances commitment. Santiago (2020) emphasized that internal communication plays a critical role in shaping employees' perceptions of organizational care for their contributions, directly strengthening identification.

Openness in communication between staff and leadership, along with supportive horizontal communication, positively affects organizational commitment (De Nobile & Bilgin, 2022). Effective internal communication has been highlighted as a key prerequisite for strengthening employee engagement. Karanges et al. (2015) empirically showed that both organizational-level and supervisor-level communication positively influence engagement. Similarly, Barresi (2025) concluded that formal communication has a dominant effect on affective commitment in the retail sector, while communication with superiors plays a secondary but still significant role. A systematic review by Synitsia et al. (2024) further confirms that internal communication, analyzed through various theoretical frameworks, significantly contributes to the development of organizational loyalty.

In the public sector, Glenn et al. (2023) found in their study of local government units in Surigao that perceived organizational support strongly correlates with organizational commitment. Jimenez et al. (2021), in research conducted in local government institutions in the Philippines, discovered that effective communication positively influences affective and continuance commitment, while showing a negative correlation with normative commitment. Similarly, Değirmenci Tarakcı et al. (2024) demonstrated in a public hospital in Izmir that the quality of organizational communication positively affects job satisfaction, with organizational commitment mediating this relationship. Dalal et al. (2023) emphasized that internal communication and job satisfaction together contribute to strengthening organizational commitment among healthcare workers. In educational institutions, Ma (2022) highlighted that clear internal communication and quality feedback increase engagement and commitment among teaching staff. In the industrial sector, Marhouni and Pali (2025) found that leadership style and managerial communication patterns significantly influence employee performance, job satisfaction, and organizational commitment.

Despite the abundance of research confirming the importance of communication in fostering organizational commitment, the precise communication mechanisms that lead to increased commitment remain insufficiently clarified. Compared to broader themes such as leadership, motivation, or organizational culture, the specific role of communication is often addressed as a secondary component rather than as a central topic. Therefore, future research must explore the specific aspects of communication processes that contribute to different dimensions of organizational commitment, taking into account sectoral, cultural, and organizational contexts. Based on these findings, this study proposes two research questions:

1. What is the relationship between the communication satisfaction factors and the organizational commitment?
2. Which communication satisfaction factors are the best predictors of changes in employee organizational commitment?

The aim of this study is to identify communication satisfaction factors that can positively influence strategies for enhancing employee organizational commitment.

#### **4. METHODOLOGY**

For the purposes of this research, a questionnaire was developed based on a combination of the Communication Satisfaction Questionnaire (CSQ), developed in 1977 by Downs and Hazen, and the Organizational Commitment Instrument (OCI) developed by Cook & Wall (1980). The CSQ is used as a reliable instrument for measuring communication satisfaction and is one of the most comprehensive questionnaires, as it assesses the direction of information flow in both formal and informal communication channels and refers to different members of the organization and forms of communication. The questionnaire for measuring organizational commitment (OCI) contains nine items and measures organizational identification, involvement, and employee loyalty.

The questionnaire used in this research consists of 44 statements grouped into 10 sections, with 7 sections referring to communication: organizational perspective (OP), supervisory communication (SC), communication climate (CC), personal feedback (PF), horizontal communication (HC), media quality (MQ), organizational integration (OI), while the remaining three groups of questions address the dimensions of organizational commitment – continuance (COC), affective (AOC), and normative (NOC) organizational commitment.

Responses were collected using a five-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with participants indicating their level of agreement with each statement. Data were collected through 197 completed questionnaires from employees working in organizations operating in diverse sectors.

The database was processed in three steps. First, Cronbach Alphas were calculated to determine the internal reliability of each of the instruments used in this study. Second, Pearson Correlation Analysis was performed in order to examine the relationship between communication satisfaction factors and organizational commitment composites. Finally, Stepwise Multiple Regression Analysis examined possibilities for predicting the effect of communication satisfaction factors and composite on organizational commitment composite. SPSS v.21 was used for data analysis.

#### **5. RESULTS AND DISCUSSION**

The reliability of the questionnaire was evaluated using Cronbach's alpha coefficient (Table 1). The analysis revealed a high level of internal consistency for each group of questions, and with a Cronbach's alpha value for total questionnaire of .926, indicating that the scale is highly reliable. This level of reliability provides a solid foundation for the validity of the results obtained in subsequent analyses.

*Table 1. Overview of question groups, abbreviations, and Cronbach's Alpha coefficients*

Group of questions	Abbreviation	Number of items	Cronbach's alpha
Organizational perspective	OP	5	0.928
Supervisory communication	SC	5	0.900
Communication climate	CC	5	0.876
Personal feedback	PF	5	0.856
Horizontal communication	HC	5	0.726
Media quality	MQ	5	0.652
Organizational integration	OI	5	0.864
Continuance organizational commitment	COC	3	0.712
Affective organizational commitment	AOC	3	0.880
Normative organizational commitment	NOC	3	0.856
Total questionnaire		44	0.926

Further, Pearson Correlations Analyses was used to determine the relationship between: (a) communication satisfaction composite and organizational commitment composite; (b) communication satisfaction factors and communication satisfaction composite and (c) communication satisfaction factors mutually (Table 2). The communication satisfaction composite was determined by computing the overall mean of all the communication satisfaction items, while the organisational commitment composite was determined by computing the overall mean for all the commitment items.

*Table 2. Correlation between organizational commitment and communication satisfaction factors*

	OC composite	OP	SC	CC	PF	HC	MQ	OI	CS composite
OC composite	1.000	.530	.480	.639	.587	.562	.633	.552	.668
OP	.530	1.000	.522	.675	.678	.461	.728	.663	.820
SC	.480	.522	1.000	.638	.664	.607	.594	.618	.778
CC	.639	.675	.638	1.000	.804	.619	.830	.773	.900
PF	.587	.678	.664	.804	1.000	.620	.782	.788	.903
HC	.562	.461	.607	.619	.620	1.000	.564	.561	.729
MQ	.663	.728	.594	.830	.782	.564	1.000	.769	.895
OI	.552	.663	.618	.773	.788	.561	.769	1.000	.879
CS composite	.668	.820	.778	.900	.903	.729	.895	.879	1.000

Correlation analysis confirmed strong positive relationship between communication satisfaction and organizational commitment. The nature of this relationship, however, varied for the communication satisfaction factors and composite. The Pearson correlation coefficient of 0.668 indicates that there is moderately strong positive linear correlation between communication satisfaction and organisational commitment composites. Each of the ten communication satisfaction factors had also significant ( $p < .001$ ), moderate and positive relationships with the overall commitment composite ranging from .480 for Supervisory Communication to .639 for Communication Climate. The communication climate reflects the degree to which organizational communication stimulates and motivates employees to pursue organizational objectives, as well as the extent to which it promotes their identification with the organization. It also entails an evaluation of the overall quality and effectiveness of internal communication. Obtained Pearson's coefficients between communication factors mutually indicate the correlated relationship. This is in accordance with the findings of previous study

suggesting that aspects of organisational communication may complement one another and be interrelated (Cherkowski, 2012).

Finally, Stepwise Multiple Regression was performed for the purpose of explaining the relationship between communication satisfaction factors and organizational commitment. In this analysis, ten communication satisfaction factors and composite were treated as the predictor variables and the organisational commitment composite as the dependent variable. The stepwise selection method was used to include predictors that most significantly contribute to explaining the variance in organizational commitment. Across the three models, the predictors significantly improve the explanation of the variance in organizational commitment (Table 3). In Model 1, only CS\_composite was entered as a predictor, explaining 44.7% of the variance in OC\_composite ( $R^2 = .447$ , Adjusted  $R^2 = .444$ ,  $F(1, 195) = 157.52$ ,  $p < .001$ ). The regression coefficient for CS\_composite was statistically significant ( $\beta = .668$ ,  $t = 12.55$ ,  $p < .001$ ), indicating a strong positive relationship with the outcome variable.

In Model 2, HC was added to the model, leading to a small but significant increase in explained variance ( $R^2 = .459$ , Adjusted  $R^2 = .453$ ). This change in  $R^2$  was significant ( $\Delta R^2 = .012$ ,  $F(1, 194) = 4.28$ ,  $p = .040$ ), suggesting that HC contributes additional explanatory power. HC was a significant predictor ( $\beta = .160$ ,  $t = 2.07$ ,  $p = .040$ ), though less influential than CS\_composite ( $\beta = .552$ ). In Model 3, MQ was included as the third predictor, further increasing the explained variance to 47.2% (Adjusted  $R^2 = .463$ ). The change was again statistically significant ( $\Delta R^2 = .013$ ,  $F(1, 193) = 4.67$ ,  $p = .032$ ). All three predictors remained significant in the final model: CS\_composite ( $\beta = .278$ ,  $p = .061$ ), HC ( $\beta = .209$ ,  $p = .009$ ), MQ ( $\beta = .265$ ,  $p = .032$ ). Accordingly, the final model retained three predictors: CS\_composite (communication satisfaction), HC (horizontal communication) and MQ (media quality). Notably, while CS\_composite had the strongest standardized coefficient in Model 1, its unique contribution decreased slightly as new predictors were added in subsequent models.

Table 3. Stepwise Regression Models predicting Organizational Commitment

	Predictors	R Square	Adj. R <sup>2</sup>	F	Sig.	$\beta$ – CS	Sig.	$\beta$ – HC	Sig.	$\beta$ – MQ	Sig.
1	CS_composite	.447	.444	157.52	.000	.668	.000	–	–	–	–
2	CS_composite, HC	.459	.453	82.23	.000	.552	.000	.160	.040	–	–
3	CS_composite, HC, MQ	.472	.463	57.41	.000	.278	.061	.209	.009	.265	.032

These results suggest that enhancing communication satisfaction, fostering horizontal communication, and improving media quality within the organization may contribute to higher levels of organizational commitment among employees. Horizontal communication that promotes openness and mutual support among colleagues appears to be a significant predictor of organizational commitment (De Nobile & Bilgin, 2022). Interestingly, this study found that vertical communication (communication with superiors and the provision of feedback) does not play a significant role in predicting organizational commitment, despite numerous prior studies demonstrating a strong relationship between the two (Ma, 2022; De Nobile & Bilgin, 2022; Magdalena & Tanuwijaya, 2022). In contrast, the exchange of information between colleagues or departments that are on equal hierarchical levels, rather than in superior-subordinate relationships, emerged as a stronger predictor of commitment. One possible explanation for these findings may lie in certain characteristics of Serbia's national culture, which is marked by a relatively high power distance. In such cultures, employees may not expect open and bidirectional communication with superiors in the workplace (Janićjević & Marinković, 2015; Dai et al., 2022; Abbate et al., 2025). Numerous studies highlight that media quality referring

to the clarity, reliability, and timeliness of communication channels plays a significant role in shaping employees' organizational commitment (Ammari et al., 2017; Barresi, 2025). High-quality communication media enhance employees' satisfaction and trust, fostering a stronger emotional attachment to the organization.

## 6. CONCLUSION

Research on organizational communication and employee commitment has become increasingly important in understanding how internal communication strategies impact workplace dynamics. The study's results contribute to a deeper understanding of how these strategies can influence employee commitment, offering valuable insights for managers and organizational leaders. The findings confirm the significant impact of communication satisfaction on organizational commitment, underscoring the importance of a communication environment where employees feel heard, informed, and valued. In particular, aspects such as communication climate, feedback, and media quality play a critical role in strengthening employees' emotional connection with the organization. Horizontal communication and media quality were identified as the most potent predictors of organizational commitment. Therefore, organizations should focus on enhancing these elements by fostering more collaborative communication across departments and ensuring the high quality of communication channels. Additionally, given the rise of remote and hybrid work models, future research could explore how these factors operate in virtual environments and within various industries, especially in fast-evolving sectors like IT and technology. These insights can serve as a guide for organizational leaders seeking to implement communication strategies that not only improve employee morale but also enhance organizational loyalty and overall performance.

## ACKNOWLEDGMENT

The authors are grateful to the Ministry of Education, Science and Technological Development of the Republic of Serbia for financial support according to the contract with registration number 451-03-137/2025-03/200131.

## REFERENCES

- Abbate, S. C., Bonfanti, C. R., Misuraca, R., & Ruggieri, S. (2025). Power distance in the workplace and its effect on prosocial behavioral intentions. *Acta Psychologica*, 253, 104695. <https://doi.org/10.1016/j.actpsy.2025.104695>
- Barresi, M. (2025). Perception of communication satisfaction and its impact on employee organizational commitment in two multinational supermarkets chains: An Argentine case. *Management Research*, ahead-of-print. <https://doi.org/10.1108/MRJIAM-10-2023-1467>
- Bucăța, G., Virca, I. & Popescu, F. (2022). Organisational commitment, motivation and job satisfaction. *Land Forces Academy Review*, 27(2), 124-133. <https://doi.org/10.2478/raft-2022-0017>
- Buyukyilmaz, O., & Kara, C. (2024). Linking leaders' toxic leadership behaviors to employee attitudes and behaviors. *Serbian Journal of Management*, 19(2), 393 – 412. <https://doi.org/10.5937/sjm19-43650>

- Cherkowski, S. (2012). Teacher commitment in sustainable learning communities: A new “ancient” story of educational leadership. *Canadian Journal of Education*, 35(1), 56–68. <https://journals.sfu.ca/cje/index.php/cje-rce/article/view/717>
- Chhabra, B. (2015). Person – Job fit: mediating role of job satisfaction & organizational commitment. *Indian Journal of Industrial Relations*, 50(4), 638–651. <http://www.jstor.org/stable/24547010>
- Clampitt, P. G., & Downs, C. W. (1993). Employee perceptions of the relationship between communication and productivity: a field study. *The Journal of Business Communication*, 30(1), 5-28. <https://doi.org/10.1177/002194369303000101>
- Cook, J., & Wall, T. (1980). New work attitude measures of trust, organizational commitment and personal need non-fulfillment. *Journal of Occupational Psychology*, 53, 39-52. <http://dx.doi.org/10.1111/j.2044-8325.1980.tb00005.x>
- Dai, Y., Li, H., Xie, W., & Deng, T. (2022). Power distance belief and workplace communication: the mediating role of fear of authority. *International Journal of Environmental Research and Public Health*, 19(5), 2932. <https://doi.org/10.3390/ijerph19052932>
- Dalal, H. J. A., Ramoo, V., Chong, M. C., Danaee, M., Aljeesh, Y. I., & Rajeswaran, V. U. (2023). The mediating role of work satisfaction in the relationship between organizational communication satisfaction and organizational commitment of healthcare professionals: a cross-sectional study. *Healthcare (Basel)*, 11(6), 806. <https://doi.org/10.3390/healthcare11060806>
- De Nobile, J., & Bilgin, A. A. (2022). A structural model to explain influences of organisational communication on the organisational commitment of primary school staff. *Education Sciences*, 12(6), 395. <https://doi.org/10.3390/educsci12060395>
- Değirmenci Tarakcı, H., Yıkılmaz, İ., & Sürücü, L. (2024). The mediating role of organizational commitment in the effect of organizational communication quality on job satisfaction. *International Journal of Economics and Administrative Studies*, 45, 97-114. <https://doi.org/10.18092/ulikidince.1427925>
- Downs, C. W., & Hazen, M. D. (1977). A factor analytic study of communication satisfaction. *Journal of Business Communication*, 14(3), 63-74. <https://doi.org/10.1177/002194367701400306>
- Dr. Glenn R. Andrin, Christy Joy A. Gabrieles, Martha Joan R. Gregorio, Diodelia B. Gorgonio, Loren C. Brazil, Loutchin C. Capitin, Maricel G. Pulido, Jerum R. Dumale (2023). Organizational support and employees’ commitment at the local government units of Surigao City. *International Journal of Science and Management Studies*, 6(1), 8-40. <https://doi.org/10.51386/25815946/ijsms-v6i1p102>
- Gautam, T., Dick, V. D. & Wagner, U. (2004). Organizational identification and organizational commitment: Distinct aspects of two related concepts. *Asian Journal of Social Psychology*, 7(3), 301–315. <https://doi.org/10.1111/j.1467-839X.2004.00150.x>
- Ghalia Ammari, G., Al Kurdi, B., Alshurideh, M., Obeidat, B., Abu Hussien, A., & Alrowwad, A. (2017). Investigating the impact of communication satisfaction on organizational commitment: a practical approach to increase employees’ loyalty. *International Journal of Marketing Studies*, 9(2), 113-133. <https://doi.org/10.5539/ijms.v9n2p113>
- Janićijević, N., & Marinković, I. (2015). Empirical testing of Hofstede’s measures of national culture and their impact on leadership in four countries. *Economics of Enterprise*, 63(5-6), 264-278. <https://doi.org/10.5937/ekopre1506264J>
- Karanges, E., Johnston, K., Beatson, A., & Lings, I. (2015). The influence of internal communication on employee engagement: A pilot study. *Public Relations Review*, 41(1), 129–131. <https://doi.org/10.1016/j.pubrev.2014.12.003>



- Lin, P. -C. (2014). A study on the expatriates, organizational justice, organizational commitment, job engagement, and organizational effectiveness. *Acta Oeconomica*, 64(S2), 53–68. <https://doi.org/10.1556/AOecon.64.2014>
- Lyndon, S., & Rawat, P. S. (2015). Effect of leadership on organizational commitment. *Indian Journal of Industrial Relations*, 51(1), 97–108.
- Ma Y. (2022). Role of communication strategies in organizational commitment, mediating role of faculty engagement: evidence from English language teachers. *Frontiers in Psychology*, 13, 921797. <https://doi.org/10.3389/fpsyg.2022.921797>
- Magdalena, P. & Tanuwijaya, J. (2022). Factors of organizational identification influencing affective commitment at the Direktorat Jenderal Pemasyarakatan Kementerian Hukum dan Hak Asasi Manusia Republik Indonesia in Jakarta. *International Journal of Research and Review*, 9(9), 385-390. <https://doi.org/10.52403/ijrr.20220944>
- Marhouni, E., & Pali, S. (2025). The relationship between leadership style and managers' communication patterns on employee performance, job satisfaction, and organizational commitment. *International Journal of Innovation Management and Organizational Behavior*, 5(1), 122-132. <https://doi.org/10.61838/kman.ijimob.5.1.13>
- Meyer, J. P., Allen, N. J. (1991). A three-component conceptualization of organizational commitment. *Human Resources Management Review*, 1(1), 61–89. [https://doi.org/10.1016/1053-4822\(91\)90011-Z](https://doi.org/10.1016/1053-4822(91)90011-Z)
- Jimenez, B. J., Montes, T. N., Velez, D. J., & Caballero, A. M. M. (2021). Organizational Communication in Relation to the Organizational Commitment among Local Government Employees, Panglao, Bohol. *University of Bohol Multidisciplinary Research Journal*, 9(1), 30-56. <https://doi.org/10.15631/ubmrj.v9i1.132>
- Putti, J. M., Aryee, S., & Phua, J. (1990). Communication relationship satisfaction and organizational commitment. *Group & Organization Studies*, 15(1), 44–52. <https://doi.org/10.1177/105960119001500104>
- Raina, R., & Roebuck, D. B. (2016). Exploring cultural influence on managerial communication in relationship to job satisfaction, organizational commitment, and the employees' propensity to leave in the insurance sector of India. *International Journal of Business Communication*, 53(1), 97–130. <https://doi.org/10.1177/2329488414525453>
- Santiago, J. K. (2020). The influence of internal communication satisfaction on employees' organisational identification: Effect of perceived organisational support. *Journal of Economics & Management*, 42(4), 70-98. <https://doi.org/10.22367/jem.2020.42.04>
- Sinityna, E., Anand, A., & Stocker, M. (2024). The role of internal communication on employee loyalty – a theoretical synthesis, *Journal of Asia Business Studies*, 18(2), 367-384. <https://doi.org/10.1108/JABS-05-2023-0179>
- Wee Siong, I. S. & Ibrahim, F. (2023). The mediating effect of organisational identity on the relationship between dimensions of organisational climate and employee performance of Singapore small and medium size enterprises (SMEs). *Journal of Education and Social Sciences*, 25(1), 76-99.



## ENCRYPTION AND INFORMATION

**Halima Onalla Ali<sup>1\*</sup>, Sakina Almakhzoum<sup>2</sup>, Dušan Regodic<sup>2</sup>, Velimir Dedić<sup>1</sup>,  
Maja Andjelkovic<sup>1</sup>**

<sup>1</sup> *University "Union - Nikola Tesla", Faculty of Information Technology and Engineering,  
Belgrade, Republic of Serbia*

<sup>2</sup> *MB University, Faculty of Information Technology and Engineering,  
Belgrade, Republic of Serbia*

**Abstract:** Information technology (IT) can be defined as the study, design, and development of computer information systems. It is the science of the future, including software information systems, network management, databases, and communications systems design. These include networks, database management systems, information security, and software engineering. It should be noted that the goals achieved by IT in our lives are numerous, and these technologies enable us to accomplish tasks with ease and convenience. IT is responsible for all of these tasks, so the need to protect this private data through data and information security must be taken into account. The primary objective of this study is to define information security as the true means of ensuring the confidentiality of important information by ensuring its protection from theft and hacking, and preventing unauthorized access to it by individuals using modern technologies, including data encryption algorithms. This study also aims to examine the process of electronic authentication and information security in managing a private company, as well as to identify how to apply these concepts and use advanced technologies to achieve security and privacy for the data and information we use in all areas of our daily lives.

**Keywords:** Data encryption, cyber security, electronic security, electronic authentication, data protection.

---

\* Corresponding author: [halima123onalla@gmail.com](mailto:halima123onalla@gmail.com)

Halima Onalla Ali, ORCID: 0009-0002-6754-8954  
Sokina Almakzom, ORCID: 0009-0008-3395-8481  
Dušan Regodic, ORCID: 0009-0007-6804-2724  
Velimir Dedić, ORCID: 0009-0007-1402-1979  
Maja Andjelkovic, ORCID: 0009-0007-3367-1125

## 1. INTRODUCTION

The term information technology encompasses all areas related to the management and processing of information, whether in small or large organizations. It is used broadly to describe computers and their networks, as well as all systems within an organization, including operating systems, databases, storage facilities, and processing servers. It also considers wired and wireless communications networks, such as the internet and telephones, as an important foundation and essential part of the information infrastructure. Technology is defined as the processes used to produce goods and achieve objectives, such as scientific research. Technology can be defined as knowledge of techniques, processes, and the like. Technology is applied by taking inputs and changing them according to the system's use. One of the most important aspects that must be taken into account is information security and encryption. Technology is the most important element in all fields because it plays a fundamental and influential role at every level. It has given life at every level a more precise meaning and made the world more accessible than before. It has been introduced in the most sensitive fields. It has become an important driver of entrepreneurship and is also considered an application of skills and knowledge (Jamal, 2010).

The **most important** areas of information technology specialization are:

- **Network security specialization** - Due to the increasing incidence of cybercrime, demand for this specialty has increased to protect the sensitive data of both large and small companies. This makes this field one of the most important in global markets.
- **Database systems specialization** - A database management system (DBMS) is a set of computer programs that control the organization, storage, and management of data from a database.
- **Specialization in information security** - Information security is the discipline responsible for securing information circulating online from threats posed by cybercrimes. With the development of technology and the means of storing and exchanging information in various ways (data transfer) across the network from one location to another, information security is becoming more and more important.

## 2. INFORMATION SECURITY

Given the critical importance of data confidentiality and security, protection mechanisms, threats, risks, hackers, intruders, and attackers, the most important IT specializations make information security a never-ending process, requiring comprehensive protection. Information security refers to a set of measures that protect an organization's sensitive information from misuse, unauthorized access, disruption, or destruction (Al-Arish, 2019).

### 2.1. Information security policy

The information protection policy focuses on applying international standards in information protection and taking appropriate measures. The information security policy includes:

- Determine the purpose of protecting information.
- Applying the concept of information protection.
- Determine the responsible parties (authority levels).

- Determine implementation constraints.

## **2.2. The importance of information security**

Information security is one of the basics that every company or individual seeks to secure and work with, with the aim of preserving the confidentiality of information and avoiding exposure to theft and deliberate sabotage, due to the high competition between companies, some of which seek to Undermining its competitors by carrying out attacks in order to disrupt and sabotage its data or steal it in order to imitate it, learn its secrets, and penetrate it for the purpose of overcoming it. Therefore, the importance of protecting information is evident in a number of points, the most important of which are (Othman, 2022).

- Determine the parties authorized to access the information.
- Avoid random hacks carried out by professionals.
- Ensure the production process and prevent its obstruction.
- Ensuring institutional excellence by protecting the confidentiality of information.
- Reducing costs and avoiding losses‘ by protecting information.

## **2.3. Information security objectives**

Information security primarily aims to protect information from hacking and intentional sabotage, as well as preventing it from being stolen. Among the most important objectives of information security are:

- Protect information from theft and hacking.
- Reducing potential losses from sabotage or theft of information.
- Limiting the disruption of services and businesses due to sabotage operations.
- Ensure the implementation of laws and controls that prevent unauthorized modifications (Holistic Training, 2008).

## **2.4. Information security elements**

The concept of information security is based on fundamental principles that no modern technology can guarantee success. The elements of information security include:

- Complete confidentiality of information.
- Security and availability of information and how to access it.
- Information safety from malware and loss.

## **3. ENCRYPTION**

Encryption is the conversion of a readable text into an incomprehensible text using one of the encryption methods, which may not be secret, but uses a secret key that enables the person who possesses it to return the cipher text to plain text.

### **3.1. Encryption objectives**

There are four main goals behind the use of cryptography, which are as follows.

- Confidentiality or privacy.
- Data integration (Integrity).
- Verification and proof of identity (Authentication).
- Non-repudiation.

- The most important traditional encryption methods (Al-Hamami, 2009; Zaid, 2022).

Before beginning to explain traditional encryption methods, it is important to clarify that all of these methods rely on symmetric encryption. The most important feature of this type of encryption is that both the encryption and decryption processes are performed using a single key owned by the sender and receiver. Traditional encryption is divided into two main types:

- Substitution encryption.
- Transposition encryption

**Multiplicative Cipher:** It is an encryption method that uses a measure of 26 (MOD 26) and an encryption key (K) such that the greatest common divisor between the key we choose and the number 26 equals one. This method follows the following law:

$$C = (K * M) \text{MOD } 26 \quad (1)$$

Where K is the encryption key, M is a plaintext letter; C represents the result of the equation and is the encrypted letter. **(Note: The greatest common divisor of two numbers is the largest integer divisible by both numbers.)**

In this method, we need to convert letters into their corresponding numbers from zero to 25. To illustrate this method, we take the following example:

We would like to encrypt the word NETWORK using the tax encryption method, and with the key (K=5) we follow the above law as follows:

$$5 * 13 = 65 \text{ MOD } 26 = 13 \leftrightarrow N = C_1 \quad (2)$$

$$5 * 4 = 20 \text{ MOD } 26 = 20 \leftrightarrow U = C_2 \quad (3)$$

$$5 * 19 = 95 \text{ MOD } 26 = 17 \leftrightarrow R = C_3 \quad (4)$$

$$5 * 22 = 110 \text{ MOD } 26 = 6 \leftrightarrow G = C_4 \quad (5)$$

$$5 * 14 = 70 \text{ MOD } 26 = 18 \leftrightarrow S = C_5 \quad (6)$$

$$5 * 17 = 85 \text{ MOD } 26 = 7 \leftrightarrow H = C_6 \quad (7)$$

$$5 * 10 = 50 \text{ MOD } 26 = 24 \leftrightarrow Y = C_7 \quad (8)$$

Thus, we see that the word NETWORK was transformed into the cipher word NURGSY after encrypting it in this way and using the key (K=5).

However, when we use another key, the result will certainly differ. For example, when we encrypt the same previous word (NETWORK) in the same previous way (the tax encryption method), with the key being different this time, let it be (K=7), we will obtain the following result:

$$C_1 = 7 * 13 = 91 \text{ MOD } 26 = 13 \leftrightarrow N \quad (9)$$

$$C_2 = 7 * 4 = 28 \text{ MOD } 26 = 2 \leftrightarrow C \quad (10)$$

$$C_3 = 7 * 19 = 133 \text{ MOD } 26 = 3 \leftrightarrow D \quad (11)$$

$$C_4 = 7 * 22 = 154 \text{ MOD } 26 = 24 \leftrightarrow Y \quad (12)$$

$$C_5 = 7 * 14 = 98 \text{ MOD } 26 = 20 \leftrightarrow U \quad (13)$$

$$C_6 = 7 * 17 = 119 \text{ MOD } 26 = 15 \leftrightarrow P \quad (14)$$

$$C_7 = 7 * 10 = 70 \text{ MOD } 26 = 18 \leftrightarrow S \quad (15)$$

The output will be the code word NCDYUPS, which is different from what we got last time.

### 3.2. Encryption method

#### 3.2.1. Perfect square method

This method is summarized as follows:

- The number of columns for the box is determined by the same length as the key used.
- The clear message is written in order under the key letters.
- If empty boxes remain, they are completed with frequently used letters, such as the letter (e).
- We give numbers to the main letters, according to the sequence in which they are arranged.
- We start writing the encrypted text, from the first column, then the second column, to the rest of the columns, in order (Al-Ghathbar, 2009).

**Note:** We must be careful to choose an encryption key such that all letters are different from each other in a word and no two letters are the same, because this will lead to errors when encrypting and decrypting.

To illustrate the encryption mechanism using the perfect square method, we take the following example:

If we had the clear text: There is nothing new under the sun It is intended to be encrypted using the full square method and the key (ENGLISH)

The first step in the solution begins by creating a table whose number of columns is the length of the key (i.e. the number of letters of the key). In this case, it is 7 letters, meaning a table consisting of 7 columns. As for the number of its rows, it depends on the length of the text to be encrypted. Then we give numbers to the letters of the key according to the sequence in which they are arranged. In letters of the alphabet as follows, Table 1:

*Table 1. Alphabetical order.*

E	N	G	L	I	S	H
1	6	2	5	4	7	3
T	H	E	R	E	I	S
N	O	T	H	I	N	G
N	E	W	U	N	D	E
R	T	H	E	S	U	N

Now we start writing the cipher text, starting from column number 1, then column number 2, and so on until column number 7, to get the following cipher text, which is an encryption of the phrase mentioned above.

**TNNR ETWH SGEN EINS RHUE HOET INDU**

### 3.3. Decryption method

- Create a table with the number of columns equal to the length of the key.
- We write the key in the first row of this table.
- We give numbers to the main letters according to the sequence in which they are arranged.

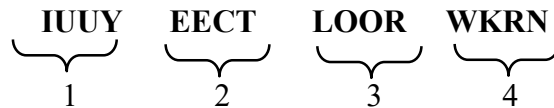
- We write the cipher text in a column in the table, taking into account the order.
- Plain text is read as rows from the table (Ali, 2013).

Let us take the following example to illustrate the decryption method.

If we have the cipher text: **IUUR EECT LOOR WKRN**

What is required is to decrypt this text and convert it to clear text using the previous method and the encryption key (TIME).

First, we give numbers to the sections of this text in order, as follows:



Then we create a table whose number of columns is the length of the key (i.e. the number of letters of the key), and in this case 4 letters, meaning a table consisting of 4 columns. Then we give numbers to the letters of the key according to the sequence in which they are arranged in the letters of the alphabet, and then we write the encrypted text in a column in the table, taking into account the order, Table 2.

*Table 2.* Shows the reading of the plain text from the first row to the last row.

T	I	M	E
4	2	3	1
W	E	L	I
K	E	O	U
R	C	O	U
N	T	R	Y

Through this table, we read the plain text across the rows from the first row to the last row, so that the following text appears:

**WELIKEOURCOUNTRY**

By making a few modifications to this text, we obtain the clear text in its final form, which represents the phrase:

**WE LIKE OUR COUNTRY**

**ADFGVX code:** It is a German code that Hitler used during World War II. This code was difficult to crack and break for a period of time, but it was eventually broken by a French scientist after it took him a lot of time and effort to try. The way this code works is summarized in three main steps. To illustrate it, we take the following example:

**Step One:** Let us have the following Table 3, which we will use to encode twice.

Table 3. Shows the use in encryption.

	A	B	C	D	E
A	A	B	C	D	E
B	F	G	H	I	J
C	K	L	M	N	O
D	P	Q/Z	R	S	T
E	U	V	W	X	Y

(Note that the letters Q and Z are together in one cell, in order to complete the table as a 5\*5 matrix). Now, for example, I want to encode the letter A. The result is the letter at the first of the row, and the letter at the beginning of the column. That is, A is encrypted into two letters AA (**that is, by taking the row and column in which the letter to be encrypted is located.**)

And so on for the rest of the letters, for example:

- The letter B is encoded into the letters AB
- The letter C is encoded into the letters AC
- The letter Q is encoded into two letters DB
- The letter Y is encoded into the letters EE
- The letter Z is encoded into the letters DB

**Example:** Let me have the following statement (original text): TAKE ME TO YOUR LEADER

We now start encrypting. The letter T is encoded into DE, the second letter A is encoded into AA, and so on to produce the code:

**DE AA CA AE CC AE DE CE EE CE EA DC CB AE AA AD AE DC**

The first step in which one letter in the original text was encoded into two letters ended.

**The second step:** We divide the cipher text into two parts (two rows), taking the first letter from the first row and the first letter from the second row, taking the second letter from the first row and taking the second letter from the second row, and so on...

The cipher text is

**DE AA CA AE CC AE DE CE EE CE EA DC CB AE AA AD AE DC**

After dividing it into two rows, we get:

**DE AA CA AE CC AE DE CE EE  
CE EA DC CB AE AA AD AE DC**

Now we take the letters D and C to be the first block, and the letters E and E to be the second block, and so on to get:

**DC EE AE AA CD AC AC EB CA CE AA EADA ED CA EE ED EC**

**Step Three:** We refer to the previous table, which we mentioned that we would use twice, and we encrypt each block separately:

The first block, DC, intersects the table at the letter R.

The second block, EE, has its letters intersect in the table at the letter Y.



We continue in the same way to produce **R Y E A N C C V K O A U P** Now we put the result in the form of blocks, each block consisting of five letters:

**RYEAN CCVKO AUPXK YXW**

With this, we have finished the encryption process, a little complicated, but pretty good. To decrypt, we perform the reverse process, to decode the resulting encryption process:

**RYEAN CCVKO AUPXK YXW**

We start by taking the first letter, then we look at the table and take the two letters, whose intersection point is the desired letter, and we put the first letter in the first row, and the second letter we put in the second row, and here the first letter in the code is **R**. We look at the table, and we notice that the letters **D** and **C** are dots. Their intersection is **R**, so we put the first letter **D** in the first row, and the second letter **C** in the second row, and we continue in.

**DE AA CA AE CC AE DE CE EE  
CE EA DC CB AE AA AD AE DC**

Now we start decrypting from the first row, we take block after block from the first row, and when it is finished, we start with the second row:

- The block DE turns into the letter T
- The block AA turns into the letter A
- The block CA turns into the letter K

Thus, we have the original text: TAKEMETOYOURLEADER

Arrange it so it is readable, to produce TAKE ME TO YOUR LEADER

#### 4. INFORMATION SECURITY FIELDS

- **Security Specialist:** The Information Security Specialist is the cornerstone of any information security team. They possess the essential expertise that any information security specialist must possess, and they are responsible for protecting information from various risks.
- **Network Security Manager:** The person all companies turn to to provide security and protection for their networks and the data and information stored within them.
- **Chief Risk Officer:** Responsible for managing risks by assessing the status of corporate systems and identifying vulnerabilities.
- **Security Analyst/Engineer:** The Security Analyst tracks hacking attempts and determines the source of cyber-attacks and the extent of the damage.
- **Software and Applications Specialist:** The primary task of an applications and software engineer is to secure the storage of information and work to correct any errors that threaten its security.
- **Ethical hackers:** To know how to avoid hacking attempts, you must think like a hacker. This has prompted many companies to employ a number of experts in the field of hacking, as their primary field of work involves uncovering any security vulnerabilities that could make information vulnerable to cyber-attacks (Al-Ghathbar, 2009; Samia, 2017).
-

**Among the most important modern techniques:**

- **Programming Algorithms:** Programming algorithms are defined as a set of specific, sequential steps that are implemented to solve a problem or perform a specific task. In our current era, almost no science is devoid of the application of algorithmic concepts; Algorithms are not a modern concept. Rather, they appeared in one form or another in ancient civilizations. They are named after the scholar Muhammad ibn Musa al-Khwarizmi, who coined the term in the ninth century AD. An algorithm works by following a procedure consisting of inputs. Once all the inputs are followed, the resulting output is obtained. This output is also known as the output (Ibrahim, 2012).
- **The Concept of Programming Algorithms in Computer Science:** Programming algorithms in computer science are defined as a set of programming instructions executed by a computer to achieve a specific task. Algorithms vary in their degree of difficulty and method of finding a solution. They may be as simple as determining whether a number is even or odd, or as complex as determining the shortest route to a specific city from hundreds of available routes.

The most common types of algorithms are:

- Searching, sorting, ordering, and merging algorithms.
  - o Numerical algorithms.
- Graph algorithms.
  - o String algorithms.
- Computational geometric algorithms.
- Combinational algorithms.
- Artificial intelligence algorithms.
- Cryptographic algorithms (Mililani, 2018; Qahtani, 2015).

## **5. ELECTRONIC AUTHENTICATION**

Electronic authentication is the process of building trust in a user's identity presented electronically to an information system. Digital or electronic authentication is used interchangeably when referring to the authentication process that confirms or authenticates a person's identity and actions. Many electronic authentication methods are available, ranging from passwords to higher levels of security (Mohammed, 2022).

## **6. RESEARCH CONCLUSION**

Based on the conducted research, the following key findings can be established regarding secure data exchange and network protection:

### **6.1. Secure Network Architecture:**

- Establishment of protected connections for confidential data transmission between networked devices
- Implementation of comprehensive threat mitigation strategies against:
  - o Malicious actors (hackers, cybercriminals)
  - o Internal and external security breaches
  - o Emerging cyber threats

## **6.2. Security Governance:**

- Clear identification and authorization of personnel responsible for:
  - Information security policy enforcement
  - Confidentiality protocol maintenance
  - Compliance oversight.

## **6.3. Proactive Defense Mechanisms:**

- Systematic vulnerability assessment across all platforms
- Development of advanced anti-intrusion systems
- Continuous security patch management

## **6.4. Cryptographic Protection:**

- Employment of modern encryption standards for:
  - Data-at-rest protection
  - Data-in-transit security
  - Multi-layer information safeguarding

## **6.5. Algorithmic Security Framework:**

- Implementation of standardized cryptographic procedures
- Protocol-specific security implementations
- Regular algorithm review and updates.

## **REFERENCES**

- Al-Arish, J. H. (2019). Information security systems. Al-Dar Al-Muthaziha.
- Al-Ghathbar, K., & Al-Qahtani, M. (2009). Information security in easy language (2nd ed.). Center of Excellence for Information Assurance, King Saud University.
- Al-Hamami, A. H., & Al-Hakim, M. S. (2009). Protection from encryption and coding against piracy and infiltration. Arab House.
- Ali, M. D. F. (2013). Encryption and information security: History of encryption and information security. Noor Library. <https://www.noor-book.com>
- Holistic Training. (2008). Information – Security. <https://holistquetraining.com>
- Ibrahim, S. H. (2012). Basic introduction to algorithmic programming. Dar Al-Ma'rifa Library.
- Jamal, M. D. E. M. (2010). Information technology. [Publisher not specified].
- Mililani, K. A. (2018). Security and protection. Khwarizmi Scientific Publishing House.
- Mohammed, M. A. (2022). Journal of Informatics and Information Security and its Issues with Health, Engineering, Agricultural, Social, Economic and Governmental Dimensions. Arab Republic of Egypt.
- Othman, K. (2022, April 19). "Information Security Basics": A guide for journalists and newsroom managers. Al-Sahafa Magazine, Al Jazeera Media Institute. <https://institute.aljazeera.net>
- Qahtani, D. A. (2015). Programming languages. King Abdul-Aziz City for Science and Technology.

- Samia, J. (2017). Contribution of modern information systems to re-engineering in the Algerian economic corporation [Master's thesis, Mohamed Khaddar University].
- Zaid, A. A. (2022). [Title not specified]. Department of Political Science and Public Administration, Faculty of Commerce, Assiut University.



## AUTONOMOUS SYSTEMS ON THE BATTLEFIELD: THE MILITARY POTENTIAL AND RISKS OF SELF-DRIVING VEHICLES

Péter Szikora\*

*Obuda University, Keleti Károly Faculty Business and Management, Hungary*

**Abstract:** The technological development of self-driving cars offers new opportunities for both civil and military applications. In the military domain, the development and application of autonomous vehicles deserves particular attention as it raises new challenges and risks, including cyber security, ethical issues and national security. This research aims to explore the societal acceptance of, and fears and concerns about, the use of autonomous vehicles in combat applications. The study analyses the views of different demographic groups, taking into account confidence in technological developments, transport safety, and ethical and legal issues related to military applications. The results show that the acceptance of military autonomous systems is closely related to public confidence in technology and concerns about the safety of technology. The research will contribute to future research investigating the integration of self-driving vehicles in military environments.

**Keywords:** autonomous vehicles, military applications, cybersecurity, ethical dilemmas

### 1. INTRODUCTION

Self-driving cars represent one of the most controversial areas of technological development, as they raise a number of social, legal and ethical issues. The operation of self-driving vehicles is based on different levels of automation, as defined by SAE International (2021) (SAE International, 2021). In the EU, there are legal barriers to their introduction, as the Vienna Convention requires all vehicles to have a human driver. In contrast, in the United States, technology adoption is moving faster, while in China, the government is providing significant support for R&D (Bai et al., 2025). One of the biggest challenges for autonomous vehicles is gaining public trust. Research has shown that people's attitudes are significantly influenced by age, gender, education and attitudes towards the technology (Kyriakidis et al., 2015; Kettles & Van Belle, 2019; Lee et al., 2025). For manufacturers, rapid adoption of the

---

\* Corresponding author: [szikora.peter@kgk.uni-obuda.hu](mailto:szikora.peter@kgk.uni-obuda.hu)

Péter Szikora, ORCID: 0000-0001-8680-3880

technology is key, but various strategic steps are needed to build user confidence, such as demonstration programmes and education campaigns (Howard & Dai, 2014; Servin et al., 2023). However, the public is sceptical about the reliability and pricing of self-driving cars, and many people do not feel ready to use fully autonomous vehicles (Kyriakidis et al., 2015; Schoettle & Sivak, 2016).

## 2. LITERATURE REVIEW

The development of self-driving vehicles is one of the biggest challenges of modern technology, offering new opportunities in terms of road safety, efficiency and environmental protection. At the same time, this development also raises a number of new risks and problems, particularly for military and combat applications, which cannot be ignored by future transport systems. Key issues include communication security, cyber threats, ethical issues and social acceptance. Combat applications, such as military autonomous vehicles, carry a particular responsibility, as proper decision making can directly affect not only transport security but also national security ().

The safety of the various communication systems, in particular vehicle-to-vehicle communication (V2V), which plays a critical role in maintaining road safety, is essential for the operation of self-driving vehicles. Research shows that the development of V2V communication has not yet reached the desired level and that cybersecurity threats to self-driving cars, such as hacker attacks and system failures, remain a major challenge. The potential for group attacks, which will increase with the interconnection of autonomous systems, underscores the importance of new authentication protocols and key agreement schemes that minimize the risk of eavesdropping and replay while requiring low computational overhead (Bai et al, 2025; Bo, 2024; Dehler & Buchholz, 2025; Gál et al.,2024; Gogoll & Müller, 2017; Goodall, 2014; Kettles & Van Belle, 2019; Kovács et al., 2021; Moller et al., 2025; Perger, 2022; Servin et al., 2023; Tang et al., 2025; Viktor & Fodor, 2024; Zheng et al., 2025).

Protecting data exchanges between vehicles can be particularly important in military applications where combat situations require rapid decision-making. For military autonomous vehicles and drones performing responsible tasks such as transport or reconnaissance, it is vital that communications are not compromised. The risk of cyberterrorism and cyberattacks for military purposes, which can also manifest themselves in attacks against physical assets such as drones and self-driving vehicles, can affect not only the security of technology but also global relations between warring parties (Borenstein et al., 2019; Cavoli et al., 2017; Chougule et al., 2023; Howard & Dai, 2014; König & Neumayr, 2017; Kyriakidis et al, 2015; Li et al., 2022; McCarthy, 2017; Othman, 2023; Szatmáry & Lazányi, 2022; Woollard, 2023).

Legal and ethical challenges become particularly acute in military applications, where decision-making affects people's lives. The classic "trolley problem" - which asks how an autonomous vehicle should make decisions when faced with an unavoidable accident - is also raised here, but requires a new, more responsible approach. Programmers must take into account not only traffic rules, but also the law of war and international humanitarian law in the case of military applications. For military autonomous systems, ethical protocols are needed that can handle the reconciliation of human morality and the decision-making capabilities of machines. In addition, international regulation and cooperation between states are essential for global security. As the organisation responsible for global security, NATO can play a key role in standardising cybersecurity protocols and regulating the safe operation of autonomous vehicles. In the case of combat applications of autonomous systems, security measures require closer coordination, as advances in technology open up opportunities for new types of attacks

that target the vulnerabilities of self-driving systems (Kumar & SM, 2019; McCarthy, 2017; Perger, 2022; Viktor & Fodor, 2024).

The social acceptance of self-driving vehicles is closely linked to technological progress, human factors and the management of safety issues. Although the convenience and safety benefits of self-driving vehicles, particularly in reducing road accidents, are increasingly recognised, adoption is still hampered by cyber security risks, concerns about loss of control and liability issues. To increase social acceptance, a gradual deployment strategy is needed that takes into account the security fears of the population and the different attitudes of different demographic groups (Cavoli et al., 2017; Howard & Dai, 2014; Jaradat et al., 2020; Kettles & Van Belle, 2019; König & Neumayr, 2017; Kovács et al., 2021; Kyriakidis et al., 2015; Li et al., 2022; Othman, 2023).

A safe and ethical implementation of autonomous transport requires a complex, systemic approach. Development strategies need to take into account the social and technological context, as well as the various ethical dilemmas that will determine not only the operation of the technology, but also its future legal and military applications. Continuous development and proactive risk management are essential for the societal acceptance and safe operation of self-driving systems. In parallel with the development of new technologies, the role of human judgement and global cooperation is becoming increasingly important (Bo, 2024; Borenstein et al., 2019; Gogoll & Müller, 2017; Goodall, 2014; Perger, 2022; Servin et al., 2023; Szatmáry & Lazányi, 2022; Woollard, 2023).

### 3. DATA AND METHODOLOGY

Data was collected through an anonymous online questionnaire, which allowed respondents to express their opinions honestly, thus increasing statistical reliability. The online questionnaire format provided a quick and convenient way to collect and analyse the data. The questionnaire was completed on a voluntary basis, which also contributed to obtaining real, personal opinions. While the voluntary nature of the respondents and the convenience sampling method do not guarantee a fully representative sample, the large number of respondents (1 840) already provides a strong basis for the reliability of the survey results and helps to ensure that the conclusions are valid for a wider audience.

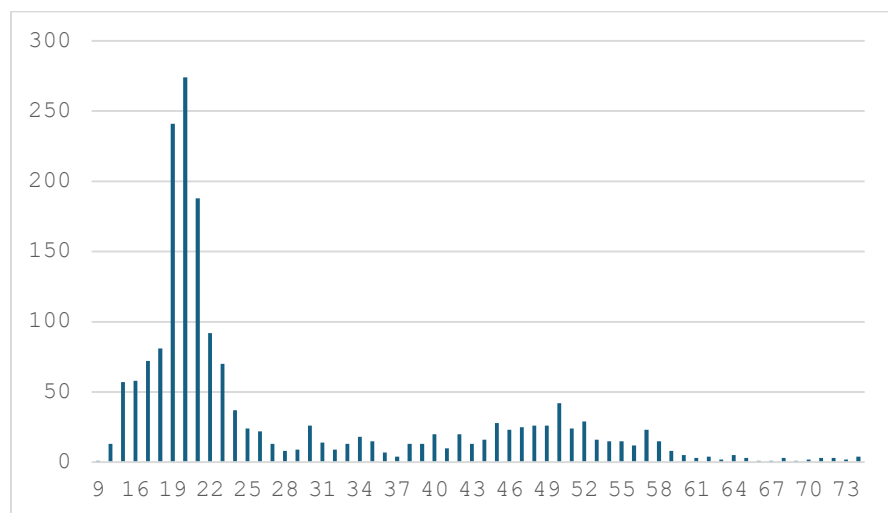


Figure 1. Age distribution of respondents (n=1840)

The aim of the research was to investigate the social acceptance of self-driving cars in particular. The results will contribute to a better understanding of the topic and may provide useful guidance for future research. The age of the respondents ranges from 9 to 75 years, with a mean age of 28.49 years and a median of 21 years, and a standard deviation of 13.819. The mean age is higher than the median, suggesting that more respondents were younger, but the wide age distribution shows that the questionnaire addressed several age groups, allowing a detailed analysis of different aspects of social acceptance.

The results of the survey, although not representative, can provide important insights into the evolution of public opinion and contribute to a better understanding of the social acceptance of future self-driving vehicles.

The research explored attitudes towards self-driving technologies along eight targeted questions covering perceived challenges, risks and potential uses of autonomous vehicles. The dimensions surveyed provide a comprehensive picture of respondents' views on both civilian and military applications. The following variables formed the basis of the analysis:

- **Biggest technological challenge:** The question aims to find out what respondents consider to be the biggest technological challenge in the development and deployment of self-driving vehicles. The responses will help identify the main barriers limiting technological adoption.
- **Cybersecurity of self-driving cars:** This question explores concerns about the cybersecurity risks of self-driving vehicles. The answers provide an indication of the extent to which respondents feel vulnerable to hacking and unauthorised access.
- **Communication between drivers and pedestrians:** This question measures the importance respondents attach to the establishment of effective communication between self-driving vehicles and human road users. This issue is particularly relevant in the context of urban transport, where implicit human interaction is common.
- **The need for regulation:** This question addresses the need for a regulatory framework for autonomous vehicles. Respondents express their views on the importance for them of regulating responsibility, ethics and safety at the level of legislation.
- **Most challenging traffic environment:** This question asks respondents which traffic environment (e.g. city, motorway, extreme weather) they consider most challenging for self-driving systems. The results highlight socially perceived technological barriers.
- **Combat use of self-driving military vehicles:** This question explores societal attitudes towards the use of autonomous vehicles for combat purposes in the military. It focuses on the acceptability of military decision-making without human intervention.
- **Most suitable military tasks for self-driving vehicles:** This question explores which military tasks (e.g. logistics, reconnaissance, surveillance, combat) respondents consider most suitable for autonomous vehicles. The results contribute to the societal perception of autonomous military technology developments.
- **Likelihood of terrorist use:** This question assesses the extent to which respondents fear that self-driving vehicles could be used for malicious purposes, such as terrorist attacks. The answers reflect societal perceptions of the technological threat.



#### 4. RESULTS AND DISCUSSION

Table 1. Spearman's correlations between the variables (n=1840)

		Biggest technological challenge	Cybersecurity of self-driving cars	Communication between drivers and pedestrians	Need for legal regulation of self-driving cars?	Most challenging transport environment	Combat applications of self-driving military vehicles?	The most suitable military tasks for self-driving vehicles	Likelihood of terrorist use of self-driving vehicles
Hackers hack into car systems	Correlation Coefficient	,076**	-,269**	,164**	,184**	-0,028	-0,034	-0,032	,209**
	Sig. (2-tailed)	0,001	0,000	0,000	0,000	0,238	0,139	0,167	0,000
The self-driving car breaks down	Correlation Coefficient	-0,004	-,250**	,246**	,263**	-,057*	-,111**	-0,034	,164**
	Sig. (2-tailed)	0,865	0,000	0,000	0,000	0,014	0,000	0,144	0,000
The car does not decide/respond the way we want it to	Correlation Coefficient	,046*	-,269**	,232**	,265**	-,082**	-,089**	-0,029	,160**
	Sig. (2-tailed)	0,048	0,000	0,000	0,000	0,000	0,000	0,209	0,000
Fear of new technology	Correlation Coefficient	,106**	-,256**	,099**	,068**	-0,022	-,115**	-0,034	,108**
	Sig. (2-tailed)	0,000	0,000	0,000	0,003	0,350	0,000	0,141	0,000
People lose their jobs because of it (e.g. taxi drivers)	Correlation Coefficient	0,032	-,241**	,123**	,098**	-0,022	-,106**	-,053*	,085**
	Sig. (2-tailed)	0,174	0,000	0,000	0,000	0,342	0,000	0,023	0,000
Control cannot be taken back.	Correlation Coefficient	,051*	-,259**	,187**	,214**	-0,013	-,086**	-,055*	,139**
	Sig. (2-tailed)	0,029	0,000	0,000	0,000	0,578	0,000	0,017	0,000
Too expensive	Correlation Coefficient	0,043	-,091**	,102**	,097**	-,071**	0,005	0,031	,091**
	Sig. (2-tailed)	0,066	0,000	0,000	0,000	0,002	0,815	0,179	0,000
The driving experience is lost	Correlation Coefficient	,049*	-,184**	,099**	,146**	-0,026	-0,011	-,069**	0,041
	Sig. (2-tailed)	0,034	0,000	0,000	0,000	0,264	0,635	0,003	0,078
Lack of security of personal data	Correlation Coefficient	,056*	-,306**	,129**	,165**	-0,022	-0,032	-,064**	,160**
	Sig. (2-tailed)	0,017	0,000	0,000	0,000	0,339	0,167	0,006	0,000
Gender	Correlation Coefficient	0,023	-,204**	,094**	,079**	-0,028	-,118**	-,079**	,050*
	Sig. (2-tailed)	0,317	0,000	0,000	0,001	0,222	0,000	0,001	0,033
Age	Correlation Coefficient	,099**	-,135**	,095**	,140**	-,163**	,047*	0,031	,243**
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,042	0,186	0,000
Place of residence	Correlation Coefficient	0,002	,079**	-,047*	-0,023	-0,035	-0,005	0,022	-0,040
	Sig. (2-tailed)	0,921	0,001	0,044	0,325	0,130	0,834	0,354	0,090
Level of education	Correlation Coefficient	,091**	-,102**	,052*	,114**	-,103**	,051*	,059*	,170**
	Sig. (2-tailed)	0,000	0,000	0,025	0,000	0,000	0,029	0,012	0,000
Level of study	Correlation Coefficient	-,073*	0,021	0,053	,111**	-0,050	,100**	,063*	,092**
	Sig. (2-tailed)	0,013	0,466	0,069	0,000	0,085	0,001	0,031	0,002
In Education	Correlation Coefficient	-,109**	,138**	-,050*	-,068**	,158**	-0,046	0,014	-,157**
	Sig. (2-tailed)	0,000	0,000	0,032	0,004	0,000	0,051	0,560	0,000
Work	Correlation Coefficient	0,036	-,083**	,065**	,066**	-,102**	,049*	0,009	,125**
	Sig. (2-tailed)	0,125	0,000	0,005	0,005	0,000	0,037	0,708	0,000
Driving licence	Correlation Coefficient	0,034	-0,021	,076**	,090**	-,054*	,059*	0,018	,098**
	Sig. (2-tailed)	0,146	0,369	0,001	0,000	0,020	0,012	0,446	0,000

The first interesting relationship is observed between Combat applications of self-driving military vehicles? and Too expensive, with a weak negative relationship (correlation coefficient: -0.071; p: 0.002). Those who are more in favour of military applications of driverless cars do not consider such technology expensive. This suggests that those interested in combat applications are less concerned about the cost and more likely to see the useful military benefits that the technology can offer. The next correlation is between Combat applications of self-driving military vehicles? and People lose their jobs because of it (e.g. taxi drivers), where a weak positive relationship is observed (correlation coefficient: 0.085; p: 0.000). Those who are more concerned about losing jobs are more inclined to support combat applications of driverless cars. This suggests that potential social impacts of technology, such as job losses, do not necessarily affect confidence in military applications. The relationship between Control cannot be taken back and Combat applications of self-driving military vehicles? is weakly negative (correlation coefficient: -0.055; p: 0.017), indicating that those who fear that they cannot regain control in an emergency are less likely to support military applications of driverless cars. This is an important reminder that gaining and regaining control is a key factor in military applications, which may be perceived by the public. The correlation between Fear of new technology and Combat applications of self-driving military vehicles? has a stronger negative direction (correlation coefficient: -0.089; p: 0.000), suggesting that those who are more fearful of new technologies are less supportive of combat applications of driverless cars. Fear of technology may therefore reduce confidence in combat applications, as the introduction of new technologies may also raise concerns in the military sector. There is also a negative relationship between The self-driving car breaks down and Combat applications of self-driving military vehicles? (correlation coefficient: -0.111; p: 0.000). Those who are more concerned about driverless cars breaking down are less supportive of their combat applications. This suggests that reliability is a key issue, especially when it comes to the application of the technology in a military environment. There is a weak negative relationship between Lack of security of personal data and Combat applications of self-driving military vehicles? (correlation coefficient: -0.032; p: 0.167), suggesting that those who are concerned about the security of personal data are less likely to support the use of driverless cars for military purposes. There is therefore a degree of tension between privacy and military applications, where the issue of personal data security may reduce confidence in military developments. A weak negative relationship is observed between The driving experience is lost and Combat applications of self-driving military vehicles? (correlation coefficient: -0.069; p: 0.003), suggesting that those who feel that the driving experience is lost are less willing to support military applications of driverless cars. Personal experiences, such as the pleasure of driving, may also influence perceptions of military applications of the technology. There is a weak negative relationship between Age and Combat applications of self-driving military vehicles? (correlation coefficient: -0.163; p: 0.000), suggesting that older people are less likely to support combat applications of driverless cars. Age is therefore an important factor, as older generations may be less willing to adopt new technological innovations, especially in a military context. A positive relationship between Level of education and Combat applications of self-driving military vehicles? is also observed (correlation coefficient: 0.059; p: 0.012), suggesting that people with higher levels of education are more likely to support military applications of driverless cars. Education is therefore an important factor that can increase confidence in technology, especially in combat applications. There is also a positive relationship between Work and Combat applications of self-driving military vehicles? (correlation coefficient: 0.125; p: 0.000), suggesting that workers who are up-to-date with technological developments are more likely to support military applications of driverless cars. Thus, the interplay between employee background and openness to technology reinforces confidence in the development of

combat-oriented technologies. Finally, there is also a strong relationship between Driving licence and Combat applications of self-driving military vehicles? (correlation coefficient: 0.098;  $p$ : 0.000), indicating that those who have a driving licence are more likely to support the military applications of driverless cars. Driving experience and openness to military applications may therefore be closely related.

The analysis shows that those who are more in favour of combat applications of driverless cars do not consider the technology expensive and are more inclined to consider its use for military purposes. At the same time, those who fear new technologies, worry about job losses, or lack confidence in the reliability and privacy of the technology are less likely to support military applications. Higher educational attainment, employment background and management experience can all help to encourage the adoption of combat-oriented developments

A t-test analysis was conducted to see if there is a significant difference between respondents who hold different views on self-driving cars. The results show that in several cases significant differences were observed between the more distrustful and the more confident groups, confirming the previous correlation analysis.

Based on the results of the t-test, the following findings can be made: Fear of new technologies: those who are less confident in self-driving cars show a higher degree of fear of the risks of new technologies ( $M = 3.22$ ) than those who are more confident ( $M = 2.32$ ). The difference is significant ( $t = 2.502$ ;  $p = 0.019$ ). Ability to take back control in case of emergency: those who are more distrustful of self-driving cars ( $M = 4.12$ ) are more concerned that they will not be able to take back control in case of an emergency than those who are more trustful ( $M = 3.09$ ). The difference is significant ( $t = 3.977$ ;  $p < 0.001$ ). Use of self-driving military vehicles in combat situations: those who are less confident in self-driving cars ( $M = 2.57$ ) are less likely to consider the use of self-driving military vehicles in combat situations acceptable than those who are more confident in technological advances ( $M = 3.05$ ). The difference is significant ( $t = -2.166$ ;  $p = 0.032$ ). Risk of terrorist attacks: more distrustful respondents ( $M = 2.92$ ) are less likely to believe that terrorists could use self-driving vehicles for attacks than those who are more confident in the security of the technology ( $M = 3.36$ ). The difference is significant ( $t = -2.633$ ;  $p = 0.013$ ).

The results suggest that respondents who are distrustful are more fearful of new technologies, technological failures and loss of control, while those who are more confident are more open to the use of self-driving systems but more sensitive to the possibility of potential misuse. This research helps to understand that attitudes towards self-driving cars can vary and that trust and fear are important factors in the social acceptance of the technology.

Based on the results of the K-means clustering, the three clusters that emerged reflect the different attitudes towards machine learning technology. According to the numbers in the first table, the largest group is the "Sceptics" (843 people), while the "Neutrals" and "Cautious Optimists" are smaller groups, with 576 and 421 people respectively. In the analysis, respondents rated the advantages and disadvantages associated with automated driving, as well as the safety of the technology and potential risks.

The "Neutral" group showed mixed attitudes, with moderate opinions on the pros and cons of automated driving, while the "Sceptics" are highly distrustful of the technology, especially in relation to potential security risks such as hacking and malfunctions. They are also most concerned about the social and economic impacts of new technology, such as unemployment and excessive costs. In contrast, the group of "Cautious Optimists" tend to emphasize the benefits of automated driving, while remaining cautious and showing lower scores on fears and risks.

Overall, the different attitudes of the clusters clearly show that attitudes towards machine learning are not homogeneous and that perceptions of benefits and drawbacks, as well as fears and concerns about them, play a key role in the attitudes of each group. The "Sceptics" group is the largest, as they are the most distrustful, while the "Cautious Optimists" are the most open to the benefits of technology, but still cautious.

Table 2. ANOVA Summary Table (n=1840)

	Cluster		Error		F	Sig.
	Mean square	df	Mean square	df		
Self-driving cars will have a positive impact on emissions	227,785	2	1,087	1837	209,565	0,000
Self-driving cars will have a positive impact on society	308,296	2	1,008	1837	305,783	0,000
Self-driving cars reduce car accidents	353,777	2	1,222	1837	289,480	0,000
Hackers are hacking into your car's system.	703,394	2	1,403	1837	501,251	0,000
The self-driving car breaks down	562,394	2	0,902	1837	623,220	0,000
The car does not decide/respond the way we want it to	637,414	2	0,884	1837	721,199	0,000
Fear of new technology	547,354	2	1,374	1837	398,487	0,000
People lose their jobs because of it (e.g. taxi drivers)]	634,621	2	1,369	1837	463,705	0,000
Control cannot be taken back	775,813	2	0,972	1837	798,508	0,000
Too expensive.	290,775	2	1,646	1837	176,679	0,000
The experience of driving is lost.	432,457	2	1,492	1837	289,840	0,000
Lack of security of personal data.	655,956	2	1,183	1837	554,430	0,000
The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.						

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Based on the results of the t-tests conducted between the Neutrals, Skeptics and Cautious Optimists clusters, Levene's test showed that for most of the variables tested, there was no significant difference in the within-cluster variances, thus the condition of equal variance was met. This was the case for the following variables: communication between drivers and pedestrians ( $F = 1.866$ ;  $p = 0.172$ ), the need for legal regulation of self-driving cars ( $F = 15.063$ ;  $p < 0.001$ ), the likelihood of self-driving cars being used for terrorist purposes ( $F = 18.020$ ;  $p < 0.001$ ) and the level of education ( $F = 14.738$ ;  $p < 0.001$ ). This suggests that for these factors, although the opinions of the three clusters may have differed in content, they showed a similar distribution in terms of variance, i.e. the variance of responses did not differ significantly.

However, significant differences were found for the variable "cybersecurity of self-driving cars" ( $F = 10.932$ ;  $p = 0.001$ ) and for the variable "biggest technological challenge" ( $F = 0.380$ ;  $p = 0.538$ ). For these questions, the variance of responses differed significantly within clusters, which may suggest that the three groups perceive the importance of cybersecurity and the weight of technological challenges differently. In particular, the Sceptics and Cautious Optimists clusters showed the largest differences.

Differences were also found for the following variables: age ( $F = 36.332$ ;  $p < 0.001$ ), location ( $F = 0.161$ ;  $p = 0.688$ ), and educational attainment ( $F = 50.512$ ;  $p < 0.001$ ). Significant differences were found between clusters for age and educational attainment, while no such differences were found for the location variable. Age and education level indicate that different

patterns in the distribution of responses were observed for the Neutral and Cautious Optimist clusters.

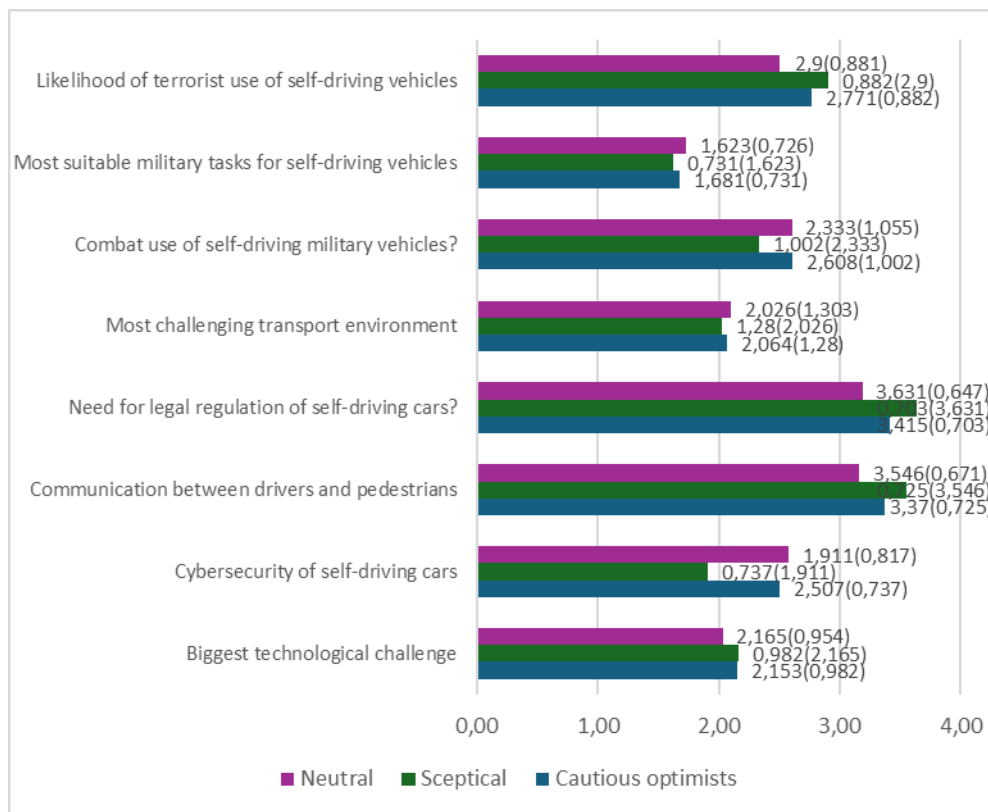


Figure 2. Means and Standard Deviations of Clusters

The aim of my research was to explore the social attitudes towards self-driving vehicles and to compare the three attitude clusters (Neutrals, Sceptics, Cautious Optimists). As a result of the K-Means clustering, I identified three groups: the Neutrals cluster, which does not completely reject self-driving vehicles but does not embrace them; the Skeptics cluster, which rejects new technologies but is sensitive to the risks; and the Cautious Optimists cluster, which is open to self-driving technologies but expresses concerns about the risks. The t-test analyses suggest that there are significant differences between the clusters, especially in terms of cyber security, age and education level. The results suggest that building trust and addressing concerns about risks are key to the adoption of technological innovations.

## 5. CONCLUSION

As one of the most revolutionary technological advances, self-driving cars are having a major impact not only on the transport industry but also on military applications. Research focuses on the development and application of autonomous vehicles in combat environments, in particular autonomous military vehicles and drones. Cybersecurity threats to autonomous vehicles, communications security and ethical issues in combat applications pose serious challenges that have implications not only for technological development but also for national security. The survey analysed respondents' views on the acceptance of the use of military autonomous vehicles. The responses reveal that different sectors of society have different perceptions of the role of autonomous systems in military applications, especially in combat. Older age groups and groups fearful of technological innovation are less supportive of the

introduction of autonomous systems for combat purposes, while younger, more open-minded groups are more accepting of new technologies if they meet safety and ethical standards. The results of this research show that the successful integration of future developments and applications in military systems can be achieved by building on the safe use of new technologies and social acceptance. The introduction of military autonomous systems requires increased public confidence, which requires education, demonstrations and appropriate regulation.

## REFERENCE

- Bai, W., Fu, C., Zhao, B., Li, G., & Yao, Z. (2025). An Optimal Scheduling Model for Connected Automated Vehicles at an Unsignalized Intersection. *Algorithms*, 18(4), 194. <https://doi.org/10.3390/a18040194>
- Bo, M. (2024). Are programmers in or out of control? The Individual Criminal Responsibility of Programmers of Autonomous Weapons and Self-Driving Cars. In S. Gless, & H. WhalenBridge (Eds.), *Human-Robot Interaction in Law and Its Narratives: Legal Blame, Procedure, and Criminal Law* (pp. 23-47). Cambridge University Press.
- Borenstein, J., Herkert, J. R., & Miller, K. W. (2019). Self-driving cars and engineering ethics: the need for a system level analysis. *Science and Engineering Ethics*, 25, 383-398. <https://doi.org/10.1007/s11948-017-0006-0>
- Cavoli, C., Phillips, B., Cohen, T., & Jones, P. (2017). Social and behavioural issues associated with automated vehicles: a literature review. UCL Transport Institute January.
- Chougule, A., Chamola, V., Sam, A., Yu, F. R., & Sikdar, B. (2023). A comprehensive review on limitations of autonomous driving and its impact on accidents and collisions. *IEEE Open Journal of Vehicular Technology*, 5, 142-161. <https://doi.org/10.1109/OJVT.2023.3335180>
- Dehler, R., & Buchholz, M. (2025). A Generic Service-Oriented Function Offloading Framework for Connected Automated Vehicles. *IEEE Robotics and Automation Letters*, 10(5), 5098-5105. <https://doi.org/10.1109/LRA.2025.3555939>
- Gál, I., Hima, Z., & Tick, A. (2024). Reducing the risks of automotive production. *Safety Science Review*, 6(1), 27-40.
- Gogoll, J., & Müller, J. F. (2017). Autonomous cars: in favour of a mandatory ethics setting. *Science and Engineering Ethics*, 23(3), 681-700. <https://doi.org/10.1007/s11948-016-9806-x>
- Goodall, N. J. (2014). Ethical decision making during automated vehicle crashes. *Transportation Research Record*, 2424(1), 58-65. <https://doi.org/10.3141/2424-07>
- Howard, D., & Dai, D. (2014). Public perceptions of self-driving cars: the case of Berkeley, California (No. 14-4502).
- Ito, S., Masoodi, F. S., & Ahmad, M. (2025). Ensuring secure connectivity in smart vehicular to grid technology: an elliptic curve-based authentication key agreement framework. *Sustainable Energy, Grids and Networks*, 101696. <https://doi.org/10.1016/j.segan.2025.101696>
- Jaradat, M., Jibreel, M., & Skaik, H. (2020). Individuals' perceptions of technology and its relationship with ambition, unemployment, loneliness and insomnia in the Gulf. *Technology in Society*, 60, 101199. <https://doi.org/10.1016/j.techsoc.2019.101199>
- Kettles, N., & Van Belle, J. P. (2019). Investigation into the antecedents of autonomous car acceptance using an enhanced UTAUT model. In: 2019 International conference on advances in big data, computing and data communication systems (icABCD) (pp. 1-6). IEEE.

- König, M., & Neumayr, L. (2017). Users' resistance towards radical innovations: the case of the self-driving car. *Transportation Research Part F: Traffic Psychology and Behaviour*, 44, 42-52. <https://doi.org/10.1016/j.trf.2016.10.013>
- Kovács, G., Högye-Nagy, Á., & Kurucz, G. (2021). Human Factor Aspects of Situation Awareness in Autonomous Cars-An Overview of Psychological Approaches. *Acta Polytechnica Hungarica*, 18(7), 7-24.
- Kumar, N., & SM, V. (2019) Use of Modern Technology to Counter Terrorism, Centre for Internal and Regional Security.
- Kyriakidis, M., Happee, R., & De Winter, J. C. (2015). Public opinion on automated driving: results of an international questionnaire among 5000 respondents. *Transportation Research Part F: Traffic Psychology and Behaviour*, 32, 127-140. <https://doi.org/10.1016/j.trf.2015.04.014>
- Lee, D., & Kwon, M. (2025). Episodic Future Thinking with offline Reinforcement Learning for Autonomous Driving. *IEEE Internet of Things Journal*, early access. <https://doi.org/10.1109/JIOT.2025.3535594>
- Li, Z., Niu, J., Li, Z., Chen, Y., Wang, Y., & Jiang, B. (2022). The impact of individual differences on the acceptance of self-driving buses: a case study of Nanjing, China. *Sustainability*, 14(18), 11425. <https://doi.org/10.3390/su141811425>
- McCarthy, T. (6 September 2017). Self-driving cars must have technology to prevent use in terror, lawmakers say. *The Guardian*. Retrieved from [https://www.theguardian.com/technology/2017/sep/06/self-driving-cars-terrorism-cybersecurity-technology]
- Moller, K., Nyberg, T., Tumova, J., & Betz, J. (2025). Pedestrian-aware motion planning for autonomous driving in complex urban scenarios. arXiv preprint arXiv:2504.01409. <https://doi.org/10.48550/arXiv.2504.01409>
- Othman, K. (2023). Investigating the Influence of Self-Driving Cars Accidents on the Public Attitude: Evidence from Different Countries in Different Continents. In: 2023 5th International Conference on Smart Systems and Inventive Technology (ICSSIT) (pp. 1579-1584). IEEE.
- Perger, Á. (2022). Potential targets of cyber-attacks: legal regulation of drones and self-driving cars. *Journal of Law and Social Sciences*, 7, 46-52.
- SAE International. (2021). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. [https://www.sae.org/standards/content/j3016\_202104]
- Schoettle, B., & Sivak, M. (2016). Motorists' preferences for different levels of vehicle automation: 2016. University of Michigan Sustainable Worldwide Transportation.
- Servin, C., Kreinovich, V., & Shahbazova, S. N. (2023). Ethical dilemma of self-driving cars: conservative solution. In: Recent Developments and the New Directions of Research, Foundations, and Applications: Selected Papers of the 8th World Conference on Soft Computing, February 03-05, 2022, Baku, Azerbaijan, Vol. II (pp. 93-98) Cham: Springer Nature Switzerland.
- Sz atmáry, R., & Lazányi, K. (2022). Are self-driving cars a safer solution? In: IFIP International Conference on Human Choice and Computers (pp. 443-455) Cham: Springer Nature Switzerland.
- Tang, Y., He, H., Wang, Y., & Wu, Y. (2025). Flexible anchor-based trajectory prediction for different types of traffic participants in autonomous driving systems. *Expert Systems with Applications*, 127629. <https://doi.org/10.1016/j.eswa.2025.127629>

- Viktor, P., & Fodor, M. (2024). Adapting self-driving technology. In: 2024 IEEE 11th International Conference on Computational Cybernetics and Cyber-Medical Systems (ICCC) (pp. 000153-000158).
- Woollard, F. (2023). The new trolley problem: Driverless cars and deontological distinctions. *Journal of Applied Philosophy*, 40(1), 49-64. <https://doi.org/10.1111/japp.12610>
- Zheng, Y., Pu, Z., Li, S., Han, Y., Xi, H., & Ran, B. (2025). Measuring platooning performances of connected and automated vehicles in energy consumption, emission, and efficiency. *Energy*, 326, 136172. <https://doi.org/10.1016/j.energy.2025.136172>





## ANALYSIS OF TRAINING NEEDS OF PROFESSIONAL DEVELOPMENT OF SENIOR CIVIL SERVANTS IN THE REPUBLIC OF SERBIA

Jelena Ruso<sup>\*1</sup>, Ana Rakić<sup>1</sup>, Sara Dimitrijević<sup>1</sup>, Isidora Milošević<sup>2</sup>

<sup>1</sup> University of Belgrade, Faculty of Organizational Sciences, Serbia

<sup>2</sup> University of Belgrade, Technical Faculty in Bor, Serbia

**Abstract:** One key resource for efficient public administration is a senior civil servant (SCS), who plays a fundamental role in integrating political decisions into administrative implementation. Therefore, the state's investment in their professional development and training is vital for the quality of public administration services. In order to achieve a high quality of public services, it is necessary to determine the real need for professional development of civil servants in managerial positions. After surveying 110 SCSs in Serbia, the results show that they generally positively evaluate the proposed features of the training program, with a particularly high level of agreement for the elements of practical application, use of technology, interactivity and creative thinking. The highest percentage of strong agreement was recorded for practical examples and enabling knowledge transfer through useful methods, indicating a preference for an applicable and dynamic approach to learning.

**Keywords:** public administration, senior civil servants, training needs, professional development.

### 1. INTRODUCTION

Although no universally accepted definition of SCS exists, several generally accepted frameworks can be identified. According to the definition cited by UNDP (2020:5), derived from the SIGMA Methodological Framework for the Principles of Public Administration, Public Service, and Human Resource Management (2019), SCSs are defined as “professional civil servants employed in the highest-level managerial positions in the national civil service, formally or informally recognized as a distinct group.” This definition highlights their special

---

\* Corresponding author: [jelena.ruso@fon.bg.ac.rs](mailto:jelena.ruso@fon.bg.ac.rs)

Jelena Ruso, ORCID: 0000-0003-4120-8759

Ana Rakić, ORCID: 0000-0001-7110-6441

Sara Dimitrijević, ORCID: 0009-0000-2278-9952

Isidora Milošević, ORCID: 0000-0001-5539-8253

status within the civil service and their role in ensuring professionalism and continuity in governance. In line with this, the role of SCSs is further clarified through their daily work and practical application. As stated by Rijksoverheid (2022), “SCSs are responsible for and guide the achievement of organizational goals in the context of societal challenges. They are political-strategic advisers and the first point of contact for ministers.” This emphasizes their dual role — as professional managers within the administration and as key advisers to political decision-makers.

An important aspect of the work of SCSs is their professional development, as insufficient expertise among staff can lead to inadequate managerial decisions, which may negatively affect the quality of governance at the national, regional, or local level (Zinich et al., 2022). Training and development of civil servants can be viewed as a mechanism to ensure the quality of meeting the needs of a nation’s citizens (Le et al., 2023). According to Cuong & Phuong (2018), “training refers to acquiring new skills, while retraining involves updating and expanding the knowledge and skills of civil servants in line with societal developments. Today, various approaches are taken to training and professional development of SCSs. It is important to highlight that, according to UNDP (2020), SCSs are required to undergo a mandatory level of training in most EU member states. Since training is conducted to improve existing competencies, evaluating the training process after its implementation is necessary. According to Safety Culture (2024), “training evaluation is a systematic process of analyzing a training program to ensure it is implemented effectively and efficiently. Evaluation identifies training gaps and reveals opportunities for improvement.” Various training evaluation methods exist, depending on the type of training, with one of the most well-known being the Kirkpatrick Model.

The 2024 training program for managers in government agencies in Serbia has been developed in collaboration with the relevant authority for personnel management within the public sector, along with individuals responsible for managing personnel in state bodies. This executive training initiative is designed to address the specific requirements of the target audiences, such as civil servants preparing for managerial responsibilities. Therefore, the paper aims to analyze and determine the needs for professional development of SCSs in the Republic of Serbia. This type of research creates the foundation for creating targeted, effective and relevant training programs. By determining specific knowledge, skills and competencies necessary for modern challenges in public administration, it contributes to strengthening the capacity of the civil service, improving management and making decisions based on knowledge, which is crucial for efficient, responsible and professional public administration.

## **2. PROFESSIONAL DEVELOPMENT IN PUBLIC ADMINISTRATION**

Author Kettunen discussed the importance of training in public administration in 2001, using Finland as an example. Back then, it was said that adequate programs were necessary due to the variety of client demands and needs. These programs were important in maintaining and increasing the professional knowledge of participants in public administration and expanding their competencies in various fields (Kettunen, 2003).

Some papers provide an overview of education and training programs in the broader public administration and management field in Europe. (Reichard & Schröter, 2017). The trends and developments over time and across nation states are studied with particular attention to

institutional arrangements of programs, their contents, curricular developments, and their teaching philosophies (Reichard & Schröter, 2017). While several converging trends can be identified, e.g., regarding commonalities of institutional patterns and program content, divergent forces—such as traditional recruitment patterns and teaching styles—are still at work (Reichard & Schröter, 2017).

Public service staff, managers, and politicians must also embrace the necessity to mediate between societal and individual value creation and between value creation aspirations of different stakeholders to a public service (Osborne et al., 2022). The importance of providing continuous training for employees in public administration is also shown by research on the motivation of employees in public administration (Ponomariov & McCabe, 2017). Over the last three decades, investigation on motivation in public service has experienced rapid growth (Ritz et al., 2016). Notably, in the discussion of professional education in public administration programs, a decline in empathy is positively associated with exposure to clients/patients (Ponomariov & McCabe, 2017). It is difficult to imagine that public servants whose commitment to the public interest declines with increased exposure to the diverse stakeholders they are expected to serve (Ponomariov & McCabe, 2017). For these reasons, a more active involvement of academic institutions in the professional training of employees in public administration is also necessary. Institutional leaders feel challenged in their search for effective strategies to encourage faculty participation in public service activities (Holland, 2023). The perception of the role of public service as a legitimate component of the institution's goals is crucial for those faculty who lack personal or disciplinary motivations for engagement (Holland, 2023).

## **2.1. Regulatory framework for the professional development of civil servants in Serbia**

In the Republic of Serbia, the system of professional development for civil servants is regulated by several legal and bylaw acts, with the most significant being the *Law on Civil Servants*, the *Decree on Professional Development of Civil Servants*, and the *Decree on Determining Competencies for the Work of Civil Servants*. These documents define obligations, types and methods of training, and the responsibilities of relevant institutions. The *National Academy for Public Administration (NAPA)* plays the central role in implementing training programs, while the *Ministry of Public Administration and Local Self-Government* is responsible for shaping and monitoring professional development policies.

Within the strategic framework for public administration reform, particular importance is given to improving civil servants' professional development. The key document in this area is the *Public Administration Reform Strategy in the Republic of Serbia for the period 2021–2030*, which sets the foundation for an efficient human resource development system, emphasising training quality, effect evaluation, and digital learning.

This strategy defines several specific objectives related to civil service human resources, including: attracting and employing competent staff (Specific Objective 2); retaining and motivating employees in a stimulating work environment (Specific Objective 3); and modernizing professional development and examinations based on competency needs analysis (Specific Objective 4). Notably, Objective 4 introduces reforms in civil service professional examinations, previously excluded from development efforts, and calls for the modernization and standardization of training programs (Стратегија, 2021).

Although no longer in force, the *Strategy for Professional Development of Civil Servants* provides a solid foundation for further improvements. It emphasizes the continuous enhancement of competencies and defines principles of professional development for all individuals falling under the legal definition of a civil servant. According to the *Law on Civil Servants*, a civil servant is a person employed in state administration bodies and other institutions performing legal, IT, financial, accounting, and administrative tasks (Стратегија, 2013).

The strategy also highlights the creation of a sustainable and efficient training system, including programs for new employees, continuous training, and managerial development. Training is understood as a planned process for acquiring knowledge and skills necessary for specific duties. Training needs are determined through strategic documents, evaluations, and specific job requirements. Effectiveness is measured through reports and evaluations to ensure the direct impact on civil servants' performance and public service quality (Стратегија, 2013).

Importantly, the legal definition of civil servants extends beyond ministries to include other state bodies whose functions align with standard public administration roles. This broad definition is relevant for designing general training programs (Стратегија, 2013).

The *Law on Civil Servants* represents the legal backbone for regulating rights, duties, and professional development. Article 10 states that civil servants have both the right and obligation to pursue professional development based on institutional needs. Article 96 defines professional development as a continuous process including various training programs. Article 97 mandates that such programs be based on identified needs and financed through the state budget, while Article 97v assigns NAPA the role of program development, implementation, and accreditation (Закон, 2025).

The *Decree on Determining Competencies* (Уредба, 2022) defines standards for identifying and evaluating the competencies necessary for quality public service delivery. It supports objective assessment processes through recruitment and performance evaluation, forming a foundation for targeted training and career advancement (Уредба, 2022).

The *Decree on Professional Development* (Уредба, 2019) specifies program types, development needs, and general training categories, ensuring a structured approach to enhancing civil servants' competencies and administration efficiency (Уредба, 2019).

Finally, the *National Academy for Public Administration (NAPA)*, established in 2017, is the key institution for coordinating professional development. It organizes and implements training, accredits providers, promotes e-learning, and supports competency-based public sector management (HAJV, 2025).

## **2.2. Effects and needs for training in the public administration of Serbia and international comparisons**

The effective and efficient utilisation of human resources is valuable to brace sustainable national development (Zacharias et al., 2021). Obtaining a community with dependable human resources requires quality education, offering various social facilities, and adequate employment (Yusriadi et al., 2019). However, weaknesses in distributing these facilities will cause social disturbance, influencing public safety (Zacharias et al., 2021).

In the first example of this paper, the professional training study examines the impact of demographic characteristics on the effectiveness of the training and development programs in the national public administration of Serbia (Štrbac et al., 2024). In particular, the aim is to assess the effectiveness of the training programs in public administration and to examine how components such as gender, educational level, years of work experience and job title affect the result of training programs. The study sample included over 1,000 public administration

employees in Serbia who participated in at least one training program in the National Academy of Public Administration during 2022. The effectiveness of the training programs is evaluated to the extent to which they contribute to meeting the established objectives. The study outputs indicate that age, gender and education level do not affect the effectiveness of the training programs in public administration. Nevertheless, training effectiveness is remarkably affected by professional experience and job titles in public administration (Štrbac et al., 2024).

The professional development and training of employees in public administration is a continuous, methodically planned and established process in which, via studying and practical service, knowledge is enhanced, and abilities refined gave the authors Zlatanović & Antonijević (2007) in a second example of this paper analysing professional training in public sector in Republic of Serbia. Nowadays, in the “knowledge society”, the continuous improvement of knowledge and abilities in professional life is needed; so, civil servants must continually upgrade their knowledge and abilities. The authors find that the main motive that regulates the significance and requirement for continual professional training and development is the fact that in transition countries, such as Serbia, we experience changes in the legal system. Specifically, every year, a significant number of laws are passed which pose new challenges for employees in public administration and require, besides sufficient understanding, their appropriate implementation (Zlatanović & Antonijević, 2007).

The first analysed international study in this paper examines cultural and organizational motivations for success in the Department of Public Works in the province of Maluku, Indonesia (Zacharias et al., 2021). The approach utilised for this research was quantitative, using a survey. The Department of Public Works of the Province of Maluku was the research site with a sample of 149 contributors in public administration. The main discovery was 1) organizational culture has a direct impact on employee performance, 2) organizational culture effects organization performance, 3) organizational environment has a straight impact on employee performance and motivation and 4) organizational environment contribute to organization performance. The outcomes show that the organizational environment can be enhanced by composing regulatory policies and implementing strategies for professional development and rules for employees to perform their duties. Motivation for performances can be raised by awarding, for example, through professional training. In establishing an organizational culture, awareness must be given to the values held in organizational culture, professional development and organizational goals (Zacharias et al., 2021).

Another example of international professional training in public administration is Finland's case (Kettunen, 2003). They noted that it is necessary to provide diversity training for public administration employees, given the various nature of their jobs and the clients they interact with. These educational trainings of employees in Finland's public administration included continuous training that was oriented towards the client. From the characteristics when contracting such training, the following are noticed: training goals, methods by which those goals will be achieved, time frame for the completion of the training, evidence that the goals are met, the means to achieve the goals, and evaluation of the level of goal fulfilment. Interestingly, these professional development programs support the development of each individual employee. Such programs of continuous development of employees supported by the University of Helsinki led, among other, to an increase in competence in understanding changes in the environment, developing strategies and adopting the latest knowledge in the field; increasing management performance; developing goal-oriented management and change management; and supporting motivation for continuous development (Kettunen, 2003).

### 3. DATA AND METHODOLOGY

This study is part of the IPA project aimed at enhancing the professional capacities of SCSs in Serbia. The project's goal is to improve SCS training programs and strengthen public administration efficiency. A research survey was distributed to identify the professional development needs of SCSs in Serbia. A questionnaire was chosen as one of the methods and techniques for determining the professional development needs of SCSs. The questionnaire consists of three groups of questions. The first collects mandatory demographic data such as gender, age, and work experience. The second gathers information about the respondent's position and role within the state administration. The third identifies training needs and evaluates key functions of SCSs, incorporating statements based on the Kirkpatrick and Anderson quality models, rated on a Likert scale. The questionnaire was developed using the LimeSurvey platform and sent by the National Academy of Public Administration to 247 email addresses of civil servants in managerial positions. It was available for completion from November 20 to December 2, 2024. A total of 179 participants responded, with 110 SCSs fully completing the survey.

### 4. RESULTS AND DISCUSSION

Before conducting a detailed demographic analysis, the reliability of the measuring instrument was assessed using Cronbach's  $\alpha$ , which yielded a high value of 0.935, indicating excellent reliability. Most surveyed SCSs (66.4%) have over 10 years of experience in state administration, while smaller percentages fall into lower experience categories. This dominance of experienced respondents strengthens the relevance and credibility of their insights regarding work in public administration. Most respondents (36.4%) have been in their current positions for 1 to 3 years, while only 11.8% have held their roles for 10 or more years. Other groups include those with 4–6 years (18.2%), 7–9 years (20%), and less than a year (13.6%) of service. This distribution shows a predominance of newer employees, while also ensuring a diversity of perspectives based on varying lengths of tenure. The majority of respondents (62.7%) have over 10 years of management experience, while smaller groups have between four and nine years (28.2%) and fewer than three years (9.1%). This dominance of highly experienced managers enhances the value and credibility of their insights for the research. Women made up a slightly larger portion of the sample, accounting for 56.4% of respondents, while men represented 43.6%. The majority of respondents were aged 41–50 (43.6%) and 51–60 (39.1%), while smaller shares were aged 31–40 (9.1%) and 61 or older (8.2%). No respondents were under 30 years old. Most respondents work in special organizations (30%) and ministries (29.1%), followed by those in administrative bodies within ministries (15.5%), government services (12.7%), and the "Other" category (12.7%), which includes one respondent from the Commissioner for the Protection of Equality. This distribution reflects the diversity of state administration structures represented in the sample. The majority of respondents (57.3%) are appointed civil servants in positions filled through competition, while 33.6% are acting officials. The remaining 9.1% fall into the "Other" category, which includes roles such as group leader, head of a narrower internal unit, and acting civil servant. The majority of respondents (41.8%) have an education in legal sciences, followed by economic sciences (20.9%) and technical/technological sciences (15.5%). Smaller groups are represented in social/humanistic sciences (10%), natural/mathematical sciences (8.2%), and other fields like medical sciences, arts, and political sciences (0.9% each), with one respondent indicating a background in veterinary science. This distribution highlights the prominence of legal and economic expertise among the respondents, influencing their work in state bodies and public institutions. Finally,

descriptive statistics reveal varying perceptions of role importance within the organization. Problem-solving (49.1%), advocacy (47.3%), and coordination (36.4%) are seen as the most crucial, reflecting their impact on organizational stability and efficiency, while roles like finance specialist are viewed as less important, with only 10% of respondents considering them essential. Roles like mentors, trainers, and transparency promoters receive moderate support, suggesting their importance may not always be fully recognized. This highlights the need for clear definitions of core competencies and priorities to ensure each role is adequately supported and aligned with organizational goals.

Table 1 results show a generally positive response to the training program, with most agreeing on aspects like practical examples, workshops, and simulations. The least common response was "I completely disagree," indicating strong acceptance of the proposed features. However, some statements, such as the need for post-training mentoring support, received more neutral responses, suggesting varied perceptions. The higher number of "Strongly Agree" responses for creative thinking and work application highlights the importance of these elements, emphasizing the need for an interactive, practical, and technology-supported training approach.

*Table 1. SCS's needs for the training program*

<b>The training program should:</b>	<b>Strongly Disagree (%)</b>	<b>Disagree (%)</b>	<b>Neutral (%)</b>	<b>I agree (%)</b>	<b>I strongly agree (%)</b>
... to use methods that would help the more efficient transfer of knowledge and the development of skills	0.9	-	4.5	27.3	22.7
... to meet my needs in terms of acquiring complex knowledge and skills	0.9	-	4.5	29.1	20.9
... to include more workshops and simulations to ensure practical application of acquired skills	0.9	-	5.5	27.3	21.8
... to enable the use of technology and tools that improve my engagement and interest	0.9	-	5.5	30.0	19.1
... to be focused on how to apply what I have learned in my daily tasks	0.9	-	5.5	26.4	22.7
... to focus on practical examples	0.9	-	2.7	22.7	29.1
... to enable greater interactivity to engage participants more	-	-	10.9	23.6	20.9
... to enable mentoring support after the end of the training	0.9	1.8	16.4	25.5	10.9
... to include more group activities and discussions that encourage the exchange of ideas	0.9	0.9	10.9	26.4	16.4
... to contain a section for individual consultations with lecturers or mentors	0.9	0.9	10.9	30.0	12.7
... to provide adequate support that helps me master the material	0.9	1.8	10.0	34.5	8.2
... to include more activities that encourage creative thinking and innovation	0.9	0.9	5.5	30.9	17.3
... to directly contribute to my ability to make better decisions	0.9	1.8	6.4	24.5	21.8
... to help improve my work performance in specific areas of my work	0.9	1.8	5.5	27.3	20.0
.. to provide access to resources that help me acquire new skills	0.9	1.8	7.3	29.1	17.3
... to include regular evaluation and feedback	0.9	0.9	9.1	32.7	15.5

The most valued learning method was small group discussions, with 72.7% of respondents finding them useful, highlighting the importance of interactivity and idea exchange. Other highly valued methods include study visits (66.4%), case studies (50.9%), simulations (43.6%), and advanced training with experts (43.6%). All of these methods emphasize practicality, active involvement, and specialized knowledge, making them key for personal development (Figure 1).

The most popular personal development activity was reading professional literature, with 70.9% of respondents engaging in it. Conferences (56.4%) and direct participation in training or workshops (48.2%) were also common. Fewer respondents acted as mentors (16.4%) or had their own mentor (2.7%). Only 3.6% reported not engaging in any personal development activities, suggesting strong involvement in training (Figure 2).

Most respondents (54.5%) can dedicate less than two hours daily to professional development, while 35.5% can allocate two to four hours. Only 7.3% can devote the entire workday to it, and 2.7% fall into the "Other" category, with one respondent noting they can allocate 3-4 hours weekly.

The majority of respondents (44.5%) can allocate two to three days per month for professional development, followed by 33.6% who can dedicate about one day per month. Smaller groups can allocate four to five days (11.8%) or more than five days (3.6%), while 4.5% can commit less than one day, and 1.8% fall into the "Other" category.

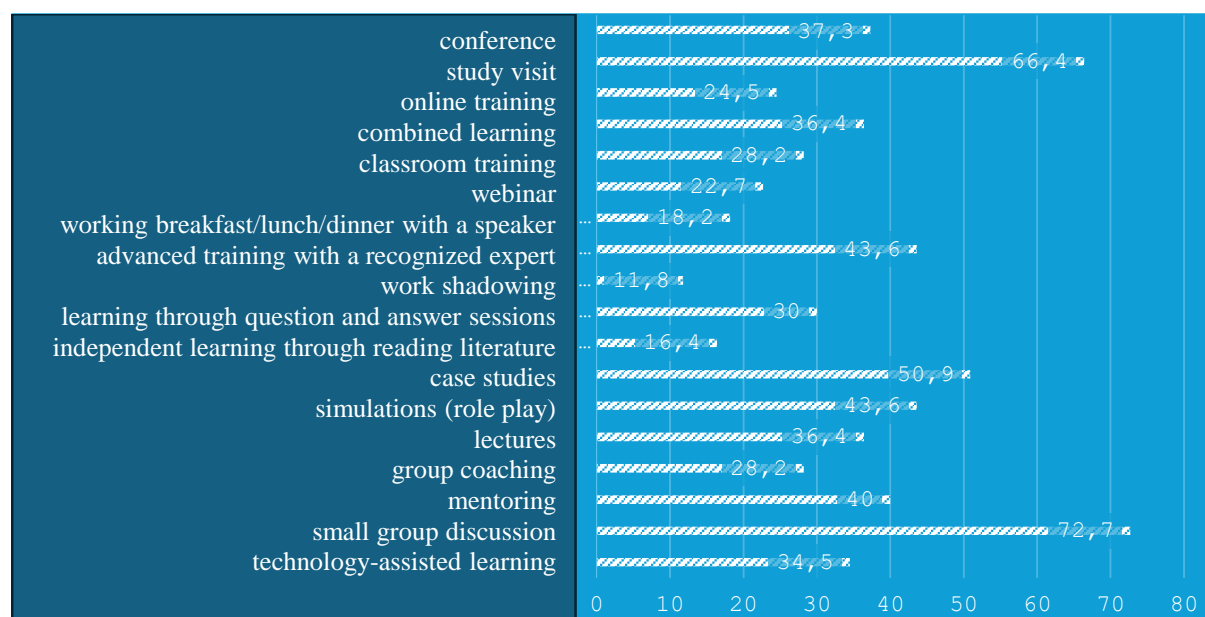


Figure 1. The most useful learning methods

Finally, the topics most frequently mentioned by respondents as having the most significant impact on improving their knowledge, abilities, and skills in the past three years include: ethics and integrity, public appearance, performance appraisal, leadership, information security, strengthening professional capacities of civil servants in Serbia, public procurement, and assertive communication.



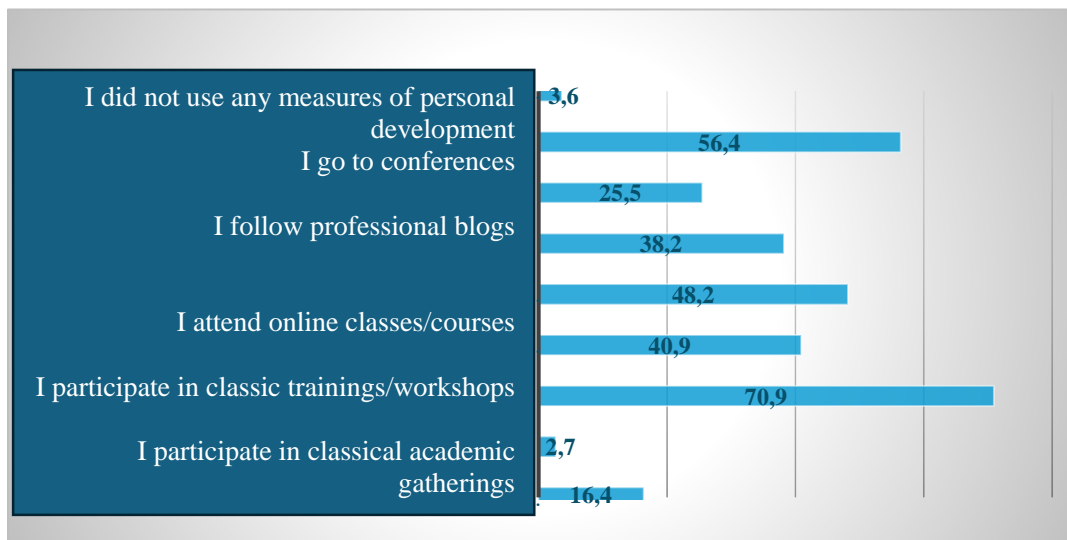


Figure 2. Personal development activities

## 5. CONCLUSION

This paper examined the professional development needs of senior civil servants (SCSs) in Serbia, recognizing their pivotal role in ensuring effective, accountable, and responsive public administration. Through the conducted survey of 110 SCSs, most of whom have over a decade of experience in state administration, the study revealed strong alignment among participants on the importance of practical, technology-supported, and interactive training approaches, with a strong emphasis on applicability, creative thinking, and group-based learning methods like small group discussions, study visits and case studies. Most respondents indicated that they are able to dedicate two to three days per month to professional development activities. The research confirms that targeted training, based on clearly identified competencies and real professional challenges, is crucial for strengthening managerial performance in the public sector. Furthermore, the analysis of Serbia's strategic and regulatory framework illustrates that, while a foundation for professional development exists, continuous adaptation and modernization of training content and evaluation mechanisms remain essential to meet contemporary public governance demands. This paper contributes to that effort by offering evidence-based insights to support the design of future training programs aligned with the evolving role and expectations of SCSs.

## ACKNOWLEDGMENT

This research was funded by the EU through the project of the National Academy for Public Administration entitled "Strengthening professional capacities of Senior Civil Servants in Serbia".

## REFERENCES

- Cuong, T. V., & Phuong, N. M. (2018). Renovating and improving the quality of training and training cadres and civil servants in Vietnam in international integration.
- Holland, B. A. (2023). Factors and strategies that influence faculty involvement in public service. In *Building the Field of Higher Education Engagement* (pp. 55-62). Routledge.)

- Osborne, S. P., Powell, M., Cui, T., & Strokosch, K. (2022). Value creation in the public service ecosystem: An integrative framework. *Public Administration Review*, 82(4), 634-645.
- Kettunen, J. (2003). Professional development in public administration. *Pakistan Journal of Social Sciences*, 1(2), 74-79.
- Le, D. T., Trung, N. S., Tuan, N. T., Dai, L. D., & Ngoc, H. M. (2023). The Quality of Training and Retraining Civil Servants in Vietnam. *Russian Law Journal*, 11(3), 516-525.
- Ponomariov, B., & McCabe, B. (2017). Professionalism vs. Public Service Motivation: Can Public Administration Education Alleviate the Tension? *Administrative Theory & Praxis*, 39(2), 80–99. <https://doi.org/10.1080/10841806.2017.1309802>
- Reichard, C., & Schröter, E. (2017). Education and training in public administration and management in Europe. In *The Palgrave handbook of public administration and management in Europe* (pp. 41-60). London: Palgrave Macmillan UK.
- Rijksoverheid (2022). Functiegebouw Topmanager-generaal. <https://www.functiegebouwrijksoverheid.nl/functiegebouw/functiefamilies/lijnmanagement/topmanager-generaal>
- Ritz, A., Brewer, G. A., & Neumann, O. (2016). Public service motivation: A systematic literature review and outlook. *Public administration review*, 76(3), 414-426.
- Safety Culture. (2024). Training Evaluation Guide – What is training evaluation? <https://safetyculture.com/topics/training-evaluation/>
- SIGMA, (2019). Methodological Framework for the Principles of Public Administration Public Service and Human Resource Management. <http://sigmaweb.org/publications/Methodological-Framework-for-the-Principles-of-Public-Administration-May-2019.pdf>
- Štrbac, D., Paunović, M., & Pavlović, D. (2024). The influence of demographic characteristics on the effectiveness of public administration training programs. *Stanovništvo*, 62(2), 251–266. <https://doi.org/10.59954/stnv.637>
- UNDP. (2020). Political independence of civil servants and the role of SCSs. Georgian Institute of Public Affairs, Georgia
- Yusriadi, Sahid, A., Amirullah, I., Azis, A., & Rahman, A. A. (2019). Bureaucratic reform to the human resources: A case study on the one-stop integrated service. *Journal of Social Sciences Research*, 5(1), 61–66. <https://doi.org/10.32861/jssr.51.61.66>
- Zacharias, T., Rahawarin, M. A., & Yusriadi, Y. (2021). Cultural reconstruction and organization environment for employee performance. *Journal of Ethnic and Cultural Studies*, 8(2), 296-315.
- Zinich, L. V., Kuznetsova, N. A., & Kondratieva, O. V. (2022). Featuring Professional Development Of Civil Servants. *European Proceedings of Social and Behavioural Sciences*.
- Zlatanović, I., & Antonijević, S. (2007). Experiences of civil servants training in Serbia. *Public Policy and Administration: Challenges and Synergies*, 257.
- Закон. (2022). Закон о државним службеницима. Службени гласник РС, бр. 79/2005, 81/2005, 83/2005, 64/2007, 67/2007, 116/2008, 104/2009, 99/2014, 94/2017, 95/2018, 157/2020 и 142/2022.
- HAJU. (2025). О нама. Национална академија за јавну управу, Република Србија. <https://napa.gov.rs/tekst/34/o-nama.php>
- Стратегија. (2013). Стратегија стручног усавршавања државних службеника у Републици Србији. Службени гласник РС, број 51/2013.
- Стратегија. (2021). Стратегија реформе јавне управе у Републици Србији за период од 2021. до 2030. године. Службени гласник РС, бр. 42/2021 и 9/2022-Одлука.

- Уредба. (2019). Уредба о стручном усавршавању државних службеника. Службени гласник РС, број 15/2019.
- Уредба. (2022). Уредба о одређивању компетенција за рад државних службеника. Службени гласник РС, број 9/2022.



## PRICE AND VOLUME DYNAMICS: A CORRELATION ANALYSIS OF MAJOR OIL COMPANIES

Adrijana Jevtić Tomić\*, Dejan Riznić

*University of Belgrade, Technical Faculty in Bor, Republic of Serbia*

**Abstract:** Understanding the relationship between trading volume and price movements is crucial for analyzing market dynamics. This study examined the correlation between monthly price changes and monthly volume changes for three major oil companies: Exxon Mobil (XOM), Chevron (CVX) and ConocoPhillips (COP). The monthly price and volume data for the period from January 2020 to May 2025 were analyzed using Pearson's correlation coefficient. The results showed a statistically significant positive correlation between price and volume changes for Exxon Mobil, suggesting that increased trading activity tends to be associated with price increases for this company. However, the correlations for Chevron and ConocoPhillips were not statistically significant during the period under review. A strong positive correlation is also found when looking at the correlation between the monthly price changes of the companies observed. On the other hand, the correlation between the volume changes of the observed companies is only strong and positive for one pair of the analyzed companies, while the other companies show a slightly negative correlation. Major oil companies may have varying short-term price-volume relationships, necessitating further research to understand these dynamics and consider other market factors.

**Keywords:** Price change, Volume change, Oil companies, Correlation Analysis, Stock market.

### 1. INTRODUCTION

The energy sector is a vital and diverse sector that forms the basis of modern society. It encompasses a wide range of industries and activities concerned with production, distribution and consumption of energy in various forms. This includes traditional sources such as fossil fuels (coal, oil and natural gas) as well as increasingly important renewable sources such as solar, wind and hydroelectric power. Its importance is visible based on its market values. According to Yahoo finance (n.d.) the energy market capitalization is determined at 2.804 trillion USD, it contains 8 industries and on this market are 257 companies present.

---

\* Corresponding author: [ajevtic@tfbor.bg.ac.rs](mailto:ajevtic@tfbor.bg.ac.rs)

Adrijana Jevtić Tomić, ORCID: 0000-0002-6870-5790  
Dejan Riznić, ORCID: 0000-0002-8213-2722

The oil and gas industry remains a cornerstone of the global economy, providing energy for transportation, heating, power generation and manufacturing. That is one of the largest industries in the world, and crucial component within the overall energy sector due to its significant role in global energy supply and its far-reaching economic and geopolitical impact.

In recent years, the global oil market has been significantly impacted by COVID-19 disruptions, price wars between oil-producing nations, Russia's war in Ukraine and the conflicts in the Middle East. Despite the rise of renewables, oil and gas continue to be the engine of economic growth, employment and infrastructure development worldwide. According to the Economipedia website, oil contributes approximately 2.5% of the world's gross domestic product (GDP), and provides almost a third of the total energy used by the world's population (Innova, 2022). The global oil and gas analysis market size was estimated at USD 8.46 billion in 2024. It is projected to increase from USD 10.34 billion in 2025 to USD 63.5 billion in 2033, registering a CAGR of 22.3% during the forecast period (2025-2033) (Straits Research, 2024). Rising global energy demand is driving the industry significantly.

The first half of 2025 was characterized by geopolitical instability; tariff threats and OPEC+ production increases were among the most important trends affecting the oil and gas sector (Pistilli, 2024). Taking into consideration the importance of this sector, it is reasonable why the change of price is one of the determining factors in the financial and political power worldwide.

According to available data, the world top 5 oil producers are: USA, China, Saudi Arabia, Russia, Canada (EIA, 2024). According to Pistilli (2024), the newest available production data, the US is the largest oil-producing country in the world with 21.91 million barrels per day in 2023. As well as the producer, the USA is the biggest oil consumer in the world, too. The same author listed Saudi Arabia as second ranked by production (11.13 million barrels per day), and the Russia is on the third place with production of 10.75 million barrels per day.

As market capitalization is prone to frequent changes, it's tricky when trying to determine which are the biggest oil and gas companies worldwide. The world's largest oil and gas companies by market capitalization in March 2025, according to the report by Straits Research (2025) are listed in Table 1.

*Table 1.* The world's largest oil and gas companies by market capitalization in March 2025

Rank	Company	Headquarters	Market Capitalization	Primary listing*	Currency listing
1	Saudi Aramco	Dhahran, Saudi Arabia	\$1.648 trillion	SSE	SAR
2	ExxonMobil	Irving, Texas, USA	\$493.62 billion	NYSE	USD
3	Chevron	San Ramon, California, USA	\$279.44 billion	NYSE	USD
4	Shell	London, UK	\$210.03 billion	AEX	EUR
				LSE	GBP
5	PetroChina	Beijing, China	\$196.17 billion	SHH	CNY
				HKG by HKEX	HKD
6	TotalEnergies	Paris, France	\$139.20 billion	Euronext, Paris	EUR
7	ConocoPhillips	Houston, Texas, USA	\$126.42 billion	NYSE	EUR
8	CNOOC	Beijing, China	\$115.72 billion	HKG by HKEX	HKD
9	Southern Company	Atlanta, Georgia, USA	\$99.30 billion	NYSE	USD
10	TAQA	Abu Dhabi, UAE	\$95.82 billion	ADX	AED

\* SSE – Saudi Stock Exchange, NYSE – New York Stock Exchange, AEX – Euronext Amsterdam, LSE – London Stock Exchange, SHH – Shanghai Stock Exchange, HKG by HKEX – Hong Kong Stock Exchange, ADX – Abu Dhabi Securities Exchange.

Table 1 illustrates the hierarchical structure of the largest oil and gas companies by capitalization. According to this criterion, the largest companies mainly include companies from North America and Asia, while companies from Europe are very poorly represented. It can also be observed that each company carries out its share trading primarily on the stock exchange of its country, so that we have a greater number of markets as well as different currencies in which the values of their shares are expressed on the stock exchange. It is also interesting to note that the company in first place in the ranking, measured by the value of capitalization, is many times higher than the company in next place. The United States of America also has many companies in this sector whose individual capitalization is not significant, but which together contribute to making the United States of America the largest producer and trader of oil and oil derivatives in the world. For this reason, the focus of this analysis will be on companies from the United States of America market and the analysis of their stock market transactions.

The aim of this paper is to determine the relationship between the change in share prices and trading volume for the companies observed and to determine whether there is a relationship between the change in share prices or trading volume between them. Following a brief introduction emphasizing the significance of this sector, a literature review will be conducted, succeeded by a description of the methodology employed in this research, along with a presentation and analysis of the results.

## 2. LITERATURE REVIEW

Based on the available literature on the stock market in the energy sector, the analyzes of numerous authors are aimed at two main directions: the prediction of the share prices of selected companies using various methods and the investigation of the relationship between the price movements between the companies or the relationship between the prices and certain factors influencing the prices.

It has already been said that the period from 2020 onwards is characterized by the crisis caused by Covid-19 and the war between Ukraine and Russia, and since these are the biggest crisis moments in the immediate past, there are many works in the literature that deal with the impact of the aforementioned factors on the energy stock market (Cardinale et al., 2024; Mao et al., 2024; Olayungbo et al., 2024; Saif-Alyousfi, 2025;). Olayungbo et al. (2024) reveals that stock price returns respond positively to oil price returns in Italy, Germany, and the US during the COVID-19 period, while only the US responds positively during the Russia-Ukraine war period. Saif-Alyousfi (2025) found that energy price shocks generally improved returns in various sectors like oil and gas. However, the EU's energy policy, influenced by domestic market competition, has made it susceptible to price and supply shocks despite external factors like Covid recovery and Ukraine war (Cardinale et al., 2024). Cui et al. (2024) in their research highlighted that geopolitical risks significantly impact total skewness spillovers during crisis periods. Implications on world market of the instabilities were noted by Shafique and Bhutta (2024) who examines the impact of the Trade War on G-7 countries' stock markets. It reveals that strong market efficiency inversely correlates with stock market volatility, but not for America, France, Japan, and the UK.

Some authors focused on analysing the energy market for a longer period. Tiwari et al. (2025) examines the link between oil price fluctuations and stock market returns in emerging market economies, using data from 2001-2021. Xiang and Borjigin (2024) analyzes risk spillover effects between 42 global stock markets using daily data from 2004-2022, revealing heterogeneity in spillovers, with trading volume significantly influencing risk contagion. Cadena-Silva et al. (2025) using data from 2003 to 2023 reveals that oil shocks significantly

impact G7 countries' stock market indices, with Canada, Japan, and the UK showing high sensitivity, highlighting the need for economic policies. Li and Shi (2024) examines the relationship between customer concentration and stock price volatility in China's A-share listed companies from 2012-2022. Results show that increased customer concentration negatively impacts stock price volatility, with state-owned companies less affected.

In the literature, there are some authors that analyzed the impact of secondary factors on the energy sector. Gao et al. (2025) in a study of 26,819 firms found a positive correlation between media coverage and investment-to-price sensitivity, suggesting optimizing media use for decision-making and supporting media development in the capital market. Gaganis et al. (2025) reveals that stock prices in secretive societies increase more due to cultural biases and less informed trading due to the enforcement of insider trading laws. Zhang and Wang (2024) examines the impact of stock market rumors on price efficiency, finding that favorable rumors positively correlate with stock price synchronicity, while unfavorable rumors negatively. Both rumors are positively correlated with mispricing levels and crash risk. Demirer et al. (2024) reveals oil price shocks significantly impact factor returns in 62 stock markets, suggesting a conditional global factor investing strategy can enhance returns. Bajzik's study (2021) examines 468 estimates from 44 studies on the correlation between trading volume and stock returns, revealing publication bias, varying predictability across markets and stock types.

Some analysis in the literature focus on certain geographic parts of the market and problems related to market volatility, stock returns, trading volume, etc. like China stock market (Fang et al., 2024; Zhang et al., 2024; Ge, 2023), Pakistan's stock market (Khan et al., 2025), African Stock Markets (Ngene & Mungai, 2022). Latin American markets (Saatcioglu & Starks, 1998), and market of EU countries (Grecu et al., 2025).

Some authors (Choi et al., 2024) focused on the long-term dependence of natural gas (NG), crude oil, and stock markets in energy-producing and consumer countries, revealing oil's more pronounced co-movements and implications for financial risk assessments and stock market stability.

Trading volume and price volatility are one of the issues discussed in literature (Bastidon & Jawadi, 2024; Fang et al., 2024; Zhang et al., 2024). Narayan et al. (2013) presents a cross-sectional model revealing that trading volume and share price volatility significantly impact asset price bubbles.

It is interesting to note that there are fewer works in the literature that analyze the topic of the relationship between price and trading volume on the market. Saatcioglu and Starks (1998) in their paper investigates the stock price-volume relationship in Latin American markets, finding a positive correlation between volume and price change. However, it does not show a strong link between stock price changes and volume, unlike developed markets. The study suggests that the differences in institutions and information flows in these emerging markets could affect equity securities valuation and warrant further analysis. Zhang et al. (2024) examines Chinese stock market volatility, trading volume, and return using Markov-switching and vector autoregressive models. Results reveal instability, asymmetric dynamics, and a positive correlation between volatility and trading volumes.

There are authors that focused on analyzing top oil and gas companies' market trends (Chrascina et al., 2024; Senteza et al., 2018; Ulusoy & Özdurak, 2018). However, the literature is more focused on top oil and gas companies' success than market trends.

Based on the given literature review, it can be stated that there are not many recent works that deal with determining the relationship between price changes and changes in trade volume, as well as determining the correlation in price changes of certain companies or changes in volumes. On this basis, the research hypotheses in this paper are as follows:

**H1:** There is statistically significant positive linear correlation between the monthly change in stock price and the monthly change in trading volume for at least one of the major energy companies (ExxonMobil – XOM, Chevron – CVX, and ConocoPhillips - COP) during the period of January 2020 to May 2025.

**H2:** There is a strong positive linear correlation between the monthly price change of each pair of the analyzed companies (XOM, CVX, COP) during the period of January 2020 to May 2025.

**H3:** There is a strong positive linear correlation between the monthly volume change of each pair of the analyzed companies (XOM, CVX, COP) during the period of January 2020 to May 2025.

### 3. DATA AND METHODOLOGY

The following methodology is used in this thesis to answer the research question and the hypotheses listed. The flowchart of the research process is shown in Figure 1.

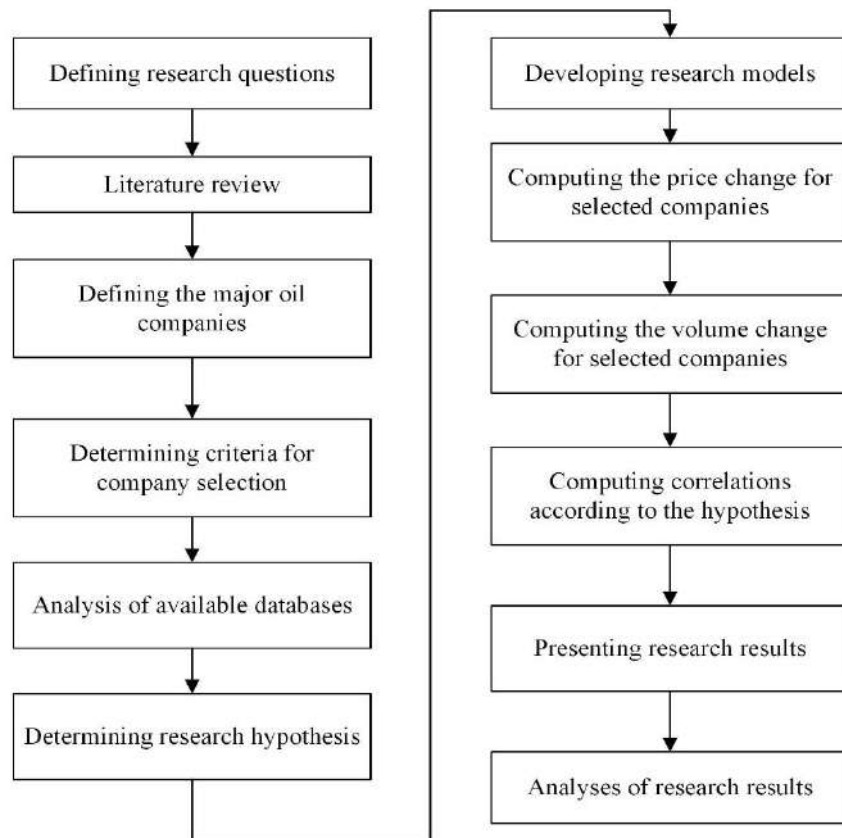


Figure 1. Research methodology flowchart

The research question corresponds to the research objective: to determine the correlation between fluctuations in share prices and trading volumes for the companies studied and to assess the relationship between changes in share prices and trading volumes. The hypotheses and the selected companies are listed based on the literature research.

The most important oil and gas companies are identified by the Straits Research report (2025) and listed in Table 1. Table 1 is supplemented with some additional data that would be helpful in determining the criteria for company selection.



Since the largest companies in terms of capital trade their shares primarily on different stock exchanges and in different currencies, and above all considering the fact that the largest producer and user in this sector is the United States of America, of the 10 companies listed, those listed primarily on the New York Stock Exchange (NYSE) were selected. These are the companies: ExxonMobil, Chevron, ConocoPhillips and Southern Company (ticker symbols: XOM, CVX, COP, SO, respectively). Of the four selected companies belonging to the energy sector, three are major oil and gas companies (XOM, CVX, COP), while Southern Company is major electricity utility company. Therefore, SO is excluded from further analysis. When analysing the currency in which it trades, COP trades in a different currency, EUR (euros), than the other two (XOM and CVX), which trade in US dollars. Since this paper analyses the percentage change in price and trading volume, this means that the influence of currency will be eliminated by calculating the percentage changes.

After the selection of potential companies, a database search was started in which it is possible to find initial data for further analysis. There are several websites that offer data on share prices and trading volumes. In this case, data was selected from the website Investing.com, which has the necessary data for all companies and is publicly accessible and downloadable. In addition to selecting the companies and the database for downloading the data, it was also necessary to determine the period for which the analysis would be carried out. The analysis was carried out for the period from January 2020 to May 2025. The data used gives monthly values, i.e. monthly share prices and monthly trading volumes on the first day of each month.

The research hypotheses were formulated following a literature review and determined criteria for analysis. Based on the research hypotheses, research models were developed for each of the hypotheses. Figures 2, 3 and 4 show research models based on specific hypotheses.

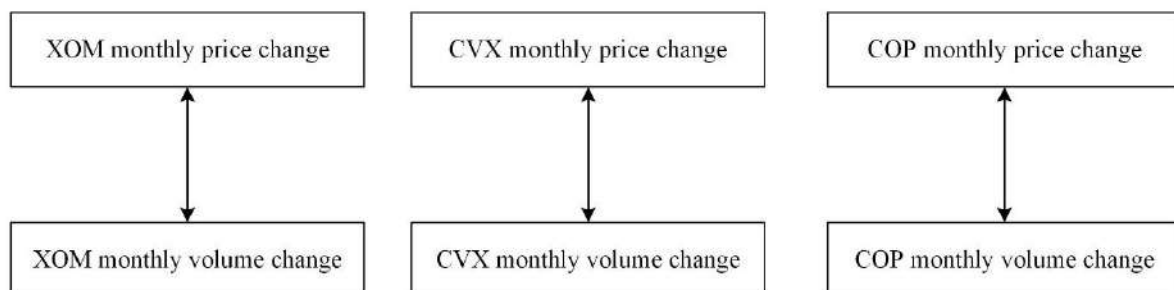


Figure 2. Research model for H1

Figure 2 shows the hypothetical relationships between the price change and the volume change of the major oil companies (XOM, CVX, COP). The model includes two key variables: Monthly Price Change (MPC), defined as the percentage change in stock price, and Monthly Volume Change (MVC), defined as the percentage change in trading volume, over the specified time period. The double arrow connecting MPC and MVC indicates an assumed correlation ( $r$ ) between these two variables, suggesting a linear relationship without assuming a causal direction. The strength and direction of this relationship is quantified by Pearson's correlation coefficient.

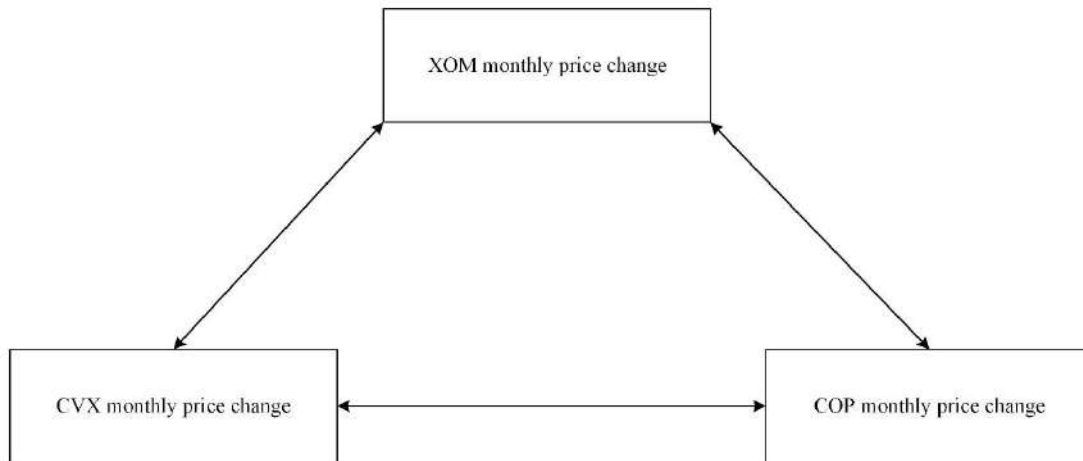


Figure 3. Research model for H2

Figure 3 shows the hypothetical relationship between the price change of the selected companies. The model includes three companies and the observed variable monthly price change, which is calculated as a percentage change in the market price. The double arrow connecting the companies indicates the expected correlation between each pair of observed variables, suggesting a linear relationship. The strength and direction of the relationship was calculated based on the Pearson correlation coefficient.

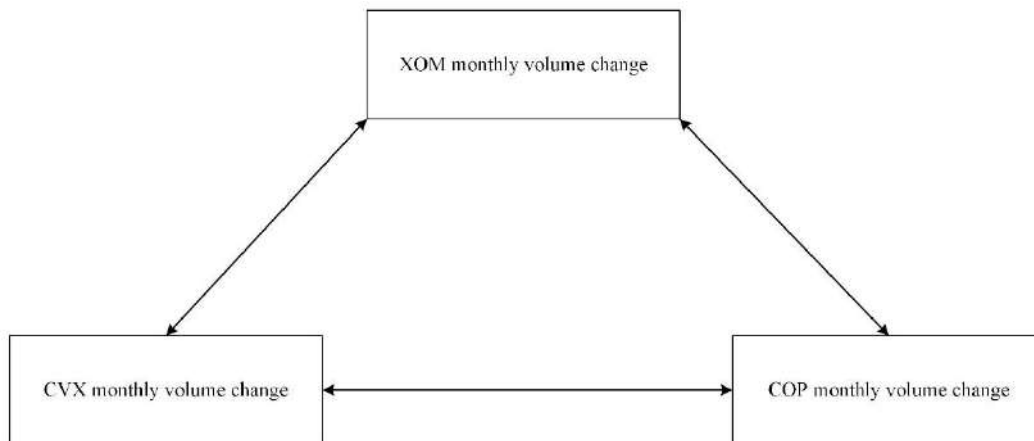


Figure 4. Research model for H3

Figure 4 shows the hypothetical relationship between the volume change of the selected companies. The model includes three companies and the observed variable monthly volume change, which is calculated as a percentage change in the trading volume. The double arrow connecting the companies indicates the expected correlation between each pair of observed variables, suggesting a linear relationship. The strength and direction of the relationship was calculated based on the Pearson correlation coefficient.

The percentage changes in price (1) and trading volume (2) were calculated using the following formulae:

$$Price\ change = \frac{(P_n - P_{n-1})}{P_{n-1}} \cdot 100 \quad (1)$$

where:  $P_n$  presents Current price, and  $P_{n-1}$  presents previous price.

$$\text{Volume change} = \frac{(V_n - V_{n-1})}{V_{n-1}} \cdot 100 \quad (2)$$

where:  $V_n$  presents Current volume, and  $V_{n-1}$  presents Previous volume.

The percentage changes calculated using formulas (1) and (2) were used to calculate the Pearson correlation coefficient. The Pearson correlation coefficient ( $r$ ) is a basic measure in statistics that quantifies the strength and direction of a linear relationship between two continuous variables. The Pearson correlation coefficient ( $r$ ) is computed using Microsoft Excel formula “CORREL”.

The value of ( $r$ ) is always between -1 and +1, inclusive. Value  $r = +1$  indicates a perfect positive linear relationship. As one variable increases, the other increases proportionally. All data points lie perfectly on a straight line with a positive slope. Value  $r = -1$  indicates a perfect negative linear relationship. If one variable increases, the other decreases proportionally. All data points lie perfectly on a straight line with a negative slope. Value  $r = 0$  means that there is no linear relationship between the two variables. The points on a scatter plot appear randomly distributed. Values between -1 and +1 indicate the strength of the linear relationship. The closer the absolute value of ( $r$ ) is to 1, the stronger the linear relationship. The sign of the correlation coefficient indicates the direction of the relationship. A positive correlation means that as one variable increases, the other variable also tends to increase ( $r > 0$ ). A negative correlation means that one variable tends to increase while the other variable tends to decrease ( $r < 0$ ). By interpreting the obtained value of the Pearson correlation coefficient, we determine the strength of the relationship between the two observed phenomena. If the absolute value of the Pearson correlation coefficient is less than absolute 0.3, the correlation is weak. The average correlation has values from absolute 0.3 to absolute 0.5 in absolute terms. If the absolute value of the correlation coefficient is greater than absolute 0.5, we speak of a strong correlation, while values greater than absolute 0.8 indicate an extremely strong correlation.

After the calculated values of the correlation coefficients in accordance with the established hypotheses, the results and the interpretation of the obtained values are presented in the continuation of the work.

## 4. RESULTS AND DISCUSSION

### 4.1. Results of monthly price change and monthly volume change

Data from the investing.com website for three selected companies was used to conduct the analysis: XOM, CVX and COP. The analysis was conducted for the period from January 2020 to May 2025, but the data covered the period from December 2019 to May 2025 (due to the calculation of percentage changes). Share prices monthly (on this website the prices on the first day of the month) and trading volume monthly were used. Based on this data, the monthly percentage changes in prices and trading volumes were calculated, which are shown in the following Figures (5, 6, 7).

Figure 5 shows the monthly price and volume changes of XOM. While the price change shows a slight volatility, the volume change is larger. The visual assessment of the correlation is further quantified by the Pearson coefficient.

Figure 6 shows the monthly price and volume changes of CVX. In this case, both the monthly price change and the monthly volume change show a slight volatility. The visual assessment of the correlation is further quantified by the Pearson coefficient.

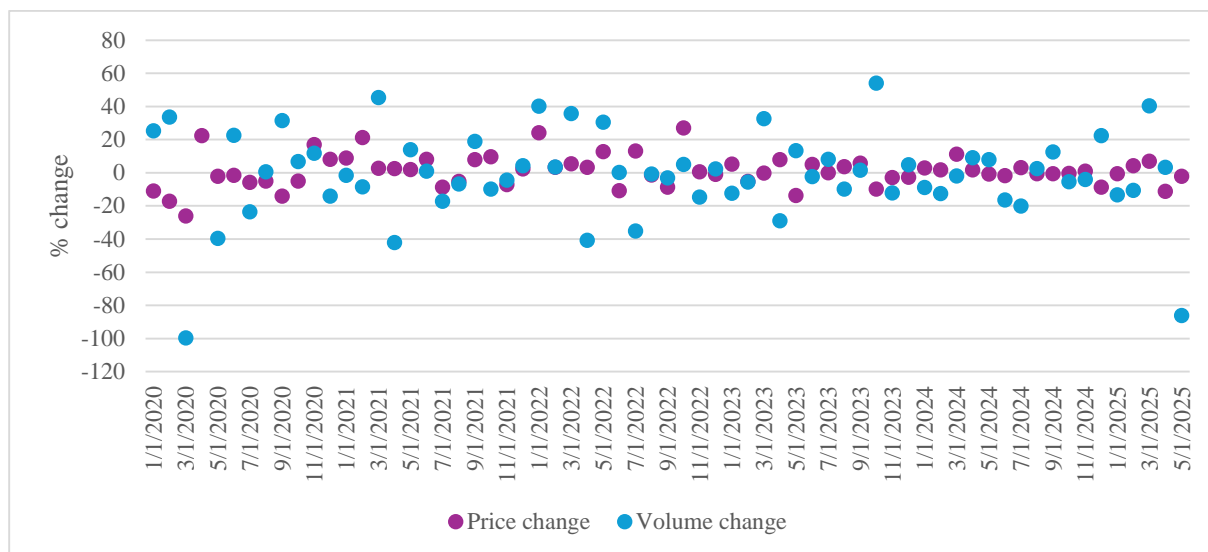


Figure 5. XOM monthly price and monthly volume for period January 2020 – May 2025

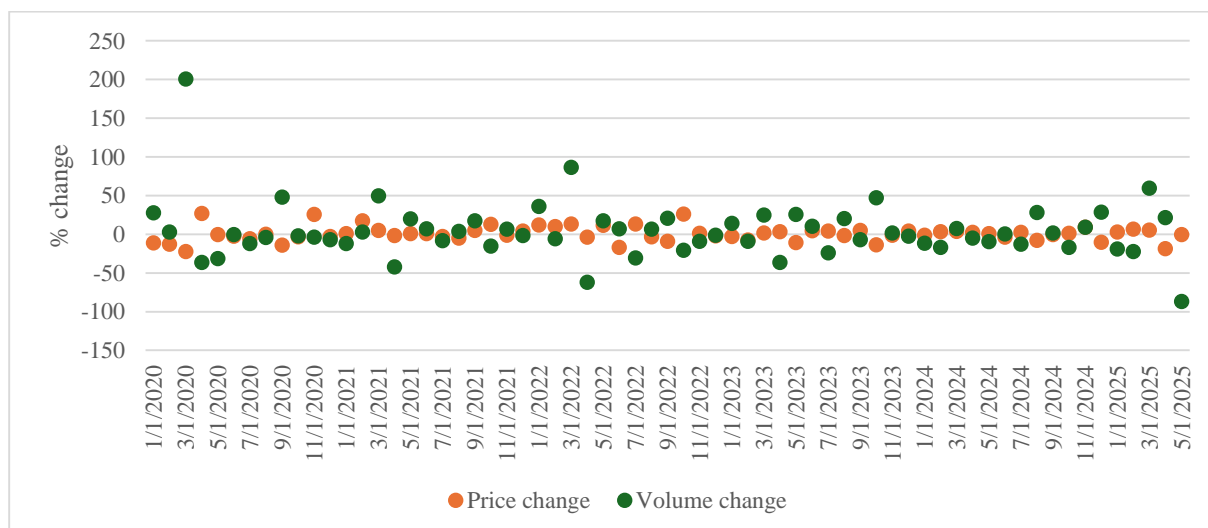


Figure 6. CVX monthly price and monthly volume for period January 2020 – May 2025

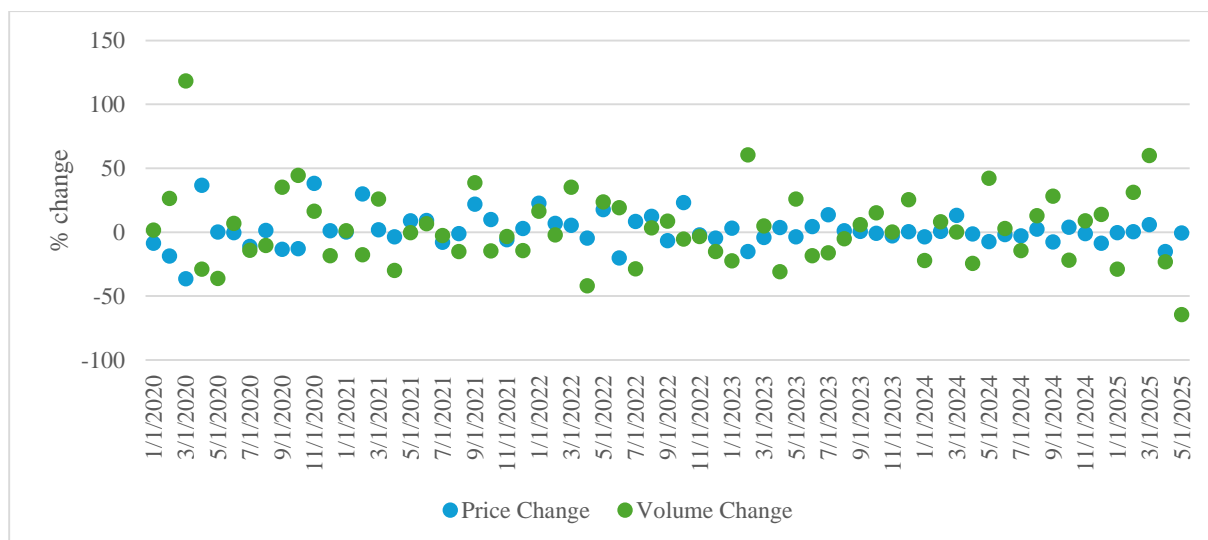


Figure 7. COP monthly price and monthly volume change for period January 2020 – May 2025

Figure 7 shows the monthly price and volume changes of COP. According to the values shown, the volatility of the change in volume is significantly greater than the change in price. The visual assessment of the correlation is further quantified by the Pearson coefficient.

#### 4.2. Correlation analysis results and Pearson coefficient values

The first hypothesis in this paper aimed to determine the strength of the correlation between price and volume changes for the observed companies. The results of the correlation analysis are shown in the figure below.

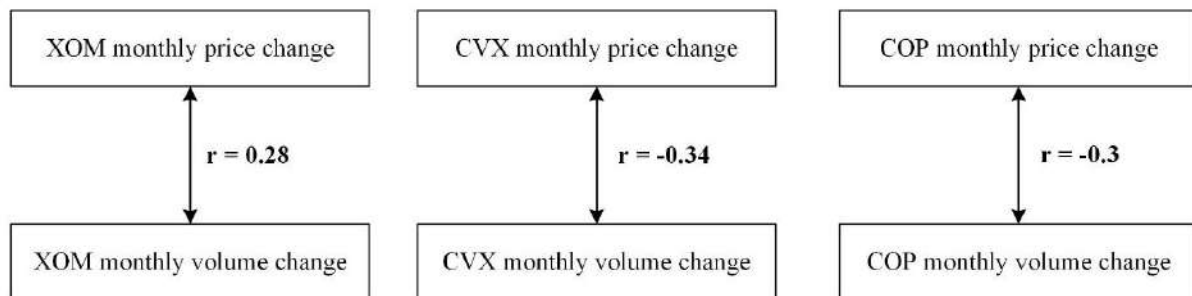


Figure 8: Pearson coefficient results for the relationships between the monthly price change and the monthly volume change of the main oil companies: XOM, CVX, COP

Figure 8 show the results of the Pearson coefficient for the relationship between the monthly price change and the monthly volume change for analysed companies. For ExxonMobil (XOM) Pearson coefficient is 0.28. This positive correlation indicates a weak positive relationship between the price change and the volume change at ExxonMobil. When the price of XOM increases, there is a slight tendency for the trading volume to increase and vice versa. However, the correlation is not very strong, indicating that other factors probably play a more important role in influencing price and volume.

For Chevron (CVX) Pearson coefficient is -0.34. This negative correlation indicates a weak negative relationship between the price change and the volume change in Chevron. When the price of CVX increases, the trading volume tends to decrease slightly and vice versa. This correlation is not very strong.

For ConocoPhillips (COP) Pearson coefficient is -0.3. Like Chevron, this negative correlation also indicates a weak negative relationship between the price change and the volume change at ConocoPhillips. Price increases are usually accompanied by a slight decrease in volume, and vice versa.

The second hypothesis was formulated on the assumption that there is a correlation between the share price changes of the companies observed. The results of the correlation analysis are shown in the following figure (Figure 9).

Figure 9 show the results of the Pearson coefficient for the relationship between the monthly price changes for analysed companies. The Pearson coefficient for the price changes of the companies XOM and CVS is 0.89. This very high positive correlation indicates that the monthly price movements of ExxonMobil and Chevron are very closely aligned. If the price of ExxonMobil rises, the price of Chevron will most likely rise as well and vice versa. This is not surprising, as both companies are major players in the same industry and are subject to many of the same market forces (oil prices, global economic conditions, etc.).

The Pearson coefficient for the price changes of the companies XOM and COP is 0.86. This also indicates a very strong positive correlation between the price movements of

ExxonMobil and ConocoPhillips. Their share prices tend to move very closely in the same direction.

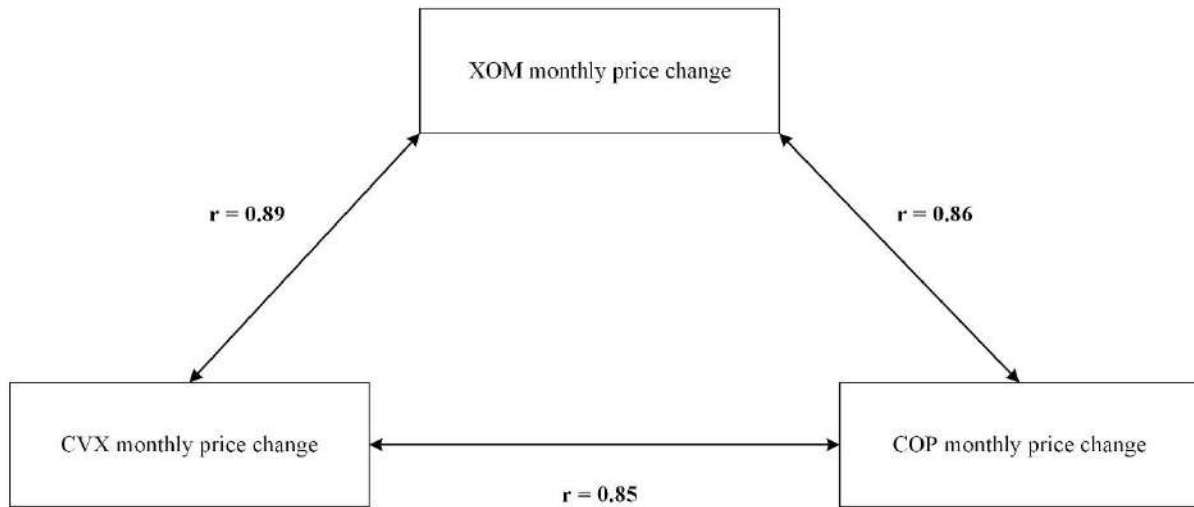


Figure 9: Pearson coefficient results for the relationships between the monthly price change of the main oil companies: XOM, CVX, COP

The Pearson coefficient for the price movements of CVX and COP is 0.85. The price movements of Chevron and ConocoPhillips also show a very strong positive correlation. It is very likely that they move in lockstep.

The high positive price correlations between these three companies suggest that their stock prices are strongly influenced by common factors affecting the oil and gas industry. They are likely to react similarly to news, oil price fluctuations and broader market trends. This could indicate a relatively high degree of systematic risk for these stocks.

The third hypothesis assumed that there is a correlation between the changes in the trading volumes of the companies observed. The results are shown in the following figure.

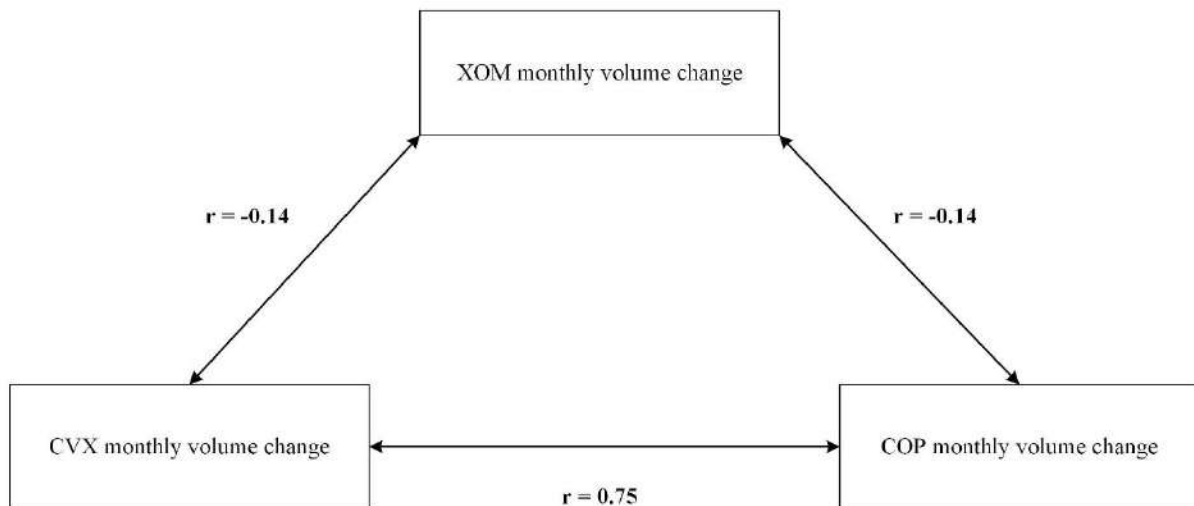


Figure 10: Pearson coefficient results for the relationships between the monthly volume change of the main oil companies: XOM, CVX, COP

Figure 10 show the results of the Pearson coefficient for the relationship between the monthly volume changes for analysed companies. The Pearson coefficient for the volume

changes of the companies XOM and CVS is -0.14. This weak negative correlation indicates a slight tendency for the trading volumes of ExxonMobil and Chevron to move in opposite directions.

The Pearson coefficient for the volume changes of the companies XOM and COP is -0.14. Similarly, there is a weak negative correlation between the trading volumes of ExxonMobil and ConocoPhillips, indicating a very slight tendency for their volume changes to be inversely related.

The Pearson coefficient for the volume movements of CVX and COP is 0.75. This strong positive correlation indicates that Chevron and ConocoPhillips trading volumes tend to move in tandem. If Chevron's trading volume increases, ConocoPhillips' trading volume is likely to increase as well, and vice versa.

The volume correlations show a more differentiated picture than the price correlations. The weak negative correlations between XOM and CVX and COP suggest that trading activity in ExxonMobil is not strongly correlated with trading activity in the other two stocks. It is possible that different factors are driving investor interest and trading in XOM compared to CVX and COP monthly.

The strong positive correlation in trading volume between CVX and COP is interesting. It could indicate that market participants often trade these two stocks in similar ways, perhaps in response to the same signals or news affecting both companies.

## 5. CONCLUSION

The aim of this study was to investigate the relationship between monthly price changes and monthly volume changes for three major oil companies: Exxon Mobil (XOM), Chevron (CVX) and ConocoPhillips (COP). The hypothesis that there would be a statistically significant positive correlation between these two variables was supported to varying degrees by the companies.

A moderately positive correlation was found for Exxon Mobil, which is statistically significant, suggesting that higher trading volumes tend to be associated with price increases. For Chevron and ConocoPhillips, on the other hand, the correlations were negative but not statistically significant within the period analyzed. This suggests that the relationship between price and volume changes may not be the same for all major oil companies or may be influenced by other factors not considered in this study. Nevertheless, the existence of a positive correlation confirms H1.

The original assumption of H2 was that there is a positive and strong linear correlation between the price changes of the observed companies. Since the Pearson's correlation coefficient values are greater than 0.8 and positive, this proves assumption 2.

The third assumption was that there is a positive and strong correlation between the changes in the trading volume of the observed companies. This assumption (H3) is not fully confirmed when looking at the values of the Pearson correlation coefficient, which shows a positive, strong relationship between the changes in trading volume of CVX and COP. On the other hand, a weak, negative relationship was found between the changes in trading volume between the companies CVX and XOM as well as XOM and COP.

These findings suggest that while there is a discernible short-term relationship between trading activity and price movements for some companies, such as Exxon Mobil, this relationship is less pronounced or more complex for others. This could have implications for understanding market behavior and developing trading strategies, although further research is needed.

A limitation of this study is that it only focuses on three major oil companies and a specific period. Future research could extend the analysis to a wider range of companies and a longer period to assess the robustness and generalizability of these results. In addition, investigating the influence of other market factors or news events on the price-volume relationship could lead to a more comprehensive understanding.

In summary, this study provides insights into the short-term relationship between price and volume changes in the oil market and highlights possible differences between the key players. While a significant positive correlation was found for one company, the lack of consistent significant results for all three companies suggests that the dynamics between these key market indicators may be nuanced and merit further exploration.

## ACKNOWLEDGMENT

The research presented in this paper was done with the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, for 2025 according to the contract with registration number 451-03-137/2025-03/ 200131.

## REFERENCES

- Bajzik, J. (2021). Trading volume and stock returns: A meta-analysis. *International Review of Financial Analysis*, 78, 101923. doi.org/10.1016/j.irfa.2021.101923
- Bastidon, C., & Jawadi, F. (2024). Trade fragmentation and volatility-of-volatility networks. *Journal of International Financial Markets, Institutions and Money*, 91, 101908. doi.org/10.1016/j.intfin.2023.101908
- Cadena-Silva, J. P., Lara, J. Á. S., & Fernández, J. M. R. (2025). Stock market volatility and oil shocks: A study of G7 economies. *International Review of Financial Analysis*, 103, 104218. doi.org/10.1016/j.irfa.2025.104218
- Cardinale, R., Cardinale, I., & Zupic, I. (2024). The EU's vulnerability to gas price and supply shocks: The role of mismatches between policy beliefs and changing international gas markets. *Energy Economics*, 131, 107383. doi.org/10.1016/j.eneco.2024.107383
- Choi, K. H., Nekhili, R., Mensi, W., Boubaker, F. Z., & Yoon, S. M. (2024). Systemic risk-sharing between natural gas, oil, and stock markets in top energy producer and consumer countries. *International Review of Economics & Finance*, 96, 103515. doi.org/10.1016/j.iref.2024.103515
- Chrascina, M., Vaněk, M., & Pekarčíková, K. (2024). Intrinsic Value Of Stocks Of "Big Oil" Companies. *GeoScience Engineering*, 70(1). DOI 10.35180/gse-2024-0107
- Cui, J., Maghyreh, A., & Liao, D. (2024). Risk connectedness between international oil and stock markets during the COVID-19 pandemic and the Russia-Ukraine conflict: Fresh evidence from the higher-order moments. *International Review of Economics & Finance*, 95, 103470. doi.org/10.1016/j.iref.2024.103470
- Demirer, R., Polat, O., & Sokhanvar, A. (2024). Do oil price shocks drive risk premia in stock markets? A novel investment application. *A Novel Investment Application*. doi.org/10.1016/j.ribaf.2024.102591
- EIA. (2024, 11 Apr.). What countries are the top producers and consumers of oil?. U.S. Energy Information Administration. Retrieved from: <https://www.eia.gov/tools/faqs/faq.php?id=709&t=6> [May 2025]



- Fang, Y., Zhou, X., Wen, Y. F., & Ou, Q. L. (2024). Volume and stock returns in the Chinese market. *International Review of Financial Analysis*, 94, 103265. doi.org/10.1016/j.irfa.2024.103265
- Gaganis, C., Leledakis, G. N., Pasiouras, F., & Pyrgiotakis, E. G. (2025). National culture of secrecy and stock price synchronicity: Cross-country evidence. *Journal of Banking & Finance*, 170, 107341. doi.org/10.1016/j.jbankfin.2024.107341
- Gao, X., Xu, W., & Li, D. (2025). Media coverage and managerial investment learning from stock markets: International evidence. *Research in International Business and Finance*, 76, 102862. doi.org/10.1016/j.ribaf.2025.102862
- Ge, Z. (2023). The asymmetric impact of oil price shocks on China stock market: Evidence from quantile-on-quantile regression. *The Quarterly Review of Economics and Finance*, 89, 120-125. doi.org/10.1016/j.qref.2023.03.009
- Grecu, R. A., Cramer, A. A., Pele, D. T., & Lessmann, S. (2025). The link between energy prices and stock markets in European Union countries. *The North American Journal of Economics and Finance*, 78, 102420. 10.1016/j.najef.2025.102420
- Innova. (2022, 22 Jul.). Petroleum and its decisive role in the world economy. Investing News Network. Retrieved from: <https://innovamas.nakasawaresources.com/en/petroleum-and-its-decisive-role-in-the-world-economy/> [May 2025]
- Investing. (n.d.). United States Stocks. Retrieved from: <https://www.investing.com/equities/united-states> [May 2025]
- Khan, M., Karim, S., Naz, F., & Lucey, B. M. (2025). How Do Exchange Rate and Oil Price Volatility Shape Pakistan's Stock Market?. *Research in International Business and Finance*, 102796. doi.org/10.1016/j.ribaf.2025.102796
- Li, X., & Shi, X. (2024). The role of large shareholder holdings in customer concentration and stock price volatility. *Finance Research Letters*, 65, 105643. 10.1016/j.frl.2024.105643
- Mao, Z., Wang, H., & Bibi, S. (2024). Crude oil volatility spillover and stock market returns across the COVID-19 pandemic and post-pandemic periods: An empirical study of China, US, and India. *Resources Policy*, 88, 104333. doi.org/10.1016/j.resourpol.2023.104333
- Narayan, P. K., Mishra, S., Sharma, S., & Liu, R. (2013). Determinants of stock price bubbles. *Economic Modelling*, 35, 661-667. dx.doi.org/10.1016/j.econmod.2013.08.010
- Ngene, G. M., & Mungai, A. N. (2022). Stock returns, trading volume, and volatility: The case of African stock markets. *International Review of Financial Analysis*, 82, 102176. doi.org/10.1016/j.irfa.2022.102176
- Olayungbo, D. O., Zhuparova, A., Al-Faryan, M. A. S., & Ojo, M. S. (2024). Global oil price and stock markets in oil exporting and European countries: Evidence during the Covid-19 and the Russia-Ukraine war. *Research in Globalization*, 8, 100199. doi.org/10.1016/j.resglo.2024.100199
- Pistilli, M. (2024, 29 Oct.). 10 Top Oil-producing Countries. Retrieved from <https://investingnews.com/daily/resource-investing/energy-investing/oil-and-gas-investing/top-oil-producing-countries/> [May 2025]
- Saatcioglu, K., & Starks, L. T. (1998). The stock price–volume relationship in emerging stock markets: the case of Latin America. *International Journal of forecasting*, 14(2), 215-225.
- Saif-Alyousfi, A. Y. (2025). Energy shocks and stock market returns under COVID-19: New insights from the United States. *Energy*, 134546. doi.org/10.1016/j.energy.2025.134546
- Senteza, J., Suh, I., & White, T. (2019). Battling the Oil “Death Spiral”: ConocoPhillips vs. Antero Resources Corp. *Southeast Case Research Journal*, 16(2), 95-116.

- Shafique, A., & Bhutta, N. T. (2024). Assessing conditional volatility due to trade war in the G-7 stock markets. *Social Sciences & Humanities Open*, 9, 100768. doi.org/10.1016/j.ssaho.2023.100768
- Straits Research. (2024). Oil and Gas Analytics Market Size and Trends. Retrieved from <https://straitsresearch.com/report/oil-and-gas-analytics-market> [May 2025]
- Straits Research. (2025, 19 Mar.). Leading 10 Oil and Gas Companies by Market Cap in 2025. Retrieved from <https://straitsresearch.com/statistic/largest-oil-and-gas-companies> [May 2025]
- Tiwari, A. K., Dam, M. M., Altıntaş, H., & Bekun, F. V. (2025). The dynamic connectedness between oil price shocks and emerging market economies stock markets: Evidence from new approaches. *Energy Economics*, 141, 108101. doi.org/10.1016/j.eneco.2024.108101
- Ulusoy, V., & Özdurak, C. (2018). The impact of oil price volatility to oil and gas company stock returns and emerging economies. *International Journal of Energy Economics and Policy*, 8(1), 144-158.
- Xiang, Y., & Borjigin, S. (2024). Multilayer networks for measuring interconnectedness among global stock markets through the lens of trading volume-price relationship. *Global Finance Journal*, 62, 101006. doi.org/10.1016/j.gfj.2024.101006
- Yahoo Finance. (n.d.). Energy. Retrieved from: <https://finance.yahoo.com/sectors/energy/> [May 2025]
- Zhang, F., Zhang, Y., Xu, Y., & Chen, Y. (2024). Dynamic relationship between volume and volatility in the Chinese stock market: evidence from the MS-VAR model. *Data Science and Management*, 7(1), 17-24. doi.org/10.1016/j.dsm.2023.09.003
- Zhang, W., & Wang, C. (2024). Rumors and price efficiency in stock market: An empirical study of rumor verification on investor Interactive platforms. *China Journal of Accounting Research*, 17(2), 100356. doi.org/10.1016/j.cjar.2024.100356



## ENVIRONMENTAL ASPECTS IN THE CASE-LAW OF THE COURT OF JUSTICE OF THE EUROPEAN UNION UNDER ARTICLE 260(2) TFEU

Deimilė Prapiestytė \*

*Vilnius University, Faculty of Law, Lithuania*

**Abstract:** This article explores how the European Commission ensures compliance with environmental obligations by Member States through infringement procedures, particularly under Article 260(2) TFEU. The analysis begins by outlining the legal framework governing non-compliance and financial penalties, focusing on the role of the Court of Justice of the European Union in sanctioning persistent breaches of environmental law. A review of selected judgments illustrates how the Court of Justice has applied financial penalties in cases involving waste management, air quality, and water protection. Special attention is given to the proportionality of fines and the reasoning behind the Commission's decision to initiate proceedings. The article also presents recent developments in 2024, including formal notices and actions brought against Greece and Portugal, drawing on data published by the Commission. These examples reveal that the timing and intensity of enforcement are often influenced by the complexity of the environmental issues at stake. The study concludes that while the Commission actively monitors and enforces environmental law, it adopts a flexible approach in certain cases, especially where compliance involves long-term infrastructural or administrative reform.

**Keywords:** Environmental law, Waste management, Air quality, European Commission, Infringement procedure, Court of Justice, Judgment of the Court establishing a failure to fulfil obligations, Non-compliance, Article 260(2) TFEU.

### 1. INTRODUCTION

In recent years, the European Union has set out ambitious plans in the fight against climate change, including in the field of environmental protection. The overarching goals are articulated in the European Commission's Communication the European Green Deal (European Commission, 2019), which – beyond environmental protection in the broad sense – also aims at climate neutrality, the promotion of a circular economy, clean industry, and climate justice and fairness.

A growing – albeit modest – increase in the number of cases heard by the Court of Justice of the European Union (CJEU, the Court of Justice, the Court) also reflects this trend. Over the past few years, there has been a gradual rise in cases concerning environmental issues,

---

\* Corresponding author: [deimile.prapiestyte@tf.vu.lt](mailto:deimile.prapiestyte@tf.vu.lt)

Deimilė Prapiestytė, ORCID: 0009-0002-0854-7484

brought either through direct actions or references for a preliminary ruling. For instance, there were 23 such cases in both 2020 and 2021, 35 in 2022, 43 in 2023, and 44 in 2024 (Court of Justice of the European Union, n.d.-a).

In 2024, the distribution of environmental cases by procedural category was as follows: the majority were references for a preliminary ruling (28), followed by direct actions (15). However, the CJEU's published judicial statistics do not specify which direct actions – whether brought under Articles 263, 258 or 260(2) TFEU – pertained to environmental matters. Such categorisation would be useful for assessing how well Member States are implementing their environmental obligations in practice, and for identifying the areas in which they face the greatest challenges.

This article focuses on the Court of Justice, one of the courts comprising the CJEU. This clarification is necessary given that the General Court also has jurisdiction to hear direct actions, including those in the field of environmental protection (Court of Justice of the European Union, n.d.-b).

In the legal literature, several studies have addressed the infringement procedure under Article 260(2) TFEU. However, most of them do not focus on the subject matter of the action. For instance, Pohjankoski (2021), Schmidt and Bogdanowicz (2018), Tizzano (2015), and Van Rijn (2015) explore broader procedural or institutional aspects of the mechanism. By contrast, Coutron (2015), in his review of the CJEU's case-law, examines four judgments adopted under Article 260(2) TFEU – all of which concerned environmental protection. This underlines the significance of environmental enforcement in the practical application of Article 260(2) TFEU and further justifies the topical relevance of the present study.

The article begins, in Section 2, by examining the CJEU's case-law based on actions brought by the European Commission under Article 260(2) TFEU in the field of environmental protection. Then, in Section 4, in order to evaluate the potential preventive effect of these judgments, the article briefly reviews the number and trends of ongoing infringement procedures initiated by the Commission against Member States in this domain.

## **2. THE CASE LAW DEVELOPED IN THE APPLICATION OF ARTICLE 260(2) TFEU IN THE FIELD OF THE PROTECTION OF THE ENVIRONMENT**

Article 260(2) TFEU provides the legal basis for imposing financial penalties on Member States that fail to comply with a judgment delivered under Article 258 TFEU. In the context of environmental protection, this mechanism serves as a crucial tool for reinforcing compliance with Union law. The case-law developed by the Court of Justice under this provision reveals the practical dimensions of enforcement and exposes the systemic challenges Member States face in fulfilling their environmental obligations.

Although the application of Article 260(2) remains relatively limited in scope, the environmental cases decided under this provision have contributed significantly to clarifying the criteria for determining penalties, the weight attached to environmental harm, and the role of proportionality in setting lump sums and periodic fines. These cases also demonstrate how persistent non-compliance in areas such as waste management, air quality, or water protection may lead to substantial sanctions, thereby highlighting the environmental sensitivity of the Union's infringement framework.

This section reviews the key environmental judgments rendered under Article 260(2) TFEU, with a particular focus on their legal reasoning, the aggravating or mitigating factors taken into account, and the broader implications for enforcement strategy within EU environmental law.

## **2.1. Key Environmental Judgments under Article 260(2) TFEU**

Several key judgments of the Court of Justice under Article 260(2) TFEU illustrate how environmental obligations have become a central concern in enforcement practice. One landmark Case is C-196/13 *Commission v Italy*, in which the Court imposed both a lump sum (€40 million) and a daily penalty payment (€42.8 for each six month period of delay in taking the necessary measures) for Italy's failure to comply with a previous judgment concerning illegal waste disposal sites. The Court emphasised the gravity of the infringement, the duration of non-compliance, and the environmental and public health risks posed by the failure to fulfil obligations under the directives on waste (75/442/EEC), hazardous waste (91/689/EEC) and the landfill of waste (1999/31/EC) (CJEU, 2014a).

Similarly, in C-298/19, *Commission v Greece* (Pollution caused by Nitrates), the Court imposed a lump sum fine of €3,500,000 for Greece's failure to comply with a previous judgement concerning the inadequate implementation of the Nitrates Directive (91/676/EEC) (CJUE, 2020a).

These judgments demonstrate the Court's readiness to impose substantial financial sanctions where Member States persistently disregard environmental obligations. The proportionality of the fines, assessed in relation to the seriousness and duration of the breach, also sets a precedent for future applications of Article 260(2) TFEU in environmental cases.

Another important Case is C-278/01 *Commission v Spain*, concerning Spain's failure to ensure compliance with Directive 76/160/EEC on the quality of bathing water. The Court found that despite its previous ruling, Spain had not taken the necessary measures to meet minimum water quality standards at several coastal sites. Although this judgment predated the Lisbon Treaty and the formal articulation of Article 260(2) TFEU, it remains significant as one of the early instances in which environmental non-compliance was addressed through financial sanctions (CJEU, 2003).

More recently, in Case C-109/22 *Commission v Romania* (Closure of landfill), the Court imposes financial penalties on Romania for having failed to close down unauthorised landfills. In its judgment, the Court of Justice notes that Romania has still not closed 31 sites not authorised to be in operation. It orders Romania to pay a lump sum of €1.5 million and a penalty payment of €600 per landfill and per day of delay (CJUE, 2023).

Similarly, in Case C-318/23 *Commission v Slovenia* (Bukovžlak landfill), in order to prevent future infringements of EU law, the Court of Justice orders Slovenia to pay the Commission a lump sum of € 1 200 000 for having failed to comply with its obligations with regard to the landfilling of waste. In order to set that amount, the Court took into consideration the relevant factors in that respect, such as the seriousness and duration of the infringements found as well as Slovenia's ability to pay. As regards the seriousness, the Court has noted that the failure fully to comply with its judgment of 16 July 2015 must be regarded as particularly serious since it gave rise to significant risks to the environment and human health, especially (CJEU, 2025).

Together, these judgments illustrate the CJEU's evolving approach to environmental enforcement under Article 260(2) TFEU. They reflect a gradual shift towards stricter accountability and the use of financial sanctions as a deterrent mechanism when Member States persistently fail to uphold environmental standards.

### **3. METHODOLOGY**

This research employs classical scientific methods typical for legal analysis. These include the logical-systematic method, used to structure and assess the functioning of Article 260(2) TFEU within the broader framework of EU environmental law; legal act analysis, applied to the relevant provisions of the Treaty on the Functioning of the European Union; and jurisprudential analysis, used to examine the Court of Justice's decisions in cases involving persistent non-compliance in the environmental field. Furthermore, a comparative approach is employed to identify patterns across different Member States, while descriptive and interpretive analysis of official infringement data published by the European Commission supports the discussion of recent trends and enforcement challenges.

### **4. RESULTS AND DISCUSSION**

This section presents and discusses the main findings related to infringement procedures initiated by the European Commission in the field of environmental protection. It focuses on trends in the application of Articles 258 and 260(2) TFEU, highlighting the scale and distribution of recent formal notices, the nature of the environmental breaches involved, and the use of financial sanctions. Drawing on official Commission data, selected judgments of the Court of Justice, and relevant EU directives, the section explores both the practical implementation challenges faced by Member States and the legal implications of non-compliance with environmental obligations.

#### **4.1. General Trends and 2024 Data Overview**

Although European Commission data suggests that the overall number of infringement procedures in the field of environmental protection has decreased – dropping from 425 in 2022 to 293 in 2023 (European Commission, 2024a) – the 2024 figures paint a more nuanced picture. According to the Commission's publicly available records, in 2024, a total of 66 formal notices were issued under Article 258 TFEU in the field of environment policy. These were addressed to various Member States, some of which received multiple notices: Hungary (5), Italy and Portugal (6 each), while others such as Latvia, Lithuania, and Luxembourg received only one.

The majority of formal notices concerned poor application of existing directives, including the Environmental Noise Directive (Directive 2002/49/EC), the Urban Wastewater Directive (Directive 91/271/EEC), and the WEEE Directive (Directive 2012/19/EU). Furthermore, initial formal notices were also issued in connection with more recent EU environmental legislation. For example, Italy was found to have incorrectly transposed Directive (EU) 2019/904 on single-use plastics; Sweden failed to notify national implementing measures for the Drinking Water Directive (EU) 2020/2184 (European Commission, 2024b).

#### **4.2. Use of Article 260(2) TFEU in 2024**

Notably, in 2024, the Commission sent formal notices under Article 260(2) TFEU to four Member States – Italy, Portugal, France, and Ireland – for failure to comply with judgments of the Court of Justice. In Case C-636/18 (Commission v France [(Exceedance of limit values for nitrogen dioxide)]), the Court had found France in breach of its obligations under Directive 2008/50/EC on ambient air quality due to exceedance of nitrogen dioxide limits (CJEU, 2019). Similar rulings were handed down in Case C-637/18 (Commission v Hungary) (CJUE, 2021)

and Case C-644/18 (Commission v Italy) (CJUE, 2020b), both concerning persistent violations of PM10 limit values under the same directive.

In addition, two actions were filed in 2024 before the CJEU under Article 260(2) TFEU – against Greece (C-368/24) and Portugal (C-613/24). In the Greek case, the Commission alleged continued non-compliance with the 2014 judgment in Case C-600/12, which had found Greece in breach of obligations under Directive 1999/31/EC and Directive 2008/98/EC regarding the management and closure of the Zakynthos landfill. The Commission now seeks a lump sum of EUR 2 050 per day for the period between delivery of the judgment in Case C-600/12 and the date of compliance by the Greece with that judgment or delivery of the judgment in Case C-368/24, whichever is earlier, the minimum lump sum payable being EUR 1 148 000; plus EUR 18,450 per day for continued non-compliance (European Commission, 2024c).

In Case C-613/24 (Commission v Portugal), the Commission contends that Portugal failed to take necessary measures to comply with the 2019 judgment in Case C-290/18, concerning the designation of special areas of conservation under Directive 92/43/EEC. The Commission has asked the Court to impose a lump sum of EUR 8,202,816 and a daily penalty of EUR 45,543 until compliance is achieved (CJEU, 2019b).

#### **4.3. Discussion: Delay, Discretion, and Practical Considerations**

These cases reveal not only the range of environmental issues at stake, but also the Commission's discretionary approach. For instance, in Commission v Greece, a decade passed between the original judgment and the Commission's Article 260(2) action, whereas in Commission v Portugal, enforcement followed within five years. The comparison suggests that the time required to comply with CJEU rulings in environmental matters can vary significantly, often depending on the complexity of the subject matter – particularly in areas such as waste management and habitat conservation.

As Coutron (2015) notes, enforcement under Article 260(2) often reflects broader systemic challenges in Member States' administrative and environmental governance. Hence, the need for flexibility may coexist with the risk of delayed enforcement. It may be concluded that the fulfilment of environmental obligations frequently requires not only legal precision but also substantial time, resources, and institutional coordination.

### **5. CONCLUSION**

The European Commission plays an active and effective role in monitoring how Member States implement their obligations in the field of environmental protection. By issuing formal notices as a first step, the Commission seeks to prevent ongoing non-compliance in sensitive areas such as waste management, chemicals, air quality, and water protection.

In situations where the Court of Justice has already delivered a judgment under Article 258 TFEU and found that a Member State has failed to fulfil its obligations in the field of environmental law, the Commission appears to assess the complexity of the specific area of non-compliance before initiating further proceedings for failure to comply with the Court's ruling. This suggests a calibrated enforcement approach that considers both the seriousness of the breach, and the practical difficulties associated with compliance.



## REFERENCES

- Court of Justice of the European Union. (2003). Judgment of the Court (Full Court) of 25 November 2003, Commission v Spain, C-278/01, ECLI:EU:C:2003:635. <https://curia.europa.eu> (Accessed: January 12, 2025).
- Court of Justice of the European Union. (2014a). Judgment of the Court (Grand Chamber) of 2 December 2014, Commission v Italy, C-196/13, ECLI:EU:C:2014:2407. <https://curia.europa.eu> (Accessed: January 12, 2025).
- Court of Justice of the European Union. (2019). Judgment of the Court (Seventh Chamber) of 24 October 2019, Commission v France (Exceedance of limit values for nitrogen dioxide), C-636/18, ECLI:EU:C:2019:900. <https://curia.europa.eu> (Accessed: January 13, 2025).
- Court of Justice of the European Union. (2019b). Judgment of the Court (Ninth Chamber) of 5 September 2019, Commission v Portugal, C-290/18, ECLI:EU:C:2019:669. <https://curia.europa.eu> (Accessed: January 13, 2025).
- Court of Justice of the European Union. (2020a). Judgment of the Court (Ninth Chamber) of 27 February 2020, Commission v Greece (Pollution caused by nitrates), C-298/19, ECLI:EU:C:2020:133. <https://curia.europa.eu> (Accessed: January 13, 2025).
- Court of Justice of the European Union. (2020b). Judgment of the Court (Grand Chamber) of 10 November 2020, Commission v Italy, C-644/18, ECLI:EU:C:2020:895. <https://curia.europa.eu> (Accessed: January 13, 2025).
- Court of Justice of the European Union. (2021). Judgment of the Court (Seventh Chamber) of 3 February 2021, Commission v Hungary, C-637/18, ECLI:EU:C:2021:92. <https://curia.europa.eu> (Accessed: January 13, 2025).
- Court of Justice of the European Union. (2023). [Judgment of the Court \(Sixth Chamber\) of 14 December 2023, Commission v Romania \(Désaffectation de décharges\), C-109/22, ECLI:EU:C:2023:991](https://curia.europa.eu), from <https://curia.europa.eu>.
- Court of Justice of the European Union. (2025). Judgment of the Court (Eighth Chamber) of 8 May 2025, Commission v Slovenia (Bukovžlak landfill), C-318/23, ECLI:EU:C:2025:342. <https://curia.europa.eu> (Accessed: May 8, 2025).
- Court of Justice of the European Union. (n.d.-a). *Judicial activity statistics*. [https://curia.europa.eu/jcms/jcms/Jo2\\_7032/en/](https://curia.europa.eu/jcms/jcms/Jo2_7032/en/) (Accessed: January 8, 2025).
- Court of Justice of the European Union. (n.d.-b). *Structure and jurisdictions*. [https://curia.europa.eu/jcms/jcms/Jo2\\_7024/en/](https://curia.europa.eu/jcms/jcms/Jo2_7024/en/) (Accessed: January 10, 2025).
- Coutron, L. (2015). Chronicle of the case-law of the European Union - The vitality of the dual infringement procedure. *Quarterly Review of European Law*, (2), 365. [Chronique Contentieux de l'Union européenne – Vitalité du recours en manquement sur manquement. *Revue trimestrielle de droit européen*, (2), 365.] (In French)
- Council Directive 75/442/EEC of 15 July 1975 on waste (OJ 1975 L 194, p. 39), as amended by Council Directive 91/156/EEC of 18 March 1991. OJ 1991 L 78, p. 32.
- Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment. OJ 1991 L 135, pp. 40–52.
- Council Directive 91/689/EEC of 12 December 1991 on hazardous waste. OJ 1991 L 377, p. 20.
- Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. OJ 1992 L 206, p. 7.
- Directive 1999/31/EC of 26 April 1999 on the landfill of waste. OJ 1999 L 182, pp. 1–19.
- Directive 2002/49/EC of 25 June 2002 relating to the assessment and management of environmental noise. OJ 2002 L 189, pp. 12–25.



- Directive 2008/50/EC of 21 May 2008 on ambient air quality and cleaner air for Europe. OJ 2008 L 152, p. 1.
- Directive 2008/98/EC of 19 November 2008 on waste and repealing certain Directives. OJ 2008 L 312, p. 3.
- Directive 2012/19/EU of 4 July 2012 on waste electrical and electronic equipment (WEEE). OJ 2012 L 197, pp. 38–71.
- Directive (EU) 2019/904 of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. OJ 2019 L 155, pp. 1–19.
- Directive (EU) 2020/2184 of 16 December 2020 on the quality of water intended for human consumption. OJ 2020 L 435, pp. 1–62.
- European Commission. (2019). The European Green Deal (COM/2019/640 final). Brussels. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640> (Accessed: January 12, 2025).
- European Commission. (2024a). 2023 Annual report on monitoring the application of EU law – Environment. [https://commission.europa.eu/law/application-eu-law/implementing-eu-law/infringement-procedure/2023-annual-report-monitoring-application-eu-law/environment-2023\\_en](https://commission.europa.eu/law/application-eu-law/implementing-eu-law/infringement-procedure/2023-annual-report-monitoring-application-eu-law/environment-2023_en) (Accessed: April 10, 2025).
- European Commission. (2024b). Implementation of EU environmental law. <https://ec.europa.eu/implementing-eu-law> (Accessed: April 10, 2025).
- European Commission. (2024c). Pending Case C-368/24, Commission v Greece – Zakynthos landfill site. <https://curia.europa.eu> (Accessed: April 10, 2025).
- Pohjankoski, P. (2021). Rule of law with leverage: Policing structural obligations in EU law with the infringement procedure, fines, and set-off. *Common Market Law Review*, 58(5), 1341–1364. <https://doi.org/10.54648/cola2021085>
- Schmidt, M., & Bogdanowicz, P. (2018). The infringement procedure in the rule of law crisis: How to make effective use of Article 258 TFEU. *Common Market Law Review*, 55(4), 1061–1100. <https://doi.org/10.54648/cola2018093>
- Tizzano, A. (2015). Recent developments in the dual infringement procedure for failure to fulfil obligations. In The Court of Justice of the European Union under the presidency of Vassilios Skouris (2003–2015): Liber amicorum Vassilios Skouris [Les développements récents de la procédure de « manquement sur manquement ». In La Cour de justice de l’Union européenne sous la présidence de Vassilios Skouris (2003–2015): Liber amicorum Vassilios Skouris (pp. 647–662). (In French)
- Van Rijn, A. (2015). Five years after the Treaty of Lisbon: Financial penalties under Article 260 TFEU. *European Law Notebooks*, 51(2–3), 557–589. [Les sanctions pécuniaires de l’article 260 TFUE: 5 ans après le Traité de Lisbonne. *Cahiers de droit européen*, 51(2–3), 557–589. ] (In French)



## DO KNOWLEDGE MANAGEMENT AND GREEN INNOVATION CONTRIBUTE TO THE GREEN TRANSITION IN SERBIAN ENTERPRISES?

**Sanela Golubović Corcione<sup>1\*</sup>, Milica Veličković<sup>2</sup>, Aleksandra Fedajev<sup>2</sup>, Jelena Ružić<sup>3</sup>**

<sup>1</sup>*University Business Academy in Novi Sad, Faculty of Contemporary Arts, Belgrade, Serbia*

<sup>2</sup>*University of Belgrade, Technical faculty in Bor, Serbia*

<sup>3</sup>*University Educons, Faculty of Project and innovation management Prof. dr Petar Jovanović, Belgrade, Serbia*

**Abstract:** Knowledge Management (KM) has garnered significant attention from the business sector over the past few decades. At the same time, in light of environmental challenges, dynamic firms have broadened the scope of KM by integrating environmental considerations. Effective KM practices are expected to assist organizations in achieving green innovation and green transition. This study employs the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique to explore the direct and indirect relationships among knowledge management (KM), green innovation (GI), and green transition (GT) within Serbian enterprises. The study also evaluates the direct influence of human capital and strategy on KM. Conducted from 2024 to early 2025, the research includes a sample of 212 employees and managers from various hierarchical levels across Serbian manufacturing and service organizations. The findings reveal a positive direct influence of KM on both GI and GT. Additionally, there is a significant positive mediating effect of GI on the relationship between KM and GT. The findings suggest a positive correlation between human capital and KM, but a negative correlation between strategy and KM. This research paper demonstrates that implementing a knowledge management system effectively promotes green transitions in enterprises. It provides valuable insights for both enterprises and developing countries aiming to enhance environmental sustainability.

**Keywords:** Knowledge Management, Green innovation, Green transition, Human capital, Strategy, PLS-SEM analysis.

---

\* Corresponding author: [sanela.golubovic@fsu.edu.rs](mailto:sanela.golubovic@fsu.edu.rs)

Sanela Golubović Corcione, ORCID: 0009-0003-1765-1002

Milica Veličković, ORCID: 0000-0002-4332-2216

Aleksandra Fedajev, ORCID: 0000-0002-6974-6631

Jelena Ružić, ORCID: 0009-0000-4715-2288

## 1. INTRODUCTION

The industrial revolution focused primarily on systems, products and services (Soto-Acosta & Cegarra-Navarro, 2016), however, there is an emerging need to reduce CO2 emissions to prevent climate change and global warming. Recent studies indicate that while new technologies and modified business models are essential for achieving a green transition, internal organizational processes, particularly knowledge management (KM), are also gaining attention. KM is recognized for its potential to facilitate the implementation of innovative concepts. Consequently, it has become a significant focus in recent literature within the broader field of sustainability research. The aim of sustainability knowledge management is to enable companies to fulfil current natural resource requirements while ensuring that future generations' needs are not compromised (Magyari et al., 2022). Topics of interest include efficient energy use through intelligent energy management systems, the transition to biofuels, and cleaner production methods that contribute to sustainable competitive advantage. Furthermore, green innovation (GI) research examines various knowledge resources that firms utilize to achieve objectives such as reducing material consumption, enhancing energy efficiency, and innovating recycling and waste reduction processes (Song et al., 2022). To meet customers' needs and achieve sustainable development (SD) goals, organizations adopt various strategies focused on green innovation and knowledge management (KM). The success of an organization heavily relies on its KM infrastructure, which encompasses the integration of people, processes, and technology. Effective KM enables companies to become more innovative and efficient (Yusr et al., 2017). Green innovation enables companies to develop environmentally friendly products (Xie et al., 2019).

Recognizing the strategic importance of green transition for both businesses and society, this study aims to investigate whether the implementation of knowledge management systems supports green transition in Serbian organizations from a strategic perspective. Additionally, it will analyze how knowledge management (KM) practices contribute to the green transition (GT) in large and medium-sized enterprises in Serbia, along with the mediating role of green innovation in linking KM practices to green transition (GT).

## 2. LITERATURE REVIEW AND HYPOTHESES

Numerous academics describe the present age as primarily influenced by intellectual capital and knowledge management (KM) (Yu et al., 2022). Individuals are the base of knowledge management, as knowledge exists within the minds of individuals (AlSondos, 2023). Grant's (1996) approach is based on the idea that in a turbulent environment, a company's most valuable resource is the specific tacit knowledge of its employees. This knowledge is unique and cannot be easily replicated by competitors, making it a potential source of sustainable competitive advantage. Organizations need well-educated people with strong problem-solving abilities, making human capital an essential asset for attaining innovations and sustainable competitive advantage in today's landscape (Campbell et al., 2012). Research by Hsu and Fang (2009) emphasizes the important role that human capital play in the performance of new product development, whereas Wang et al. (2014) demonstrated the beneficial effects of human capital on overall performance.

Recognizing and developing necessary knowledge and capabilities is challenging for companies. They need a strategy to efficiently exploit current business areas while exploring new ones to stay competitive in a changing environment (Gibson & Birkinshaw, 2004). Accordingly, green transition from organizational KM perspectives can be realized in the section of organizational strategy (i.e., new goals and resource allocation patterns supporting

sustainability), innovation (e.g., developing renewable and smart energy technologies), and change (shaping behaviour, culture, structures, control mechanisms to enable innovations) supported by a KMS (Magyari et al., 2022). Strategy is long-term planning aimed at achieving goals by efficiently using resources (Daft, 1995). A knowledge management strategy is essential for fostering innovation (Zheng et al., 2009) and enhancing performance by streamlining processes (Farida & Setiawan, 2022). Evidence indicates a good relation between strategy and knowledge management systems (AlSondos, 2023). Nonetheless, Rezaei et al. (2021) observed no impact of strategy on KM. It is recognized by Mardani et al. (2018) as a valuable resource for developing innovative products and services and for managing operational processes (Ode & Ayavoo, 2020). Spanellis et al. (2021) discussed the need for a dynamic KM model for managing explicit knowledge, knowledge sharing, and knowledge creation to support innovative technology development. As knowledge is generally found to be a key input for innovation (Grant, 1996), analyzing KMS support is important in the case of innovative green technologies.

The United Nations Global Compact (UNGC) has called on all businesses, especially those in the manufacturing sector, to adopt environmentally friendly practices and leverage the latest technologies for efficient resource utilization (UNGC, 2018). The environmental aspect of sustainable development focuses on preserving nature, ensuring clean water and air, producing eco-friendly products, and reducing hazardous emissions (Lucas, 2010). Green innovation seeks to reduce or eliminate the negative environmental impacts of organizational operations (Fernando et al., 2019). It includes innovations in products, processes, technologies, and management structures aimed at minimizing resource consumption and controlling waste and pollution (Rossiter & Smith, 2018). Siva et al. (2016) and GY Qi et al. (2010) categorize green innovation into two types: green technology innovation (GTI) and green management innovation (GMI). GTI involves creating new or improving existing products and processes to conserve resources and align environmental and economic goals (Fernando et al., 2019). GMI focuses on adopting new management structures to enhance production processes (Li et al., 2018). Additionally, GTI can be divided into green process innovation, which improves production methods (Albort-Morant, 2016), and green product innovation, which modifies designs to use renewable materials and reduce environmental impact (Zhang et al., 2019). These systems help firms achieve economic benefits while minimizing environmental harm (Siva et al., 2016).

In a knowledge-based society, the link between KM and Green Innovation (GI) is crucial, as knowledge drives development at all levels. KM activities provide resources for firms to innovate and enhance technologies (Habib et al., 2019). This allows organizations to improve products and processes, boosting performance economically, environmentally, and socially (Stanovcic et al., 2015). Abbas and Sagsan (2019) highlighted significant KM influence on Corporate Social Development (CSD) alongside green innovation. Ghorbani (2023) noted that effective management of green knowledge enables companies to create solutions for environmental challenges while achieving sustainable growth. Moreover, Rasheed et al. (2023) identified a significant impact of KM practices on GI and sustainable growth. Wang et al. (2024) found that transformative innovation mediates the relationship between the KM process and green entrepreneurial behavior. Similarly, Galindo Martín et al. (2020) support this hypothesis, stating that transformative innovation significantly enhances green entrepreneurial behaviour by facilitating the creation of new processes, business models, and sustainable products. Additionally, Shahzad et al. (2020) argue that KM processes encourage organizations to focus on green practices. This focus stimulates creativity and innovation in green entrepreneurship by promoting the sharing of ideas and knowledge, as well as encouraging experimentation and collaboration. Furthermore, Koshelieva et al. (2023)

highlighted the critical role of KM in fostering environmentally responsible practices and supporting sustainable development. Based on the previous literature review, the following hypotheses are proposed:

**H1:** Human capital has a positive influence on knowledge management in Serbian organizations.

**H2:** Strategy has a positive influence on knowledge management in Serbian organizations.

**H3:** Knowledge management positively affects green innovations in Serbian organizations.

**H4:** Knowledge management positively affects green transition in Serbian organizations.

**H5:** Green innovation positively impacts the green transition in Serbian organizations.

**H6:** Green innovation acts as a mediating variable that enhances the effect of knowledge management on green transition.

The empirical and conceptual evidence presented suggests that the KM process can enhance green transition (GT) either directly or indirectly, with green innovation acting as a mediator. Based on these arguments and the proposed hypotheses, a conceptual model has been developed, as illustrated in Figure 1.

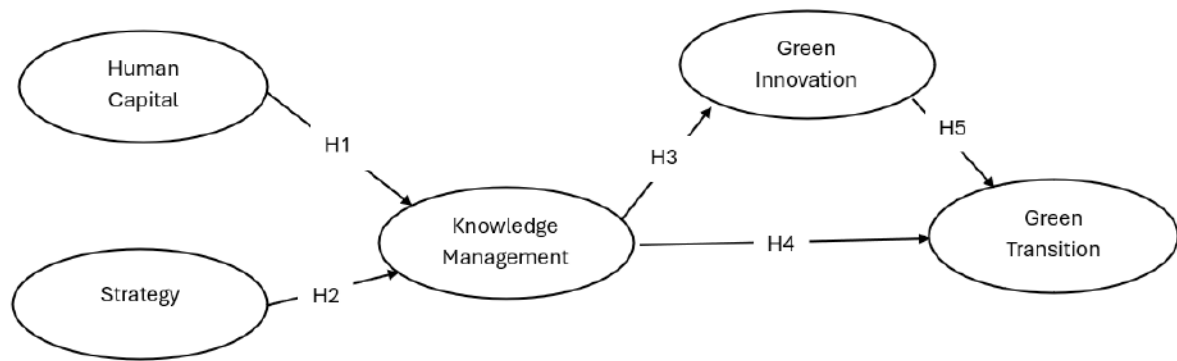


Figure 1. Conceptual model

### 3. DATA AND METHODOLOGY

This study tends to investigate the impact of human capital (HC) and strategy (STG) on KM practices, as well as their further effect on green transition (GT), considering the mediating role of green innovation (GI). Data were collected in 2024/25 from 212 employees and managers in medium and large manufacturing and service firms in the Republic of Serbia. The authors personally conducted the research by using a survey, and participation in the survey was voluntary.

Table 1. Socio-demographic characteristics of the sample (n=212)

Variables	Category	Frequency	Share (%)
Type of industry	Manufacture	153	72.2
	Service	59	27.8
Size of organization	Medium	94	44.3
	Large	118	55.7
Gender	Male	141	66.5
	Female	71	33.5
Years of employment	≤5	32	15.1
	6-10	82	38.7
	11-15	45	21.2
	≥16	53	25.0

Demographic characteristics (Table 1) showed that the statistical population included mostly male employees working in large-sized manufacturing organizations with 6 – 10 years of working experience.

The questionnaire was designed and modified based on the questionnaires from similar studies by Gold et al. (2001); Darroch (2005); Yang et al. (2012); Wong (2013); Wang et al. (2014); Park & Lee (2014); Lee & Wong (2015); Lam et al. (2021), and it contained 35 questions. The first 5 questions focused on the general characteristics of the organization (industry, size) and respondents (gender, position and working experience). The remaining 30 questions were divided into five groups: Human capital – 4 questions; Strategy – 5 questions; Knowledge management – 6 questions; Green Innovation – 6 questions; and Green transition – 9 questions. A 7-point Likert scale, which ranges from 1 (completely disagree) to 7 (completely agree), was utilized to measure the indices in the questionnaire.

The PLS-SEM (Partial Least Squares - Structural Equation Modeling) technique was used to explore the relation between the proposed indicators. The modeling process consists of two main stages: Stage 1 involves assessing the Measurement Model, while Stage 2 focuses on the Structural Model. The measurement model illustrates the interactions between the observed data and the latent variable, whereas the structural model represents the relationships among the latent variables. Additionally, we have analyzed the mediating role of the green innovation (GI) process in the relationship between knowledge management (KM) practices and green transition (GT).

## 4. RESULTS AND DISCUSSION

### 4.1. Measurement Model Assessment

The assessment of the measurement model involved evaluating the construct reliability and validity of the scale tools (Huang, 2021). To establish construct reliability and convergent validity, we used several metrics, including Cronbach's alpha (CA), rho A, Composite Reliability (CR), and Average Variance Extracted (AVE). These results are presented in Table 2.

Table 2. Construct reliability and validity

Construct	Cronbach's alpha	rho A	CR	AVE
Human Capital	0.943	0.947	0.959	0.855
Strategy	0.883	0.884	0.914	0.680
Knowledge Management	0.924	0.933	0.941	0.728
Green Innovation	0.934	0.942	0.948	0.753
Green Transition	0.977	0.977	0.980	0.845

According to Table 2, both Cronbach's Alpha and Composite Reliability (CR) values exceed the recommended threshold of 0.70, as suggested by Hair et al. (2017). The Cronbach's Alpha values indicate satisfactory internal consistency for all constructs. Additionally, the CR values ranged from 0.914 to 0.980, further demonstrating the reliability of the constructs.

Convergent validity is evaluated using the Average Variance Extracted (AVE) statistic. As recommended by Fornell and Larcker (1981), an AVE value equal to or greater than 0.5 indicates that the items effectively converge to measure the underlying construct, thereby establishing convergent validity. In this study, the AVE values for the constructs were all higher than 0.5, confirming convergent validity as well (Hair et al., 2017).

In addition to evaluating convergent validity, it is important to check discriminant validity before assessing the structural model. Henseler et al. (2015) recommended using the Heterotrait-Monotrait (HTMT) ratio of correlations for this purpose. According to Kline

(2011), the threshold value should be 0.85 or lower, while other authors, such as Franke and Sarstedt (2019), suggested a threshold of 0.90 or lower.

Table 3. Discriminant validity—HTMT ratio

Construct	GI	GT	HC	KM
Green Innovation				
Green Transition	0.859			
Human Capital	0.583	0.360		
Knowledge Management	0.657	0.788	0.346	
Strategy	0.615	0.362	0.857	0.298

Table 3 shows that all HTMT ratios are below the suggested threshold of 0.9 (Franke and Sarstedt, 2019; Henseler et al., 2015), confirming the strong discriminant validity of the model.

#### 4.2. Structural Model Assessment

As the reliability and validity of the measurement models have been confirmed, we can evaluate the hypothesized causal relationships within the inner model using PLS-SEM. The hypotheses were tested in a two-tailed manner, with a specific focus on the positive direction of the relationships. To assess the statistical significance of these relationships, we employed the bootstrapping procedure in SmartPLS4 software, generating 5,000 bootstrap samples (Ringler et al., 2022).

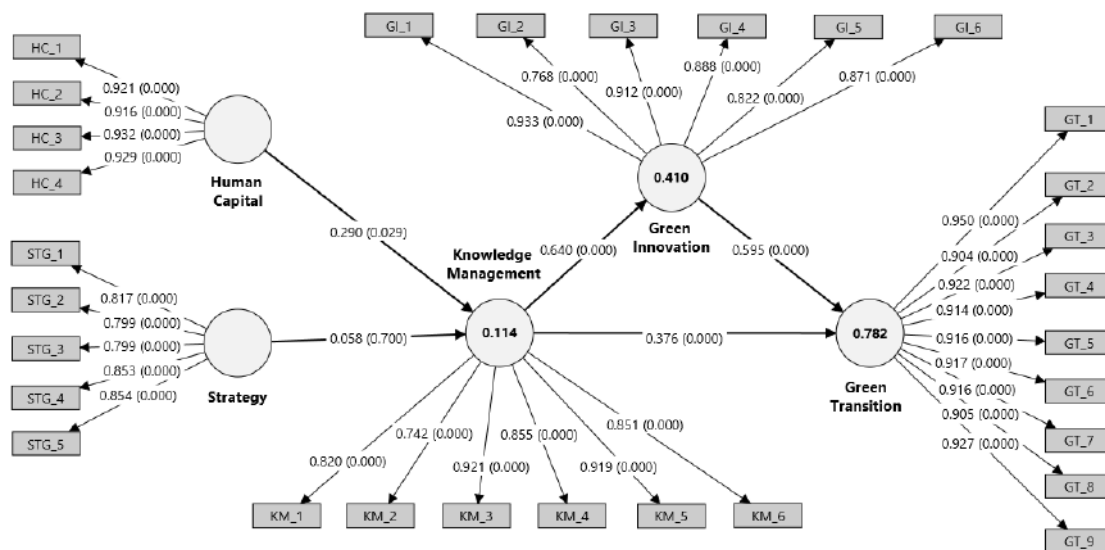


Figure 2. Structural model

Table 4. Results of the structural model assessment

Hypothesis	$\beta$	SD	$t$	$p$	Results
<i>Direct effect</i>					
H1: HC→KM	0.290	0.132	2.190	0.029	Confirmed
H2: STG →KM	0.058	0.151	0.385	0.700	Rejected
H3: KM →GI	0.640	0.025	25.450	0.000*	Confirmed
H4: KM →GT	0.376	0.041	9.160	0.000*	Confirmed
H5: GI →GT	0.595	0.040	14.965	0.000*	Confirmed
<i>Indirect effect</i>					
H6: KM → GI→GT	0.381	0.028	13.485	0.000*	Confirmed

$\beta$  – path coefficient, SD – standard deviation,  $p$  – level of significance lower than 0.000

The research model includes five direct effect hypotheses, named H1 to H5. The results, as illustrated in Figure 2 and detailed in Table 4, indicate that the path coefficient representing the relationship between Strategy and KM is statistically insignificant ( $\beta = 0.058$ ,  $t = 0.385$ ,  $p = 0.700$ ), which does not support hypothesis H2. However, Table 4 and Figure 2 show that four hypotheses (H1, H3, H4, and H5) are statistically significant and supported, with the following results: H1 ( $\beta = 0.290$ ,  $t = 2.190$ ,  $p = 0.029$ ), H3 ( $\beta = 0.640$ ,  $t = 25.450$ ,  $p = 0.000$ ), H4 ( $\beta = 0.376$ ,  $t = 9.160$ ,  $p = 0.000$ ), H5 ( $\beta = 0.595$ ,  $t = 14.965$ ,  $p = 0.000$ ).

The mediation analysis investigated the role of GI as a mediator in the relationship between KM practices and GT in the observed organizations. The results presented in Tables 4 and 5 show that the total effect of KM on GT is statistically significant ( $\beta = 0.757$ ,  $p = 0.000$ ), indicating a positive relationship between these variables without considering the mediator. When green innovation was included as a mediator, KM's direct effect on GT decreased but remained statistically significant ( $\beta = 0.376$ ,  $p = 0.000$ ). This suggests that the relationship between KM and GT is indeed mediated by green innovation, thereby confirming hypothesis H6.

Table 5. Total effect, direct effect, and indirect effect for the model mediation

Construct	Total effects			Direct effects			Indirect effects		
	$\beta$	$t$	$p$	$\beta$	$t$	$p$	$\beta$	$t$	$p$
KM $\rightarrow$ GT	0.757	32.242	0.000	0.376	9.160	0.000	0.381	13.485	0.000

$\beta$  = Path Coefficient,  $t$  = t-Statistics,  $p$  = level of significance \* $p < 0.05$ .

Ultimately, the assessment of the obtained  $R^2$  (the coefficient of determination) and  $f^2$  (the effect sizes of the paths) enhances the previous analysis (Table 6).

Table 6.  $R^2$  and  $f^2$  values

Predictor	Outcome	$R^2$	$f^2$
Human capital (HC)	Knowledge Management (KM)	0.114	0.037
Strategy (STG)			0.002
Knowledge Management (KM)	Green Innovation (GI)	0.410	0.695
Knowledge Management (KM)	Green transition (GT)	0.782	0.383
Green Innovation (GI)			0.956

$R^2$  has been used to assess the explained variance of the latent dependent variables in relation to the overall variance. According to Chin (2009), the suggested cutoff  $R^2$  values are as follows: 0.190 for weak, 0.333 for moderate, and 0.670 for substantial. Based on the results presented in Table 6, the overall model explained 78.2% of the variance in green transition (GT). Additionally, the model accounted for 41% of the variance in green innovation and 11.4% of the variance in KM, indicating that other factors may also influence this variable. Nevertheless, the model demonstrates a strong predictive capability.

The  $f^2$  value measures how well each predictor variable explains the endogenous variables. According to Cohen (1988), an  $f^2$  value between 0.02 and 0.149 indicates a small effect, values from 0.15 to 0.35 indicate a medium effect, and values above 0.35 indicate a large effect. Based on these thresholds, a large effect was identified in the relationships between KM and GI, KM and GT, as well as GI and GT, with  $f^2$  values of 0.695, 0.383, and 0.956, respectively. A small effect was observed in the relationship between Human Capital (HC) and KM ( $f^2 = 0.037$ ). Conversely, no effect was found in the relationship between Strategy and KM, which had an  $f^2$  value of 0.02.



### **4.3. Discussion and implications**

The main findings of this research outline the attitudes of Serbian manufacturing and service firms toward knowledge management, green innovation, and the green transition. These insights significantly enrich the existing literature and provide valuable practical implications.

This study expands the knowledge-based view and its theoretical extensions by conceptualizing green innovation activities to better understand achievements in the green transition. Specifically, the research examines direct and indirect relationships between knowledge management and green innovation towards green transition in the context of Serbian medium and large enterprises. Additionally, it evaluates the direct influence of human capital and strategy on the implementation of KM systems.

The study indicates a positive relationship between human capital and KM (H1). These findings are consistent with recent empirical research that suggests human capital is a key resource for organizations' knowledge (Oladele et al., 2022; Kaldeen & Nawaz, 2020).

A strong strategy contributes to the development of knowledge-based organizations, enabling companies to innovate, explore new opportunities, and take calculated risks, which can potentially position them as market leaders. To align with green transition standards, organizations should adopt a strategy focused on facilitating this transition, as it is crucial for success in achieving sustainability goals. KM programs are most effective when they align with the overall business strategy. However, the results of this study rejected the hypothesis H2, indicating that strategy does not have an impact on KM. This finding is consistent with Rezaei et al. (2021) but contradicts the results reported by AlSondos (2023). Unfortunately, the results indicate that the firms sampled in Serbia are not aligning their business strategies with green transition standards. Additionally, their management is not showing a strong commitment to incorporating green transition practices in their efforts to achieve sustainable development objectives.

Companies can leverage ecological knowledge to develop business strategies aimed at minimizing long-term environmental damage. This involves managing resource use and reducing environmental impacts. To fully capitalize on their ecological research, businesses must ensure that all employees have access to up-to-date environmental information. It is essential for them to develop a comprehensive understanding of environmental issues and the primary sources of pollution in their workplace. However, the positive impact of KM on GI (H3) indicates that the enterprises studied understand the value of green innovation and of implementing environmentally friendly practices. That is pointing out that they are leveraging their knowledge to develop products and processes that are more sustainable. This approach helps them in achieving environmental goals by appealing to environmentally conscious customers. These findings align with recent empirical studies suggesting that KM can improve firms' ability to innovate (Wang et al., 2022; Sahoo et al., 2023; Golubović et al., 2024).

The results obtained in this research indicate that KM directly affects GT (H4). This research contributes to expanding our understanding of KM frameworks, which, by continuously integrating ecological data from connected systems, provides enterprise members with valuable learning opportunities. This process fosters change and continuous operational improvement, ultimately enhancing growth and GT, which is in align with recent studies by Magyari et al. (2022), and Wang et al. (2024).

The results confirmed a positive relationship between green innovation (GI) and green transition (GT) (H5). By adopting green technologies and products, organizations can enhance their chances of successfully achieving green transition and sustainable development goals. Ahmed et al. (2022) and Abbas and Sağsan (2019) reported the same results in their studies. The study investigates how GI can improve the collaboration between KM practices and the achievement of green transition in Serbian enterprises. KM is a valuable intangible concept

that must be developed and linked to GI activities in order to improve business performance and reduce environmental damage. This claim is supported by the results related to H6, which are consistent with the theoretical assumption that the effective use of KM has a positive impact on GI capabilities, further contributing to the achievement of green transition (Abbas and Sagsan, 2019; Shahzad et al., 2020; Magyari et al., 2022; Golubović et al., 2024).

This research offers a new contribution by examining the ecological aspects associated with the impact of KM on GT mediated by GI as a cognitive precursor for organizational development. Consequently, we can conclude that GI serves as a motivating factor for Serbian companies to invest in advanced technologies, environmentally friendly services, and sustainability-oriented processes, enabling them to become more environmentally responsible.

Businesses should prioritize creating green training programs for employees to effectively utilize their knowledge, promote environmental ethics, and ensure compliance with environmental standards. This strategy provides valuable insights for administrators and policymakers who seek to shift industrial activities from causing pollution to supporting a green transition.

#### **4.4. Limitations of the study**

This research has several limitations. First, the study included only ten medium and large enterprises from Serbia, which means that the results cannot be generalized to a broader population. Second, the GT scale was based on the respondents' perceptions and evaluations, which could introduce bias and measurement errors. Future research should expand the sample size to address these limitations.

### **5. CONCLUSION**

The modern business environment emphasizes the need for performance and competitive advantage through innovation while also prioritizing environmental protection. Organizations must create and manage a robust knowledge base by encouraging individual knowledge acquisition and sharing among employees, with managerial support. In today's dynamic business landscape, it is essential for all employees to be committed to continuous learning and development.

To effectively integrate environmental knowledge into green innovation and achieve a successful green transition, organizations need to build strong knowledge-based capacities. The key message is that a successful green transition can only be attained by acquiring relevant knowledge and fostering innovation.

Evidence from previous studies (Peng et al., 2023; Magyari et al., 2022; Ahmed et al., 2022; Wang et al., 2022) supports a proposed research model that illustrates how knowledge management, along with the formalization of green innovation, directly and indirectly contributes to the achievement of green transition within Serbian enterprises.

The findings indicate that enterprises that focus on eco-knowledge can enhance their innovative capabilities, leading to the development of eco-friendly services and processes while minimizing the risks associated with environmental pollution. Furthermore, this approach significantly contributes to the success of their green transition efforts.

### **ACKNOWLEDGMENT**

This work was supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia, as part of the financing of scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-65/2025-03/200131.

## REFERENCES

- Abbas, J., & Sagsan, M. (2019). Impact of knowledge management practices on green innovation and corporate sustainable development: A structural analysis. *Journal of Cleaner Production*, 229, 611-620. <https://doi.org/10.1016/j.jclepro.2019.05.024>
- Abu-AlSondos, I. A. (2023). An empirical study of critical success factors in implementing knowledge management systems (KMS): The moderating role of culture. *Uncertain Supply Chain Management*, 11, <http://doi.org/1527-1538.10.5267/j.uscm.2023.7.016>
- Ahmed, S., Naz, F., Abbas, Z., Batool K.H. (2022). Impact of green innovation on sustainable development with mediating effect of knowledge management. *Journal of Business Management Studies-JBMS*, 1(01), 1-16.
- Albort-Morant, G., Leal-Millán, A., & Cepeda-Carrión, G. (2016). The antecedents of green innovation performance: a model of learning and capabilities. *Journal of Business Research*, 69, 4912 – 4917, <https://doi.org/10.1016/j.jbusres.2016.04.052>
- Campbell, B.A., Coff, R. & Kruscynski, D. (2012). Rethinking sustained competitive advantage from human capital. *The Academy of Management Review*, 37(3), 376 - 395, <http://dx.doi.org/10.5465/amr.2010.0276>
- Chin, W. W. (2009). How to write up and report PLS analyses. In Handbook of partial least squares: Concepts, methods and applications 655 - 690. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Cohen, J. (1988). Statistical power analysis for the behavioral sciences. Lawrence Erlbaum Associates. Hillsdale, NJ, 20-26.
- Daft, R. L. (1995). Organizational theory and design. St. Paul: West Publishing Co.
- Darroch, J. (2005). Knowledge management, innovation and firm performance. *Journal of Knowledge Management*, 9(3), 101 - 115 <https://doi.org/10.1108/13673270510602809>
- Farida, I., & Setiawan, D. (2022). Business Strategies and Competitive Advantage: The Role of Performance and Innovation. *Journal of Open Innovation: Technology, Market and Complexity*, 8, 163, <https://doi.org/10.3390/joitmc8030163>
- Fernando, Y., Jabbour, C., & Wah, W. (2019). Pursuing green growth in technology firms through the connections between environmental innovation and sustainable business performance: does service capability matter? *Resources, conservation and recycling*, 141, 8 – 20, <https://doi.org/10.1016/j.resconrec.2018.09.031>
- Fornell, C., & Larcker, D. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research*, 39 - 50.
- Franke, G., & Sarstedt, M. (2019). Heuristics versus statistics in discriminant validity testing: a comparison of four procedures. *Internet research*, 29(3), 430 - 447, <https://doi.org/10.1108/IntR-12-2017-0515>
- Galindo-Martín, M.-A., Castaño-Martínez, M.-S., & Mendez-Picazo, M.-T. (2020). The relationship between green innovation, social entrepreneurship, and sustainable development. *Sustainability*, 12(11), 4467 - 4479, <https://doi.org/10.3390/su12114467>
- Ghorbani, M. (2023). Green Knowledge Management and Innovation for Sustainable Development: A Comprehensive Framework. *Proceedings of the 24th European Conference on Knowledge Management, ECKM*, 394 - 399.
- Gibson, C. B., & Birkinshaw, J. (2004). The antecedents, consequences, and mediating role of organizational ambidexterity. *Academy of Management Journal*, 47(2), 209 - 226, <https://doi.org/10.2307/20159573>
- Gold A. H., Malhotra A., & Segars A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems*, 18(1), 185 – 214, <https://doi.org/10.1080/07421222.2001.11045669>

- Golubović, C. S., Veličković, M., & Fedajev, A. (2024). The impact of knowledge management on corporate sustainable development (CSD): The mediating role of green innovation. In *XX International May Conference on Strategic Management–IMCSM24 Proceedings*, 20(1), 167 - 179, <https://doi.org/10.5937/IMCSM24017G>
- Grant, R. M. (1996). Prospering in dynamically-competitive environments: organizational capabilities as knowledge integration. *Organization Science*, 7(4), 375 - 387, <https://doi.org/10.1287/orsc.7.4.375>
- GY Qi, L.Y. Shen, S. X. Zeng, O. J. Jorge (2010). The drivers for contractors' green innovation: an industry perspective. *Journal of Cleaner Production*, 18, 1358 - 1365, <https://doi.org/10.1016/j.jclepro.2010.04.017>
- Habib, M., Abbas, J., & Noman, R. (2019). Are human capital, intellectual property rights, and research and development expenditures really important for total factor productivity? An empirical analysis. *International Journal of Social Economics*, <https://doi.org/10.1108/IJSE-09-2018-0472>
- Hair, J., Hult, G., Ringle, C., & Sarstedt, M. (2017). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). 2nd Edition. *Thousand Oaks, CA: Sage Publications Inc.*
- Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of marketing science*, 43(1), 115 - 135. <https://doi.org/10.1007/s11747-014-0403-8>
- Hsu, Y. H., & Fang, W. (2009). Intellectual capital and new product development performance: The mediating role of organizational learning capability. *Technological Forecasting & Social Change*, 76, 664 - 677, <http://doi.org/10.1016/j.techfore.2008.03.012>
- Huang, C. (2021). Using PLS-SEM Model to Explore the Influencing Factors of Learning Satisfaction in Blended Learning . *Education Sciences*, 11(5), 249.
- Kaldeen, M., & Nawaz, S. S. (2020). Impact of human capital capabilities on knowledge management process. *International Journal of Psychosocial Rehabilitation*, 24(7), 463 - 478, <https://doi.org/10.37200/IJPR/V24I7/PR270045>
- Kline, R. B. (2011). Principles and Practice of Structural Equation Modeling. *Guilford Publications.*
- Koshelieva, O., Tsyselska, O., Kravchuk, O., I. Baida, V. M., & Miatenko, N. (2023). Knowledge Management as a New Strategy of Innovative Development. *International Journal of Professional Business Review*, 8(5), <https://doi.org/10.26668/businessreview/2023.v8i5.1592>
- Lam, L., Nguyen, P., Le, N., & Tran, K. (2021). The Relation among Organizational Culture, Knowledge Management, and Innovation Capability; Its Implication for Open Innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, 7, 66, <https://doi.org/10.3390/joitmc7010066>
- Lee, C.S., & Wong, K.Y. (2015). Development and validation of knowledge management performance measurement constructs for small and medium enterprises. *Journal of Knowledge Management*, 19, 711 - 734, <https://doi.org/10.1108/JKM-10-2014-0398>
- Li, D., Zhao, Y., Zhang, L., Chen, X., & Cao, C. (2018). Impact of quality management on green innovation. *Journal of Cleaner Production*, 170, 462 - 470, <https://doi.org/10.1016/j.jclepro.2017.09.158>
- Lucas, M. (2010). Understanding environmental management practices: integrating views from strategic management and ecological economics. *Business Strategy and the Environment*, 19, 543 - 556, <https://doi.org/10.1002/bse.662>

- Magyari, J., Zavarkó, M., & Zoltán Csedő, Z. (2022). Smart knowledge management driving green transformation: A comparative case study. *Smart Energy*, 7, <https://doi.org/10.1016/j.segy.2022.100085>
- Mardani, A., Nikoosokhan, S., Moradi, M., & Doustar, M. (2018). The relationship between knowledge management and innovation performance. *Journal of High Technology Management Research*, 29, 12 - 26, <https://doi.org/10.1016/j.hitech.2018.04.002>
- Ode, E., & Ayavoo, R. (2020). The mediating role of knowledge application in the relationship between knowledge management practices and firm innovation. *Journal of Innovation & Knowledge*, 5(3), 210 – 218, <https://doi.org/10.1016/j.jik.2019.08.002>
- Oladele, T. O., Omale, S. A., & Oyekan, M. (2022). Mediating role of knowledge management between human capital and organizational resilience of commercial banks. *Gusau International Journal of Management and Social Sciences*, 5(1), 66 - 84.
- Park, J. G., & Lee, J. (2014). Knowledge sharing in information systems development projects: explicating the role of dependence and trust. *International Journal of Project Management*, 32(1), 153 - 165, <https://doi.org/10.1016/j.ijproman.2013.02.004>
- Peng, C., Jia, X., & Zou, Y. (2023). Can “splitting” be beneficial? The impact of top management team information-knowledge faultline on enterprise green transformation. *Journal of Cleaner Production*, 406, 136935, <https://doi.org/10.1016/j.jclepro.2023.136935>
- Rasheed, M., Liu, J., & Ali, E. (2023). Incorporating sustainability in organizational strategy: a framework for enhancing sustainable knowledge management and green innovation. *Kybernetes*, <https://doi.org/10.1108/K-08-2023-1606>
- Rezaei, F., Khalilzadeh, M., & Soleimani, P. (2021). Factors Affecting Knowledge Management and Its Effect on Organizational Performance: Mediating the Role of Human Capital. *Advances in Human - Computer Interaction*, 1, <https://doi.org/10.1155/2021/88575722-13>
- Ringle, C. M., Wende, S., & Becker, J.M. (2022). "SmartPLS 4." Oststeinbek: SmartPLS GmbH, <http://www.smartpls.com>
- Rossiter, W., & Smith, D. (2018). Green innovation and the development of sustainable communities: the case of Blueprint Regeneration's Trent Basin development. *The International Journal of Entrepreneurship and Innovation*, 19, 21 - 32, <https://doi.org/10.1177/1465750317751989>
- Sahoo, S., Kumar, A., & Upadhyay, A. (2023). How do green knowledge management and green technology innovation impact corporate environmental performance? Understanding the role of green knowledge acquisition. *Business Strategy and the Environment*, 32(1), 551 - 569, <https://doi.org/10.1002/bse.3160>
- Shahzad, M., Qu, Y., Zafar, A. U., Rehman, S. U., & Islam, T. (2020). Exploring the influence of knowledge management process on corporate sustainable performance through green innovation. *Journal of Knowledge Management*, 24(9), 2079 - 2106. <https://doi.org/10.1108/JKM-11-2019-0624>
- Siva, V., Gremyr, I., Bergquist, B., Garvare, R., Zobel, T., & Isaksson, R. (2016). The support of Quality Management to sustainable development: a literature review. *Journal of Cleaner Production*, 138, 148 - 157, <https://doi.org/10.1016/j.jclepro.2016.01.020>
- Song, M., Peng, L., Shang, Y., & Zhao X. (2022). Green technology progress and total factor productivity of resource-based enterprises: A perspective of technical compensation of environmental regulation. *Technological Forecasting and Social Change*, 174, <https://doi.org/10.1016/j.techfore.2021.121276>



- Soto-Acosta, P., & Cegarra-Navarro, J.-G. (2016). New ICTs for Knowledge Management in Organizations. *Journal of Knowledge Management*, 20(3), 417 - 422, <https://doi.org/10.1108/JKM-02-2016-0057>
- Spanellis, A., MacBryde J., & Dörfler, V. (2021). A dynamic model of knowledge management in innovative technology companies: a case from the energy sector. *European Journal of Operational Research*, 292(2), 784 - 797, <https://doi.org/10.1016/j.ejor.2020.11.003>
- Stanovic, T., Pekovic, S., & Bouziri, A. (2015). The effect of knowledge management on environmental innovation: the empirical evidence from France. *Baltic Journal of management*, 10, 413 – 431, <https://doi.org/10.1108/BJM-01-2015-0012>
- UNGC. (2018). United Nations Global Compact. New York: *United Nations*.
- Wang, C.L., Ahmed, P.K., & Rafiq, M. (2008). Knowledge management orientation: construct development and empirical validation. *European Journal of Information Systems*, 17, 219 - 235. <https://doi.org/10.1057/ejis.2008.12>
- Wang, S., Abbas, J., Safdar Sial, M., Álvarez-Otero, S., & Cioca, L.I. (2022). Achieving green innovation and sustainable development goals through green knowledge management: Moderating role of organizational green culture. *Journal of Innovation & Knowledge*, 7(4), 100272, <https://doi.org/10.1016/j.jik.2022.100272>
- Wang, Y., Wang, Q., Pan, X., & Mata, M. N. (2024). Green entrepreneurial intention, knowledge management process, and green entrepreneurial behaviour through a lens of transformative innovation. *Journal of Innovation & Knowledge*, 9(4), 100567, <https://doi.org/10.1016/j.jik.2024.100567>
- Wang, Z., Wang, N., & Liang, H. (2014). Knowledge sharing, intellectual capital and firm performance. *Management Decision*, 52(2), 230 – 258, <http://dx.doi.org/10.1108/MD-02-2013-0064>
- Wong, S.K.S. (2013). Environmental requirements, knowledge sharing and green innovation: empirical evidence from the electronics industry in China. *Business Strategy and Environment* 22, 321 - 338. <https://doi.org/10.1002/bse.1746>
- Xie, X., Huo, J., & Zou, H. (2019). Green process innovation, green product innovation, and corporate financial performance: A content analysis method. *Journal of Business Research*, 101, 697 - 706, <https://doi.org/10.1016/j.jbusres.2019.01.010>
- Yang L.-R., Chen J.-H., & Wang, H.-W. (2012). Assessing impacts of information technology on project success through knowledge management practice. *Automation in Construction*, 22, 182 - 191, <https://doi.org/10.1016/j.autcon.2011.06.016>
- Yu, S., Abbas, J., Alvarez-Otero, S., & Cherian, J. (2022). Green knowledge management: Scale development and validation. *Journal of Innovation & Knowledge*, 7(4), 100244, <https://doi.org/10.1016/j.jik.2022.100244>
- Yusr, M., Mokhtar, S., Othman, A., & Sulaiman, Y. (2017). Does interaction between TQM practices and knowledge management processes enhance the innovation performance? *International Journal of Quality & Reliability Management*, 34, 955 - 974, <https://doi.org/10.1108/IJQRM-09-2014-0138>
- Zhang, D., Rong, Z., & Ji, Q. (2019). Green innovation and firm performance: evidence from listed companies in China. *Resources, conservation and recycling*, 144, 48 - 55, <https://doi.org/10.1016/j.resconrec.2019.01.023>
- Zheng, W., Yang, B., & McLean, G. N. (2009). Linking organizational culture, structure, strategy, and organizational effectiveness: mediating role of knowledge management. *Journal of Business Research*, 63(7), 763 - 771, <https://doi.org/10.1016/j.jbusres.2009.06.005>



## WOMEN'S RURAL ENTREPRENEURSHIP – AN INTEGRATED APPROACH TO THE GENDER DIMENSION

Marina Nedeljković \*

*College of Vocational Studies for Teachers and Business Informatics Sirmium, Sremska  
Mitrovica, Serbia*

**Abstract:** Contemporary social trends in the reconstruction of rural space, rurality and rural development impose the need for an adequate response and the willingness of local actors to actively engage in the development of the local community by mobilizing available resources, minimizing costs and maximizing productivity (which is viewed here from a sociological, not purely economic perspective). In modern societies, we are witnessing the changes that are taking place in the transformation of the rural into a modern economy, through the modernization of agricultural production, but also the expansion of the role and importance of rurality and the rural area. However, the postmodernization of rurality is accompanied by the diversification of the rural economy, but also by the need to create and implement gender-sensitive policy measures. In conditions where women, as part of the general population, comprise half of the world's population, their socio-economic development and capacity for entrepreneurship is increasingly attracting the attention of various scientific disciplines. The significance of the concept of (neo)endogenous rural development from the perspective of gender-sensitive rural policies is reflected in the expansion of the development capacities of human capital (rural women), and thus of a particular rural area.

**Keywords:** Female rural entrepreneurship, rural structure, gender regimes, diversification of the rural economy

### 1. INTRODUCTION

Numerous and dynamic changes in rural structures, such as the diversification of the rural economy, technical and technological innovations and the recreation of rural space by the actors themselves (neo-endogenous conception of rural development), open up a new, theoretical and practical concept of rural entrepreneurship. In particular, new theoretical trends in redefining the concept of rural entrepreneurship relate to its gender dimension, i.e. the concept of female rural entrepreneurship. Entrepreneurship is a complex (sociological) phenomenon that in many ways influences the reproduction of rural everyday life and lifestyle, and acquires special significance in the conditions of transformed rurality and multifunctional

---

\* Corresponding author: [marina.nedeljkovic89@gmail.com](mailto:marina.nedeljkovic89@gmail.com)

Marina Nedeljković, ORCID: 0009-0000-6360-8409

rural space and economy. The rural space acquires the prefix "multi" and becomes a meeting place and a place for various combinations of entrepreneurial activities, both in primary agricultural production and in all other sectors, especially in the service sector.

## **2. DATA AND METHODOLOGY**

The paper was created on the basis of the scientific-research work on the preparation of the doctoral dissertation "Rural women and the development of rural tourism in AP Vojvodina" and represents a comparative and critical analysis of available sources regarding the phenomenon of female rural entrepreneurship and its sociological, but also broader socio-economic implications. The data and methodology are part of a wider research - whether and in what way there is a connection between the development of female rural entrepreneurship and rural tourism, and for the purposes of this work, a part of the analysis of the very concept of the gender dimension of rural entrepreneurship has been set aside.

## **3. SOCIOLOGICAL CONCEPTS OF (RURAL) ENTREPRENEURSHIP**

Entrepreneurship is defined as more or less autonomous (conscious) human action in socio-economic processes, with the aim of making the most rational use of available economic factors and bearing full responsibility for one's own participation in these processes (Milošević, 1997). Scientific knowledge about entrepreneurship (Bolčić, 2003) aims to identify those entrepreneurial traits that allow individuals who possess them to be recognized in different social contexts, as well as historical periods. We can highlight six basic characteristics of entrepreneurs: the need for achievement and success, creativity and initiative, risk-taking, self-confidence and courage, needs for independence and autonomy and motivation, energy and engagement (Bolčić, 2003). Based on this, it can be concluded that an entrepreneur makes risky economic decisions, assesses risk, tries to control it and takes responsibility for that risk in business (Bolčić, 2003). Entrepreneurial activity is thus manifested in establishing and dynamizing enterprises, in finding an adequate combination of production factors, in bringing economically relevant innovations into business life, and in taking risks for such decisions (Bolčić, 2003). It is also worth mentioning the view that systematic, not random, innovations are important for successful entrepreneurs, i.e. purposeful and organized search for changes that turn materials into resources (Bolčić, 2003). Entrepreneurship is "a dynamic process of vision, creation and change, and its most important ingredients require a willingness to take risks, the ability to form an effective team, creativity in the use of resources and basic skills in formulating a business plan" (Kuratko, 2005). On the other hand, "entrepreneurship is an important mechanism for generating economic activity and growth in rural areas. It is therefore important to understand the circumstances that enable and/or constrain entrepreneurial activity in rural areas (Korsgaard et al., 2015a). Rural entrepreneurship can be analyzed from two aspects: 1. the way in which space affects spatial resources for rural entrepreneurship; 2. the way in which spatial bridging can be discussed (Müller & Korsgaard, 2018). The authors also develop a typology of rural entrepreneurs, and particularly emphasize the importance of the findings for micro-level analysis and the study of non-local circulation of values, which in this case can enrich local rural economies. Rural entrepreneurship, in the changed conditions of rural reproduction, is also understood as a response to numerous challenges and potential development problems of local communities (e.g. lack of innovation, jobs, income, quality of life, social vitality). However, space/location is a source of meaning and social life for rural entrepreneurs, and not primarily just profit – the need for personal or broader social and cultural



fulfillment is a motive that particularly distinguishes this type of entrepreneur (Korsgaard et al., 2015a).

New trends in the analysis of rural entrepreneurship emphasize its connection with the general process of globalization and analyze different aspects of this relationship: 1. the discourse and practice of rural entrepreneurship are seen as a complement to classical rural development strategies; 2. rural entrepreneur networks must be activated through social and local communities (globalization "from below"); 3. the government as an institution is still the main carrier of rural development policies (contradictions with entrepreneurship based on capitalist foundations); 4. rural development is a labor-oriented project, unlike rural entrepreneurship which is a capitalist-oriented multidimensional phenomenon; 5. rural, new concepts of rural development (multifunctional agriculture) and social movements should overcome traditional dichotomies such as rural-urban; 6. rural entrepreneurship should be linked in the long term with rural social movements and new development concepts (Shahraki & Heydari, 2019).

#### **4. ENTREPRENEURSHIP BETWEEN STEREOTYPES AND GENDER REGIMES**

Traditionally, entrepreneurship has been stereotyped as a male domain (Heilman, 2001; Powell et al., 2002; Marlow & Carter, 2004), and the skills and attributes that women bring to the job are often considered less valuable (Marlow, 2002; Hampton et al., 2009). In conditions where women make up half of the world's population, their socio-economic development and capacity for entrepreneurship must not be left out of scientific research, but also of application models for implementing strategies and support measures. Although the issue of motivation for entrepreneurship, from the perspective of gender regimes in rural development concepts and entrepreneurial behavior research, has long been neglected, recent trends show a strong interest in this issue. Women's entrepreneurship shares certain similarities with entrepreneurship in general, but there are also many aspects that make it unique - differences in motivation and goals between men and women, personal aspirations, preparation, organization and decision-making regarding the use and distribution of resources, as well as the way in which human capital is organized, strategic choices and structural barriers in the environment (Greene et al., 2003). The findings of Buttner and Moore suggest that the most important entrepreneurial motivation among women entrepreneurs was the desire for challenge and self-determination, but also the desire for a balance between family and work responsibilities (Buttner & Moore, 1997). There are also opinions that, although a certain number of female entrepreneurs share similar motives with their male counterparts, there are also those who are primarily driven by the desire to balance family and business obligations and introduce a dose of flexibility into their work schedule (McGowan et al., 2012). These women and their motives have not received sufficient research attention, and the results of such analyses can be useful in many ways. Popović Pantić (2014) points out that in societies that have gone through or are still going through a transition process, entrepreneurship often becomes entrepreneurship out of necessity, and it is mostly women who fall into this category. Babović (2014), however, distinguishes between entrepreneurs who enter business out of "economic necessity" and those who seek "business opportunities", while Čikić and Nedeljković (2019) conclude that, although entrepreneurs are motivated by many factors among women entrepreneurs, the most pronounced are those related to the feeling and need to contribute to family reproduction and meeting life's needs. In addition, a motive that falls into the non-financial category also appears. It is about the "desire to combine work and pleasure" (Čikić & Nedeljković, 2019), but also about the feeling of "independence".

## 5. MOTIVATION FOR AN ENTREPRENEURIAL TYPE OF BUSINESS

When it comes to the issue of motivation for entrepreneurship, there is one particularly noticeable gender difference that, by the nature of things, stems from the different family roles of men and women. Women are more motivated than men with the same education to become entrepreneurs due to autonomy and the ability to balance work and family responsibilities, while men are more likely to strive for wealth creation and economic and social advancement (Stanković & Markov, 2011). On the other hand, based on the data available to these two authors, it is observed that women start the majority of their businesses in typically “female fields”, such as trade, food production, accommodation and personal services, which are designated as peripheral niches (Stanković & Markov, 2011). Based on this thinking, we can conclude that women manage to find their “place under the sun” and achieve profit and productivity in areas that may be less interesting to men. However, a major problem remains the level of their income, which is lower than average incomes in traditionally male sectors. Other authors agree that women and men have different motives for venturing into entrepreneurship. According to some research, women in such cases are more driven by social factors and ensuring a balance between work and family obligations, while men are attracted by financial security and profit (Zlatkov Cvetković, 2015).

On the other hand, research has shown that the position of women who want to engage in entrepreneurship in rural areas is more difficult (Munitlak Ivanović et al., 2016). Thus, Babović (2012), analyzing what the profile of a Serbian entrepreneur actually looks like, finds that these women encounter problems of gender role limitations, which is further accentuated in rural areas. Women are perceived as less capable, successful and competent in what they do compared to their male colleagues. All this further affects the less favorable socio-economic position of female entrepreneurs in rural areas. However, Babović (2012) states that female entrepreneurs, although fewer in number, are still more creative compared to their colleagues and that this can be a very important characteristic and an opportunity to expand their businesses. However, according to this author, there is also data that out of the total number of businesses started, a greater number of women have failed than men, which requires that this topic be approached much more seriously, with adequate support from all stakeholders involved. The literature also calls for a more realistic view of the motivation factors for starting businesses among women entrepreneurs and their reasons for balancing private and business obligations (Winn, 2004), as well as the need to include and respect the spatial, historical, temporal, institutional, social, and any other context within which women's entrepreneurship takes place in research (Welter, 2011; Welter et al., 2014). Other authors also emphasize the importance of context in interpreting rural behavior and activity (Gaddefors & Anderson, 2019), while some case studies suggest that understanding the contextual aspect of women's entrepreneurship is increasingly important in contemporary literature. The concept of social capital is also introduced as an important correlation (Neumeyer et al., 2019), which can be an indicator for determining the differences between women and men in the sphere of entrepreneurship. The results of the study show that men in entrepreneurship show a greater degree of ability to convert social capital into a more aggressive management approach aimed at growth, while women are more focused on building a distinctive lifestyle and the survival of the enterprise. The importance of social capital has been noted earlier by sociologists who have investigated the functioning of microenterprises. Woolcock (2001) argues that through various forms of social capital and the diffusion of personal contacts and relationships with other business actors, micro-firms overcome limitations and shortcomings in other aspects, such as financial ones. By using social capital, they better cope with business risks and compete with

larger entrepreneurs. Studies of entrepreneurs in rural areas show how social connections and participation in community networks can provide entrepreneurs with access to local resources, but also how communities, in turn, will support their activities for the benefit of the local environment (Korsgaard et al., 2015b). Although each entrepreneurial venture was different, what they had in common was the meaning that locality had for them – as a community and as a place (McKeever et al., 2015). The local community, in the case of the research on entrepreneurial activities conducted by these authors, is understood as the key to the success of their businesses. However, other authors also point out that, although social capital is a frequently used variable in describing entrepreneurial behavior and success, empirical data does not always support this claim and that the attention of rural policymakers should be directed towards local rural networks from which entrepreneurs will draw the necessary (non-)material resources (Smallbone, 2009). Therefore, it is emphasized that entrepreneurship, from a gender perspective, is not only a topic of increasing academic interest, but also a development issue for many nations (Link & Strong, 2016). In addition, the need for networking appears as an important variable for the success of female entrepreneurship. “Networking has long been recognized as an essential entrepreneurial skill that is crucial for identifying opportunities and accessing strategic resources needed to develop new and existing ventures” (Hampton et al., 2009), and research focusing on the gender domain in entrepreneurial fields is increasingly attracting the attention of researchers. The literature also presents an explanatory model that attempts to answer the question of why women decide to become entrepreneurs (Orhan & Scott, 2001), as one of several attempts to conceptualize their motives through the theory of push and pull factors (Segal et al., 2005), which may also include a comparative approach through the category of gender (Kirkwood, 2009). One of the findings highlights the view that the assumption that women become entrepreneurs out of necessity is debatable and that other factors and secondary motives should be included in the analysis (Orhan & Scott, 2001).

## **6. WOMEN’S RURAL ENTREPRENEURSHIP – A STEP TOWARDS A DEFINITION AND SOME SOCIOLOGICAL IMPLICATIONS**

How to properly define the concept of women's entrepreneurship and is it even possible to arrive at a single and comprehensive formulation? Although the most adequate definition of female entrepreneurship, according to most authors, is one that includes entrepreneurs who simultaneously own more than 50% of a company (regardless of how they acquired ownership) and who manage their own company, however, the most widely accepted in domestic literature is the one in which the ownership criterion is significantly relaxed, referring to entrepreneurs who own at least 1% of the company's capital and who manage the company (Popović Pantić, 2014). Babović (2012) points out that "all women who own (any share) of a company are recognized as entrepreneurs, provided that they also perform a leading management role in that company, regardless of the way in which they acquired ownership of that company." In today's world, as Stanković and Markov (2011) point out, there is an evident gender asymmetry in the ownership structure of entrepreneurial companies, which is reflected in the far smaller number of women in decision-making and commanding positions. There are several problems that, as a rule, women entrepreneurs face when they aim to establish and develop their own businesses, companies, and various ways of making a living. These are problems in securing and mobilizing resources and financial capital, exercising the right to credit and obtaining guarantees, investing capital, and the discriminatory behavior of bankers, i.e. their prejudice that women are rarely successful in business and are not sufficiently prepared to take risks (Stanković & Markov, 2011).

Some authors suggest distinguishing between two types of female entrepreneurs. These are the traditional and the modern type (Zlatkov Cvetković, 2015). Traditional entrepreneurs are seen as independent entrepreneurs who extend their competences and knowledge from the household to the market, while modern female entrepreneurs tend to see their business as a career and thus penetrate traditionally male areas of business. On the other hand, we also believe that there are three main groups of female entrepreneurs: 1. classical (motive - autonomy); 2. forced (external negative motivation); 3. family-work entrepreneurs (need for family work and balance) (Zlatkov Cvetković, 2015).

The rural female population is very ready to accept new knowledge, innovations, opportunities for entrepreneurship development and new work roles (Blagojević, 2010), and therefore, it is of utmost importance to provide them with continuous and systematic support, both through various training programs, as well as through incentive measures for self-employment, the development of one's own agribusiness, as well as other options that diversification of the rural economy provides us with in modern rural development. Women's rural entrepreneurship is a special type of entrepreneurship that takes place in conditions of transformed rurality and rural space, and which is based on the principles of a diversified rural economy and multifunctional agriculture, carried out by creative, versatile and innovative individuals with their present awareness of the needs for gender-sensitive (balanced) rural development. Women's entrepreneurship is also understood as: 1. a development opportunity for the recovery of villages and the increase of their social vitality; 2. a possibility of a source of primary or additional income for vulnerable and less employable categories of the population in rural areas (youth, women); 3. a way to improve the quality of life; 4. a response to negative demographic and migration trends; 5. an opportunity to change power relations and decision-making positions in the local community, family and household; 6. a source of knowledge, innovation and information dissemination.

## 7. CONCLUSION

Women's rural entrepreneurship is not a magic wand, nor an all-powerful solution to all the problems of rural community that have accumulated over decades. It can be a powerful and effective tool, but it all depends on how, in what way and in accordance with what we use it. The success and future of women's rural entrepreneurship is not spared from all the complex problems facing rural communities, and it seems to be burdened not only by space, but also by limitations stemming from the gender development dimension. Given that entrepreneurship is associated with increasing equality between socioeconomic and demographic groups in society, the development of female entrepreneurship emphasizes the importance of access to valuable resources in society and encouraging women to receive education and training to work in non-traditional sectors, which will enable them to better position themselves in high-growth industries (Sullivan & Meek, 2012).

## REFERENCES

- Babović, M. (2012). *The starting study on entrepreneurship of women in Serbia*. Belgrade: United Nations Program for Development. (in Serbian)
- Babović, M. (2014). *Gender aspects of access to economic resources in territorialization processes: research in the Zlatibor region*. Belgrade: University of Belgrade, Faculty of Philosophy. (in Serbian)
- Blagojević, M. (2010). *Women in Vojvodina: Everyday life and rural development*. Novi Sad: Department of Gender Equality. (in Serbian)

- Bolčić, S. (2003). World of work in transformation, Belgrade: Plato. (in Serbian)
- Buttner, E. H., & Moore, D. P. (1997). Women's organizational exodus to entrepreneurship: self-reported motivations and correlates with success. *Journal of small business management*, 35(1), 34-46. <https://api.semanticscholar.org/CorpusID:140746190>
- Čikić, J., & Nedeljković, M. (2019). Female entrepreneurship-a path towards sustainable rural restructuring. *Belgrad: Institute of Agricultural Economics Belgrade*, 370-388.
- Gaddefors, J., Anderson, A. R. (2019). Romancing the Rural: Reconceptualizing Rural Entrepreneurship as Engagement with Context(s). *The International Journal of Entrepreneurship and Innovation*, 20(3), 159-169. <https://doi.org/10.1177/1465750318785545>
- Greene, P. G., Hart, M. M., Gatewood, E. J., Brush, C. G., & Carter, N. M. (2003). Women entrepreneurs: Moving front and center: An overview of research and theory. *Coleman White Paper Series*, 3(1), 1-47. <https://api.semanticscholar.org/CorpusID:36647508>
- Hampton, A., Cooper, S., & McGowan, P. (2009). Female entrepreneurial networks and networking activity in technology-based ventures: An exploratory study. *International Small Business Journal*, 27(2), 193-214. <https://doi.org/10.1177/0266242608100490>
- Heilman, M. E. (2001). Description and prescription: How gender stereotypes prevent women's ascent up the organizational ladder. *Journal of Social Issues*, 57(4), 657-674. <https://doi.org/10.1111/0022-4537.00234>
- Kirkwood, J. (2009). Motivational factors in a push-pull theory of entrepreneurship. *Gender in management: An international journal*, 24(5), 346-364. <https://doi.org/10.1108/17542410910968805>
- Korsgaard, S., Müller, S., & Tanvig, H. W. (2015a). Rural entrepreneurship or entrepreneurship in the rural-between place and space. *International Journal of Entrepreneurial Behavior & Research*, 21(1), 5-26. <https://doi.org/10.1108/IJEBR-11-2013-0205>
- Korsgaard, S., Ferguson, R., & Gaddefors, J. (2015b). The best of both worlds: how rural entrepreneurs use placial embeddedness and strategic networks to create opportunities. *Entrepreneurship & regional development*, 27(9-10), 574-598. <https://doi.org/10.1080/08985626.2015.1085100>
- Kuratko, D. F. (2005). The emergence of entrepreneurship education: Development, trends, and challenges. *Entrepreneurship theory and practice*, 29(5), 577-597. <https://doi.org/10.1111/j.1540-6520.2005.00099.x>
- Link, A. N., & Strong, D. R. (2016). Gender and entrepreneurship: An annotated bibliography. *Foundations and Trends in Entrepreneurship*, 12(4-5), 287-441. <http://dx.doi.org/10.1561/03000000068>
- Marlow, S. (2002). Women and self-employment: a part of or apart from theoretical construct?. *The international journal of entrepreneurship and innovation*, 3(2), 83-91. <https://doi.org/10.5367/000000002101299088>
- Marlow, S., & Carter, S. (2004). Accounting for change: professional status, gender disadvantage and self-employment. *Women in Management Review*, 19(1), 5-17. <https://doi.org/10.1108/09649420410518395>
- McGowan, P., Redeker, C. L., Cooper, S. Y., & Greenan, K. (2012). Female entrepreneurship and the management of business and domestic roles: Motivations, expectations and realities. *Entrepreneurship & Regional Development*, 24(1-2), 53-72. <https://doi.org/10.1080/08985626.2012.637351>
- McKeever, E., Jack, S., & Anderson, A. (2015). Embedded entrepreneurship in the creative reconstruction of place. *Journal of business venturing*, 30(1), 50-65. <https://doi.org/10.1016/j.jbusvent.2014.07.002>
- Milošević, B. (1997). Inserts of work. Novi Sad. Prometej. (in Serbian)

- Müller, S., & Korsgaard, S. (2018). Resources and bridging: the role of spatial context in rural entrepreneurship. *Entrepreneurship & Regional Development*, 30(1-2), 224-255. <https://doi.org/10.1080/08985626.2017.1402092>
- Munitlak Ivanović, O., Mitić, P., & Raspopović, N. (2016). Gender equality: Perspectives of rural women entrepreneurship in Vojvodina. *Poslovna ekonomija*, 10(1), 157-172. (in Serbian)
- Neumeyer, X., Santos, S. C., Caetano, A., & Kalbfleisch, P. (2019). Entrepreneurship ecosystems and women entrepreneurs: a social capital and network approach. *Small Business Economics*, 53, 475-489. <https://doi.org/10.1007/s11187-018-9996-5>
- Orhan, M., & Scott, D. (2001). Why women enter into entrepreneurship: an explanatory model. *Women in management review*, 16(5), 232-247. <https://doi.org/10.1108/096494201110395719>
- Popović Pantić, S. (2014). Female entrepreneurship in Serbia: Evolution from the social toward the economic category. *Poslovna ekonomija*, 8(2), 143-162. (in Serbian)
- Powell, G. N., Butterfield, D. A., & Parent, J. D. (2002). Gender and managerial stereotypes: have the times changed?. *Journal of management*, 28(2), 177-193. <https://doi.org/10.1177/014920630202800203>
- Segal, G., Borgia, D., & Schoenfeld, J. (2005). The motivation to become an entrepreneur. *International journal of Entrepreneurial Behavior & Research*, 11(1), 42-57. <https://doi.org/10.1108/13552550510580834>
- Shahraki, H., & Heydari, E. (2019). Rethinking rural entrepreneurship in the era of globalization: some observations from Iran. *Journal of Global Entrepreneurship Research*, 9(1), 42. <https://doi.org/10.1186/s40497-019-0162-6>
- Smallbone, D. (2009). Fostering entrepreneurship in rural areas.
- Stanković, F., Markov, S. (2011). *Introduction to gender theories*. Mediterran Publishing. 321-335. (in Serbian)
- Sullivan, D. M., & Meek, W. R. (2012). Gender and entrepreneurship: a review and process model. *Journal of Managerial Psychology*, 27(5), 428-458. <https://doi.org/10.1108/02683941211235373>
- Welter, F. (2011). Contextualizing entrepreneurship - conceptual challenges and ways forward. *Entrepreneurship Theory and Practice*, 35(1), 165-184. <https://doi.org/10.1111/j.1540-6520.2010.00427.x>
- Welter, F., Brush, C., & De Bruin, A. (2014). The gendering of entrepreneurship context. *Institut für Mittelstandsforschung Bonn (Hrsg.): Working Paper*, 1, 14.
- Winn, J. (2004). Entrepreneurship: Not an easy path to top management for women. *Women in Management Review*, 19(3), 143-153. <https://doi.org/10.1108/09649420410529852>
- Woolcock, M. (2001). *The Place of Social Capital in Understanding Social and Economic Outcomes*. Paper Presented at the Contribution of Human and Social Capital to Sustained Economic Growth and Well-Being, Ottawa. 1-35.
- Zlatkov Cvetković M. (2015). *Women entrepreneurship in Serbia A qualitative study of the perceived enabling factors for the female entrepreneurship*. Uppsala: Swedish Faculty of Natural Resources and Agricultural Sciences. 1-59.



## THE IMPACT OF ECONOMIC VARIABLES ON ATTRACTING FOREIGN DIRECT INVESTMENT IN LIBYA: AN ANALYTICAL STUDY OF THE PERIODS "1997–2010, 2011–2017, AND 2018–2024"

Amel Kamel Abdulmalik \*

*Misrata University, Faculty of Economics and Political Science, Libya*

**Abstract:** This study examines the impact of economic variables on attracting foreign direct investment (FDI) in Libya across three distinct time periods: 1997–2010, characterized by relative economic stability; 2011–2017, marked by economic turmoil; and 2018–2024, which witnessed a gradual stabilization following the crises. Key economic indicators such as GDP, exports, imports, and exchange rates were analyzed to assess their influence on FDI inflows. The research problem lies in understanding how economic changes affect foreign investment flows across different periods. The hypothesis tested suggests a positive relationship between these economic variables and the growth of FDI. A comparative analysis was conducted to identify significant differences in economic performance and their implications for FDI attraction. The results revealed noticeable disparities in investment responses, reflecting the unique nature of each period. Despite variations in figures, the real determinants of FDI inflows remain ambiguous, raising critical questions about how to improve Libya's investment environment. These unexplained factors present a significant area for further exploration and analysis.

**Keywords:** Foreign Direct Investment, GDP, Exports, Imports, Exchange Rates, Libya.

### 1. INTRODUCTION

Foreign Direct Investment (FDI) has long been regarded as one of the key engines of economic development, particularly in developing economies that often face limitations in domestic capital formation and technological advancement. It contributes not only to the expansion of productive capacity but also plays a transformative role in transferring managerial know-how, advanced technologies, and international business practices. This inflow of external capital is widely seen as a catalyst for integrating developing countries into the global economy, enhancing their competitiveness, and stimulating broader socioeconomic progress. According to Dunning (1993), FDI facilitates the transmission of knowledge, skills,

---

\*Corresponding author: [amel.ogv88@gmail.com](mailto:amel.ogv88@gmail.com)



and capital into the host country's economic system, thereby strengthening its capacity for sustainable development. This view is further supported by the United Nations Conference on Trade and Development (UNCTAD, 2023), which emphasizes in its most recent annual report that FDI remains a major source of external financing for developing nations, contributing to productivity growth, employment generation, and the promotion of export-oriented industrialization. In the case of Libya—a country marked by significant natural resource potential as well as economic and political volatility—understanding the determinants and behavior of FDI is of critical importance. Analyzing how various economic variables have influenced FDI inflows over different time periods provides valuable insights into the opportunities and challenges that shape Libya's development trajectory and can help inform more effective and targeted policy responses.

## **2. FOREIGN DIRECT INVESTMENT (FDI)**

In the context of evolving global economic relations and increasing competition among nations to attract foreign capital, Foreign Direct Investment (FDI) has emerged as a key indicator of the attractiveness and openness of a country's investment climate. As economies seek to integrate more effectively into the international economic system, FDI plays a pivotal role in shaping their development trajectories. It is not merely a source of financial inflows, but a strategic tool that reflects the confidence of international investors in a country's economic, financial, and regulatory environment. Several factors—including macroeconomic stability, market potential, infrastructure readiness, and institutional quality—collectively influence the volume and direction of foreign investments. In this sense, FDI serves as a catalyst for enhancing productive capacity, promoting job creation, and facilitating the transfer of knowledge and technology. For developing countries in particular, FDI offers a pathway toward achieving long-term, sustainable development goals by linking domestic markets with global value chains and fostering economic diversification.

### **2.1 Definition of Foreign Direct Investment (FDI)**

According to the Economic and Social Commission for Western Asia (ESCWA), Foreign Direct Investment (FDI) is defined as a category of international investment that reflects the objective of a resident entity in one economy to establish a lasting interest in an enterprise that is resident in another economy (UNESCWA). In line with this, the United Nations Conference on Trade and Development (UNCTAD, 2023) states that, for an investment to be classified as FDI rather than portfolio investment, the foreign investor must own at least 10% of the equity shares of the target company. This threshold is considered sufficient to establish a significant degree of influence or control over the management of the enterprise.

Foreign Direct Investment (FDI) refers to an ownership stake in a foreign company or project made by an investor, company, or government from another country. FDI is generally used to describe a business decision to acquire a substantial stake in a foreign business or to buy it outright to expand operations to a new region. The term is usually not used to describe a stock investment in a foreign company alone. FDI is a key element in international economic integration because it creates stable and long-lasting links between economies (Kenton, 2022).

### **2.2 The Economic Factors Influencing Foreign Direct Investment (FDI) Inflows:**

Foreign direct investment (FDI) inflows are considered one of the key indicators reflecting the attractiveness of the investment climate in any economy. These inflows are



influenced by a set of economic variables that play a pivotal role in shaping foreign investors' decisions to enter specific markets. In this context, the present study aims to shed light on the most prominent economic factors affecting the volume and direction of FDI inflows.

Particular emphasis is placed on gross domestic product (GDP) as a general indicator of overall economic performance, in addition to exports and imports as measures of economic openness and the degree of integration into the global market. Moreover, the exchange rate is examined as a critical factor in determining the costs and potential returns for foreign investors.

The selection of these variables in this study is based on extensive evidence from previous research, which consistently highlights their significant and effective role in influencing FDI inflows. Economic literature indicates that these factors are among the most influential economic determinants that investors consider when evaluating the attractiveness of foreign markets. As such, they serve as essential components for analyzing and understanding the dynamics of FDI attraction across different economic contexts, particularly within the unique economic environment of the country under study.

- Gross Domestic Product (GDP)

"Gross domestic product is the most commonly used single measure of a country's overall economic activity. It represents the total value of final goods and services produced within a country during a specified time period, such as one year." (IMF) . "In 2022, the Arab Monetary Fund published a comprehensive study titled "Determinants of Foreign Direct Investment Inflows to the Arab Region," which revealed a positive relationship between GDP growth and foreign direct investment (FDI) inflows. The findings indicate that countries experiencing economic growth and flourishing economic activity tend to be more attractive to foreign investors. As national economic performance improves and economic expansion increases, the capacity to attract foreign investments also rises, thereby contributing to long-term economic growth (Arab Monetary Fund, 2022).

In a study entitled "Analyzing the Determinants of Foreign Direct Investment in Arab Countries Using Principal Component Analysis (PCA)," published in October 2019 in the Journal of Finance and Business Economics by the University Center Abdelhafid Boussouf – Mila, Algeria, researchers Mohamed Khaled Sahel and Abdelhak Ben Tefat investigated the key factors influencing foreign direct investment (FDI) inflows in Arab countries. The study employed PCA to identify the most significant variables and found that Gross Domestic Product (GDP) was among the most influential, as it reflects the size of the market and overall economic activity, making it a major attractor for foreign investors (Sahel & Ben Tefat, 2019).

- Exports

The World Bank defines exports as "the total value of all goods and services provided by a country to the rest of the world. This includes not only merchandise but also services such as freight, insurance, transport, travel, royalties, license fees, and other services like communications, construction, financial services, information, business services, personal services, and government-provided services" (World Bank).

Exports are considered a vital indicator of a country's ability to compete in global markets, as well as a reflection of the efficiency of its production and marketing institutions. This, in turn, enhances the attractiveness of the national business environment to foreign investors. The World Investment Report 2024, published by the United Nations Conference on Trade and Development (UNCTAD), indicated that an increase in export capacity is among the key drivers of foreign direct investment (FDI) inflows. Many FDI promotion policies focus on strengthening the international competitiveness of domestic firms, which contributes to creating a more stable and attractive investment environment for foreign capital (UNCTAD, 2024).

– Imports

"Imports are goods and services purchased by residents of a country from the rest of the world. They include both tangible goods and intangible services, and are measured on a transaction basis between residents and non-residents" (OECD).

Economic literature suggests that imports have a dual impact on foreign direct investment (FDI) inflows. On one hand, an increase in imports may indicate a dynamic and attractive domestic market, encouraging foreign companies to invest in order to meet growing local demand. On the other hand, high import levels may exacerbate trade deficits, potentially deterring some foreign investors due to concerns about economic stability. In this context, the World Investment Report 2024 published by the United Nations Conference on Trade and Development (UNCTAD) highlights that trade tensions and global economic slowdown have affected FDI flows, underscoring the importance of understanding the relationship between imports and foreign investment (UNCTAD, 2024).

– Exchange

"The price of one currency in terms of another. An exchange rate indicates how much of one currency you need to buy a unit of another currency. Exchange rates play a key role in international trade and capital flows" (IMF, 2024).

The exchange rate is a crucial determinant of foreign direct investment (FDI) flows, as its fluctuations can significantly impact investment costs and expected returns. A depreciation of the local currency makes domestic assets cheaper for foreign investors, thereby enhancing the host country's attractiveness. A recent study using a global vector autoregressive (GVAR) model confirmed this effect, showing that even third-country exchange rate changes can influence FDI decisions (Sarnstrom & Ryan, 2023).

### **3. DATA AND METHODOLOGY**

This section of the study aims to analyze the relationship between foreign direct investment (FDI) and key macroeconomic variables in Libya, based on annual data covering the period from 1997 to 2024. The timeline is divided into three distinct phases — 1997–2010, 2011–2017, and 2018–2024 — each reflecting major political and economic shifts that have shaped the investment climate in the country.

– Period One (1997–2010):

During this phase, Libya began emerging from international isolation following the lifting of sanctions, which gradually opened the door for the return of foreign investment, particularly in the oil sector. However, the business environment continued to suffer from bureaucracy, weak infrastructure, and a lack of transparency, limiting the effectiveness of efforts to attract foreign capital.

– Period Two (2011–2017):

Following the 2011 revolution, Libya entered a period of deep instability marked by political vacuum and armed conflict, which had a direct impact on the economy. Investment projects were halted, oil production declined, and foreign direct investment plummeted due to heightened risks and the absence of clear economic policies.

– Period Three (2018–2024):

Despite ongoing political division and security challenges, this period witnessed relative stability in certain regions, contributing to a partial recovery in oil production and a modest revival of economic activity. Government efforts emerged to improve the investment climate through incentives and administrative reforms, but overall fragility continued to hinder the establishment of a stable and attractive investment environment.

The study adopts two complementary approaches: the descriptive approach was used to review the literature and define the variables, while the quantitative analytical approach was applied to measure the relationship between foreign direct investment (FDI)—considered the dependent variable—and a set of independent macroeconomic variables, namely: GDP, exports, imports, and the exchange rate. Annual data were analyzed across three time periods (1997–2010, 2011–2017, and 2018–2024), each reflecting major political and economic transformations that influenced the investment environment. Appropriate statistical tools were employed based on the nature of the data, most notably descriptive analysis and correlation matrices, using Python for its precision and efficiency in data processing. This approach aims to trace the evolution of these relationships over time and assess whether conventional economic indicators continue to exert a clear influence on FDI, or whether the unique Libyan context reveals unexpected patterns in investor behavior.

*Table 1. Economic Variables and FDI in Libya – First Period (1997–2010)*

Year	Foreign Direct Investment (Million USD)	GDP (Billion USD)	Exports (Billion USD)	Imports (Billion USD)	Exchange Rate (LYD/USD)
1997	301.4	30.7	8.22	6.71	0.46
1998	383.7	27.25	5.28	5.69	0.47
1999	354.0	35.98	7.27	5.25	0.46
2000	-43.0	38.27	12.08	5.25	0.51
2001	308.0	34.11	9.05	5.67	0.61
2002	-281.0	20.48	9.17	6.98	1.27
2003	-80.0	26.27	15.05	8.75	1.29
2004	-71.0	33.12	21.12	10.72	1.3
2005	-910.0	47.33	30.16	12.85	1.31
2006	-1590.0	60.09	43.17	15.56	1.31
2007	-756.2	68.03	49.96	19.93	1.26
2008	1776.9	86.71	64.27	25.26	1.22
2009	-206.0	60.81	38.45	26.99	1.25
2010	1780.0	75.38	49.96	23.98	1.27

*Table 2. Economic Variables and FDI in Libya – First Period (2011–2017)*

Year	Foreign Direct Investment (Million USD)	GDP (Billion USD)	Exports (Billion USD)	Imports (Billion USD)	Exchange Rate (LYD/USD)
2011	-77.6	48.17	18.37	11.97	1.22
2012	394.9	92.54	61.88	29.02	1.26
2013	439.5	75.35	45.13	35.0	1.27
2014	-294.5	57.37	18.5	25.41	1.27
2015	-159.8	48.72	10.83	16.89	1.38
2016	394.9	49.91	7.28	13.24	1.39
2017	-160.0	67.16	18.26	13.67	1.39

*Table 3. Economic Variables and FDI in Libya – First Period (2018–2024) (IndexMundi; IMF – Article IV Consultation (2024); The Global Economy)*

Year	Foreign Direct Investment (Million USD)	GDP (Billion USD)	Exports (Billion USD)	Imports (Billion USD)	Exchange Rate (LYD/USD)
2018	275.6	76.69	31.5	20.0	1.38
2019	-101.9	72.08	29.0	21.0	1.39
2020	-351.0	65.69	25.0	18.0	1.39
2021	-399.0	47.79	28.0	22.0	1.39
2022	-439.0	55.94	33.0	25.0	1.39
2023	-160.0	50.49	35.4	26.0	1.39
2024	-483.0	49.13	34.0	24.0	1.39

#### 4. RESULTS AND DISCUSSION

*Table 4. Descriptive Analysis*

Variable	Mean (1997–2010)	Std	Mean (2011–2017)	Std	Mean (2018–2024)	Std
GDP	46.04	20.60	62.75	16.68	59.69	11.76
Exports	25.94	19.78	25.75	20.03	30.84	3.68
Imports	12.83	8.07	20.74	9.05	22.29	2.87
Exchange_Rate	1.00	0.39	1.31	0.07	1.39	0.00
FDI	69.06	910.62	76.77	318.25	-236.90	266.93

Descriptive analysis reveals significant variations in the performance of Libya's economic indicators across the three periods. Foreign direct investment (FDI) experienced a substantial decline in the most recent period (2018–2024), reaching a negative average despite improvements in GDP and import levels. Meanwhile, the exchange rate showed signs of stabilization, albeit at relatively high levels. These shifts reflect the ongoing economic and political tensions that have affected FDI flows and highlight the evolving relationship between FDI and macroeconomic variables over time.

The results raise several interesting observations, highlighting the complexity of the investment environment in Libya, which may go beyond the direct influence of economic variables.

##### – Statistical Analysis of the Relationships Between FDI and Other Variables:

The correlation matrices reveal a notable evolution in the relationship between foreign direct investment (FDI) and key economic variables in Libya. While the relationship was weak during the first period (1997–2010), it showed relative improvement in the second period (2011–2017), eventually reaching its peak in the third period (2018–2024). During this phase, GDP exhibited a strong positive correlation with FDI, while the exchange rate showed a strong negative correlation.

Although the second period (2011–2017) was marked by war and political instability, the statistical relationships between foreign direct investment (FDI) and economic variables appeared stronger compared to the previous period. This can be attributed to the liberation of variables from the artificial stability that prevailed prior to 2011, as well as the heightened sensitivity of investor behavior to economic changes in a context of uncertainty. Such an environment allowed for the observation of more transparent and realistic relationships in the data, suggesting that crisis periods—despite their challenges—may reveal economic interactions more clearly due to intensified market responses.

*Table 5. Analysis of the correlation between foreign direct investment and other economic variables*

Time Period	GDP	Exports	Imports	Exchange Rate
1997–2010	0.30	0.17	0.23	-0.20
2011–2017	0.52	0.57	0.44	-0.08
2018–2024	0.76	0.06	-0.33	-0.85

The results indicate that the relationship between foreign direct investment (FDI) and economic variables in Libya varies significantly across the three time periods. During the first period (1997–2010), no statistically significant correlations were observed. However, in the second period (2011–2017), some indicators—such as GDP and exports—began to show clearer associations, despite the context of war and instability. These relationships reached their peak in the third period (2018–2024), particularly between FDI and GDP on one hand, and the exchange rate on the other. This reflects a shift in investor behavior and increased sensitivity to economic indicators in an unstable environment.

*Table 6. Descriptive Analysis*

Variable	Mean (1997–2010)	Std	Mean (2011–2017)	Std	Mean (2018–2024)	Std
GDP	46.04	20.60	62.75	16.68	59.69	11.76
Exports	25.94	19.78	25.75	20.03	30.84	3.68
Imports	12.83	8.07	20.74	9.05	22.29	2.87
Exchange_Rate	1.00	0.39	1.31	0.07	1.39	0.00
FDI	69.06	910.62	76.77	318.25	-236.90	266.93

Analysis shows variation in the performance of economic indicators in Libya over the three periods. Foreign direct investment (FDI) experienced a significant decline in the recent period (2018–2024), with a negative average, meaning that the outflows of investment were greater than the inflows, reflecting a lack of confidence in the investment climate due to economic and political tensions. Despite improvements in GDP and imports during that period, exports did not show the same noticeable improvement, reflecting the challenges faced by the Libyan economy in diversifying its income sources and increasing its exports. As for imports, they continued to increase, indicating a growing reliance on foreign products to meet domestic market needs. Meanwhile, the exchange rate remained at high levels, which impacted the competitiveness of exports and raised the cost of local products. These changes illustrate the complex relationship between foreign direct investment, exports, imports, and macroeconomic factors over time."



*Figure 1. Comparison of Economic Variables Across Three Time Periods*

- The Gross Domestic Product (GDP) increased from 46.04 to 62.75 in the second period (+36%). This rise coincided with an increase in Foreign Direct Investment (FDI) from 69.06 to 76.77 (+11%). This represents the strongest apparent relationship, with an estimated approximation of the effect: approximately 30–40% of the change in FDI may be attributed to the change in GDP.
- Exports remained almost stable before rising to 30.84 in the third period (+20%). However, FDI declined sharply to –236.90. This indicates a weak or inverse relationship.
- Imports increased from 12.83 to 22.29 (+74%). Meanwhile, FDI decreased, indicating an indirect relationship. This suggests a weak or unstable effect.
- The exchange rate increased from 1.00 to 1.39 (+39%). However, this did not coincide with an improvement in FDI, especially in the recent period. This indicates an unclear relationship.

Among the economic variables, GDP is the most influential factor on FDI, with an estimated effect ranging between 30% and 40%, particularly during the period 2011–2017. However, the sharp decline in FDI during the 2018–2024 period, despite the relative stability of GDP, indicates that non-economic factors have become the primary drivers of foreign direct investment behavior in Libya.

## 5. CONCLUSION

The preceding analysis reveals a clear discrepancy between the assumptions of conventional economic theories and previous empirical studies regarding the influence of macroeconomic variables on foreign direct investment (FDI), and the empirical realities of the Libyan economy. This divergence is evident in the patterns observed across the examined periods.

Although certain macroeconomic indicators displayed a degree of correlation with FDI flows, such associations lacked consistency over time, suggesting a disconnect between macro-level performance and actual investment behavior. This inconsistency underscores the dominant role played by structural and institutional factors—particularly political instability, weak governance, and regulatory uncertainty—which appear to overshadow the explanatory capacity of traditional economic variables.

Accordingly, future econometric models aimed at analyzing or forecasting FDI in Libya should incorporate non-economic determinants such as political stability, institutional quality, and risk perceptions. The economic indicators analyzed in this study—despite their theoretical significance—prove to be inadequate proxies for investor decision-making in the Libyan context. As such, these variables fail to constitute a robust or credible foundation for modeling aggregate investment behavior, and should be treated with caution in future empirical frameworks.

## REFERENCES

- Arab Monetary Fund. (2022). *Determinants of foreign direct investment inflows to the Arab region*. <https://www.amf.org.ae/ar/news/14-04-2022/sndwq-alnqd-alrby-yusdr-drast-hwl-mhddat-tdfqat-alastthmar-alajnby-almbashr-ildwl>
- Dunning, J. H. (1993). *Multinational enterprises and the global economy* (1st ed., pp. 298–299). Addison-Wesley Publishing Company.

- International Monetary Fund (IMF). (n.d.). *Glossary of statistical terms – Gross domestic product (GDP)*. <https://www.imf.org/en/About/Glossary>
- Kenton, W. (2022, November 30). Foreign direct investment (FDI): What it is, types, and examples. *Investopedia*. <https://www.investopedia.com/terms/f/fdi.asp>
- OECD. (n.d.). *Glossary of statistical terms – Imports*. <https://stats.oecd.org/glossary/detail.asp?ID=1350>
- Sahel, M. K., & Ben Tefat, A. H. (2019). An analysis of the determinants of foreign direct investment in Arab countries using the principal component analysis method. *Journal of Finance and Business Economics*, Abdelhafid Boussouf University Center – Mila, Algeria.
- Sarnstrom, T., & Ryan, M. (2023). Third-country exchange rate effects on foreign direct investment flows: A global vector autoregressive approach. *Review of International Economics*, 31(2), 522–549. <https://doi.org/10.1111/roie.12636>
- UNCTAD. (2023). *World investment report 2023: Investing in sustainable energy for all* (Report No. UNCTAD/WIR/2023, p. 4). United Nations Conference on Trade and Development. <https://unctad.org/publication/world-investment-report-2023>
- UNCTAD. (2024). *World investment report 2024: Investing in sustainable energy for all*. United Nations Conference on Trade and Development. <https://unctad.org/publication/world-investment-report-2024>
- United Nations Economic and Social Commission for Western Asia (UNESCWA). (n.d.). Foreign direct investment. In *Manual on international trade in services statistics* (Series M, No. 86). United Nations Conference on Trade and Development, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development. <https://www.unescwa.org/ar/sd-glossary>
- World Bank. (n.d.). *Exports of goods and services (% of GDP)*. World Bank DataBank – World Development Indicators. <https://databank.worldbank.org/metadataglossary/jobs/series/NE.EXP.GNFS.ZS>



## THE SIGNIFICANCE OF THE COURT OF JUSTICE OF THE EUROPEAN UNION JUDGMENT OF 30 APRIL 2024 IN CASE C-670/22 (“ENCROCHAT”) FOR THE ADMISSIBILITY OF EVIDENCE IN CRIMINAL PROCEEDINGS

Remigijus Merkevičius\*

*Vilnius University, Faculty of Law, Lithuania*

**Abstract:** This article analyses the judgment delivered by the Court of Justice of the European Union (CJEU) on 30 April 2024 in Case C-670/22 (“EncroChat”) and its implications for the admissibility of evidence in national criminal proceedings. According to the CJEU, a European Investigation Order (EIO) requesting evidence already held by the executing Member State may only be issued by a competent authority as defined by the issuing State's national law. When issuing such an EIO, the issuing authority must assess its compliance with (i) the classic principles of *necessity* and *proportionality* as set out in Article 6(1)(a) of the Directive and (ii) all “material conditions” prescribed by national law for the sharing of evidence in domestic proceedings. This includes, *inter alia*, evaluating the effect of the executing State’s refusal to disclose the technical features of the tools used to infiltrate the encrypted telecommunications system, comparing the categories of investigated criminal offences, and the coercive procedural measures used to obtain the data in question. The ability of the issuing State to use such evidence depends directly on (i) the conditions and procedures of its collection in the executing State and (ii) the defendant’s awareness and ability to effectively challenge it. Where the defendant cannot meaningfully dispute the authenticity, legality or reliability of the evidence, such evidence must be excluded. In addition, if, *in concreto*, such a coercive measure would not be permissible under the issuing State’s domestic law, the exclusion of that evidence is also governed by Article 31(1) and (3) of the Directive.

**Keywords:** Admissibility of evidence, Court of Justice of the European Union, EncroChat, Encrypted communication, European Investigation Order.

### 1. INTRODUCTION

Eurojust, Europol, and national law enforcement authorities almost annually report successful infiltrations into encrypted telecommunications systems used by organised criminal groups for conspiratorial purposes. These operations have yielded substantial incriminating

---

\* Corresponding author: [remigijus.merkevicius@tf.vu.lt](mailto:remigijus.merkevicius@tf.vu.lt)

Remigijus Merkevičius, ORCID: 0009-0009-4555-0018



evidence and led to severe blows against organised crime. For instance, in July 2020, it was announced that French and Dutch law enforcement authorities had jointly “cracked” the encrypted telecommunications system EncroChat, which had around 60,000 users. Notably, the infiltration was carried out without regard to the users’ territorial location or the jurisdiction in which they were situated. In March 2021, an even greater success was reported: through the joint efforts of French, Dutch, and Belgian law enforcement authorities, the encrypted communications system SKY ECC, used by more than 170,000 individuals, was intercepted, and over 20 million messages and other information transmitted via this covert channel were seized. In June 2021, it was revealed that the US Federal Bureau of Investigation had created and administered its own encrypted network, ANOM, which it monitored, controlled, and recorded *ab initio*, using the obtained data to initiate criminal prosecutions. One of the most recent developments came in December 2024, when the takeover of data from the encrypted telecommunications system MATRIX was publicly announced. Thus, covert law enforcement infiltrations into encrypted telecommunications systems represent the new reality of criminal justice. Sommer (2023) has referred to this as “the direction in which the criminal process of the future is developing – a digitalised and, above all, Europeanised criminal process” (Sommer, 2023). On the one hand, we can indeed commend law enforcement for its ability to respond effectively and pragmatically to criminal behaviour shaped by modern technologies. On the other hand, however, the use of such data in criminal proceedings can determine the fate of many individuals and is therefore permissible only if it is lawful. It is no coincidence that Strate (2022) opens his analysis with the vivid expression: “The road to hell is paved with good intentions” (Strate, 2022).

A second, equally evident, reality of contemporary criminal justice is the “free” – unrestrained and uncontrolled – sharing of covertly obtained information. U. Sommer aptly observes that the mutual “legal assistance” between democratic states and the mutual trust displayed towards investigating authorities serve as a kind of “magic hood” (Ger. *Tarnkappe*) used to cover and thereby conceal the quiet displacement of judicial transparency and foreseeability from legal processes, replacing them with a gateway to unlimited criminal prosecution (Sommer, 2024). For example, the results of secret operations by the French law enforcement authorities, which deeply intruded into individual privacy, were widely disseminated to counterparts in states that had not directly participated in those covert investigations. It is therefore unsurprising that mass arrests, searches, asset seizures, indictments and convictions followed across Europe based on this information. For instance, more than 2,000 preliminary investigations were launched in Germany alone on the basis of EncroChat data intercepted by French law enforcement authorities and transferred to Germany (Gebhard & Michalke, 2020; Kipker & Bruns, 2022; Lenk, 2024). Europol reports that, based on this information, more than 6,500 suspects were arrested, nearly €740 million in cash was confiscated, over 30 million tablets of synthetic drugs were seized, as well as more than 103 tonnes of cocaine. The scale is staggering.

Cooperation between law enforcement authorities and the sharing of information are, *per se*, undoubtedly a *conditio sine qua non* for effective criminal justice. Mutual trust is one of the core ideas uniting the Member States of the European Union (hereinafter – the EU). However, the problem that determines the relevance of this discussion lies in the fact that the “hacking” of an encrypted telecommunications system and the acquisition and use of a substantial amount of its content for incriminating purposes constitute a serious intrusion into individual privacy. Such intrusion cannot be justified merely by the popular slogan that “only or mostly criminals use encrypted communications.” From a formal procedural perspective, the information covertly obtained through infiltration of encrypted telecommunications systems by France was shared with other EU Member States by means of legal cooperation instruments –

namely, European Investigation Orders (hereinafter – EIO) submitted by the requesting states to obtain evidence already in the possession of the French authorities, acting as the executing state. However, the legal basis for the use of coercive procedural measures that restrict privacy differs across EU Member States. In some respects, it is even questionable whether national law permits actions of the nature, scale and intensity actually carried out *in concreto* by the law enforcement authorities of France, the Netherlands, or other countries. Therefore, the aim of this discussion is not to limit the capabilities of law enforcement or to deprive them of effective tools, but rather to assess and ensure legality – without which the concept of the “rule of law” cannot exist.

A third significant aspect is that the French authorities have refused to disclose the technical means, methods, and tools by which they succeeded in intercepting the data transmitted via the encrypted telecommunications system in question, how the recipients of the communication (users or end devices) were identified, and so forth. In France, this has been classified as a matter of “national security secrecy” (Fr. *secret de la défense nationale*). In such a situation, during criminal proceedings taking place in different states, not only do the accused lose the opportunity to verify and assess the integrity, authenticity, and reliability of the covertly obtained data, but so does the court. This increases the risk of fatal error – the danger that an innocent person may be convicted – and raises serious concerns about the legitimacy of using such acquired and transferred data in national criminal proceedings. For instance, Zimmermann (2022) questions the entire process of obtaining and using these data: the installation of spyware on the EncroChat server, the transmission of the data collected by French authorities to authorities in other states, and the processing and use of those data for incrimination purposes (Zimmermann, 2022). Not only criminal procedural aspects are being debated, but also constitutional and personal data protection issues (Derin & Singelnstein, 2021).

Initially, individual nation states attempted to resolve these issues independently – each in their own way, as best they could (Škulić, 2024). Recognising the seriousness of the situation in terms of privacy protection and the need to assess the matter systematically, including in the context of legal cooperation within the EU, the Berlin Regional Court (Ger. *Landgericht Berlin*), in its decision of 19 October 2022 on a request for a preliminary ruling, referred five essential questions to the Court of Justice of the European Union (hereinafter – the CJEU). These questions concerned the interpretation of Articles 7, 8, and 11 of the Charter of Fundamental Rights of the European Union (hereinafter – the Charter), as well as Article 6(1) (in conjunction with point (c) of Article 2), and Articles 31(1) and (3) of Directive 2014/41/EU of the European Parliament and of the Council of 3 April 2014 regarding the European Investigation Order in criminal matters (hereinafter – the Directive). These questions arose in the context of the use, in German criminal proceedings, of data obtained from France, which had been collected by French law enforcement authorities through covert infiltration of the encrypted telecommunications system EncroChat. The judgment in the case, registered as Case C-670/22, was delivered by the CJEU on 30 April 2024 (hereinafter – the CJEU judgment).

This naturally raises the question of whether, and if so to what extent, the judgment of the CJEU affects the legitimacy of data (evidence) used in national criminal proceedings, where such data have been collected through covert infiltration of an encrypted telecommunications system by one EU Member State and subsequently transferred to another under a European Investigation Order. Although the CJEU judgment examined and assessed only the use of data obtained through covert infiltration of encrypted communications via the EncroChat devices and system (undoubtedly taking into account the specific nature of the infiltration in that particular case), it can nevertheless be argued that, provided the essential factual and legal circumstances described in the judgment remain unchanged (lot. *mutatis mutandis*), the legal conclusions and value-based directions articulated by the CJEU regarding the admissibility of

data (evidence) should apply irrespective of the name of the encrypted communication system in question (Lödden & Mania, 2025).

## **2. LITERATURE REVIEW**

Less than a year has passed since the CJEU delivered its judgment, and it has therefore not yet attracted extensive attention in criminal procedure law scholarship. The key academic debate took place prior to the publication of the CJEU judgment. This article does not focus on the legal framework of any single Member State but rather seeks to offer broader insights. As the initiator of the judicial proceedings before the CJEU, Germany has shown a clear interest in obtaining a well-founded doctrinal justification for the legality of using such data (evidence). Accordingly, the scientific analysis in this article is based primarily on selected works by prominent German legal scholars, including R. Michalke, M. Lenk, U. Sommer, G. Strate, F. Zimmermann, among others.

## **3. METHODOLOGY**

In conducting the research and formulating conclusions, classical scientific research methods typical and essential for legal analysis were employed. These included the logical-systematic method, legal document analysis, comparative method, as well as other methods of legal interpretation and application.

## **4. RESULTS AND DISCUSSION**

Given, on the one hand, the rather superficial, formal, and prosecutorial approach taken by many states towards the use of encrypted telecommunications data covertly obtained by France in their national criminal proceedings, and, on the other hand, the profound consequences that the use of such data has had on the lives of numerous individuals, various stakeholders placed vastly different hopes in the CJEU judgment. It appears that, due to its considerable level of abstraction, somewhat convoluted rhetoric, and an evidently deliberate intention to limit itself to matters related to the issuance of the EIO, the CJEU judgment somewhat disappointed all sides. It is therefore not surprising that the judgment has been met with ambivalence in public discourse: some praised the CJEU in celebratory tones, welcoming its contribution to the effectiveness of criminal prosecution in the most serious offences; others, disappointed, questioned whether the judgment had effectively given a green light to forum shopping in criminal proceedings – that is, strategic manipulation of criminal jurisdiction (Gebhard & Michalke, 2020). It is still too early to state definitively what significance the CJEU judgment will ultimately have. In its essential part – the admissibility of evidence in the criminal proceedings of the issuing state – the judgment is formulated in terms that are far too abstract. Its actual significance will depend on how it is interpreted and applied by national courts. The first signals have already emerged. For example, by its decision of 1 November 2024 in case no. 2 BvR 684/22, the German Federal Constitutional Court declared inadmissible a constitutional complaint that raised questions regarding the inadmissibility of EncroChat data obtained from France in German criminal proceedings. Without delving into the reasoning of this decision, it seems that key legal aspects highlighted in the CJEU judgment continue to be overlooked (Meyer-Mews, 2025). This is cause for concern and calls for a more thorough discussion of the judgment, which not only directly answers questions related to the issuance of an EIO for evidence already in possession of the executing state but also sets out a clear

value-based direction for assessing the legitimacy of using such data in the criminal proceedings of the issuing state.

#### **4.1. Who Can Issue an EIO to Obtain Evidence Already in the Possession of the Executing State, and Under What Conditions?**

In its judgment, the CJEU stated that the authority entitled to issue an EIO and the conditions under which an EIO may be issued to obtain evidence already in the possession of the executing state are determined by the criminal procedure law of the issuing state. An EIO for the transfer of evidence already held by the executing state “does not necessarily have to be issued by a court, where, under the law of the issuing state, the initial collection of such evidence in a purely domestic procedure would have required a court order, but the public prosecutor is competent to request the transfer of such evidence” [§ 77]. However, “where under the law of the issuing state the public prosecutor does not have the competence to order the transmission of evidence already held by the competent national authorities <...>, the prosecutor cannot be regarded as a competent issuing authority within the meaning of this provision” [§ 75]. Thus, when assessing the issuing of an EIO aimed at obtaining evidence already in the possession of the executing state, it is not decisive whether, had the same evidence been collected within the issuing state, a judicial decision (authorisation) would have been required. An EIO may be issued by a prosecutor, provided that, under the law of the issuing state, the prosecutor is authorised to determine the “sharing” of such evidence in domestic criminal proceedings. Therefore, in evaluating the legitimacy of issuing an EIO, the decisive criterion is not the conditions for *obtaining* the evidence, but the authority, legal basis, and procedure for the *transfer* of such evidence under the law of the issuing state.

The CJEU’s interpretation was welcomed with great enthusiasm by prosecuting authorities. Although a position that excludes judicial oversight *a priori* – at the initial stage of evidence collection – significantly weakens the effectiveness of human rights protection, this interpretation must nevertheless be approached with due caution. The CJEU equated the “sharing of evidence” between EU Member States with the “sharing of evidence” within a single Member State (a position that is not without controversy, though it will not be assessed in the present context). At the same time, however, the CJEU imposed a strict obligation on the issuing state to comply fully with the procedural conditions and rules laid down in its own national law. In simple terms, the judgment does not justify an unconditional or purely formal conclusion that “the public prosecutor is always competent.”

#### **4.2. Can an EIO Seeking to Obtain Evidence Already in the Possession of the Executing State Be Issued Only If Such Evidence Was Obtained in Accordance With the Conditions Laid Down in the Law of the Issuing State?**

The CJEU essentially rejected a direct link between the *collection* of evidence and the *transmission* of evidence, and, more specifically, the notion that the lawfulness of the *transmission* depends on whether the evidence was obtained *in accordance with the law* of the issuing state. This conclusion by the CJEU once again generated enthusiasm among prosecuting authorities. However, even in this legal context, the CJEU’s reasoning must be considered in a systematic manner: although the lawfulness of the *transmission* of evidence under an EIO does not directly depend on whether such evidence could have been lawfully obtained under the law of the issuing state, the lawfulness of the *transmission per se*, by means of an EIO, does not *ipso facto* create or guarantee the issuing state’s procedural freedom to use the evidence without limitation in its own criminal proceedings.

In its judgment, the CJEU pointed out that Article 6(1)(a) of the Directive:

(i) does not require that the issuance of an EIO seeking to obtain evidence already held by the executing state necessarily depend on the existence, at the time of issuance, of a specific factual suspicion that a serious offence has been committed by each individual concerned, provided that such a requirement is not imposed by the law of the issuing state; and

(ii) does not preclude the issuance of an EIO where the integrity of the data obtained by means of the investigative measure applied in the executing state cannot be verified due to the non-disclosure of the technical basis enabling the use of that measure – again, on the condition that the right to a fair trial will be ensured in the subsequent criminal proceedings [§§ 89–90].

Thus, the CJEU clearly distinguishes, on the one hand, the initial process – the *transmission* of evidence under an EIO – from, on the other hand, the final stage – the *assessment of evidence obtained* via the EIO. Moreover, in both legal aspects concerning the use of evidence under an EIO, the CJEU’s reasoning is conditional – and such conditions may, *in concreto*, prove to be decisive.

From the perspective of “material conditions,” Article 6(1)(b) of the Directive is linked solely to the requirements laid down in the law of the issuing state [§§ 91–94]. Therefore, if, under the law of the issuing state, the transmission of evidence (within that state) is permitted only in the presence of specific facts relating to serious offences committed by the accused, or if only under such conditions may evidence containing the data in question be assessed, the issuance of an EIO is dependent on the fulfilment of all such conditions [§ 95]. In this regard, the CJEU rightly highlighted a broader value-based orientation: Article 6(1)(b) of the Directive aims to prevent the circumvention of the rules and safeguards established under the national law of the issuing state [§ 97].

According to the CJEU judgment, the issuing authority must *ab initio* – that is, at the moment of issuing the EIO – verify and assess whether the request to obtain evidence already in the possession of the executing state complies with: (i) the classical principles of *necessity* and *proportionality as laid down* in Article 6(1)(a) of the Directive; and (ii) all the “material conditions” that, under the law of the issuing state, govern the possibility of “sharing evidence” in domestic criminal proceedings. Although different Member States apply different national conditions for the internal “sharing of evidence” in criminal proceedings, issuing authorities must, as a general rule, prior to issuing an EIO seeking to obtain evidence already held by the executing state, first answer the question of whether, without knowledge of the technical characteristics of the measures used by the executing state’s law enforcement authorities to covertly infiltrate the encrypted telecommunications system and extract its data, it is possible to fulfil all the “material conditions” required under the issuing state’s national law for the internal sharing of such data. Even *in abstracto*, that is often not feasible.

On the other hand, when defining the legal possibility of “sharing evidence” in domestic criminal proceedings, the law of the issuing state often requires a comparison not only of the offences under investigation in different cases, but also of the specific coercive measures by which the requested data were obtained. A comparison of coercive measures first and foremost requires an assessment of whether, under the law of the issuing state, there is any legal basis at all for conducting investigative actions of the nature, scale, and intensity actually carried out *in concreto* by authorities from France, the Netherlands, or other states when infiltrating encrypted telecommunications systems. In some EU Member States, such as Lithuania, the criminal procedure law does not contain specific coercive measures that would legitimise remote access to a closed information system and the control of all data flows within it. However, even in those Member States whose criminal procedure laws provide for the use of certain covert measures targeting information systems, legal scholarship still questions whether the existing

legal framework can justify investigative actions of the type, scope, and intensity conducted by French and Dutch officials.

For instance, section 100b of the German Code of Criminal Procedure (Ger. *Strafprozessordnung*) provides for a special coercive measure known as *Online-Durchsuchung* (online or remote search and seizure), which allows covert (without the knowledge of the data subject) access to an IT system used by the individual and the extraction of data from it using technical means. However, even with such specific legal provisions aimed at legitimising intrusions into fundamental rights, German criminal procedure scholarship questions whether the actions and measures taken by the French authorities could be considered equivalent to and justified under section 100b of the German Code of Criminal Procedure (Gebhard & Michalke, 2020; Derin & Singelstein, 2021; Löffelmann, 2022; Schmidt, 2022; Strate, 2022; Lödden & Makepeace, 2023; Sommer, 2023; Meyer-Mews, 2024). Ultimately, the comparison of coercive measures inevitably presupposes an analysis of the essential conditions under which such measures may be applied, one of which is usually the existence of a justified *in personam* suspicion (Gebhard & Michalke, 2020; Meyer-Mews, 2024; Meyer-Mews, 2025). Without knowing the technical method by which the data were obtained, it is not even possible to conduct a rational comparison between the actions and measures taken by the authorities of France, the Netherlands, or other states and those that could hypothetically be carried out lawfully under the law of the issuing state (Schmidt, 2022). Strate (2022) also notes that, *in concreto*, both sides – German and French – knew that the Directive does not, in principle, provide a legal basis for using a “Trojan” to take over a server and access all stored mobile communication content; therefore, such use of a Trojan could not, in any case, have been the subject of an EIO (Strate, 2022).

#### **4.3. Under What Conditions May Evidence Collected by the Executing State and Transferred to the Issuing State Under an EIO Be Used in the Issuing State's Criminal Proceedings?**

In this respect, the CJEU judgment rightly points out, first of all, that the principle of mutual recognition of judicial decisions does not grant the issuing authority seeking, by means of an EIO, to obtain evidence already held by the executing state, the right to examine the lawfulness of the proceedings in which that evidence was collected by the executing state [§§ 99–100]. At the same time, however, it emphasises that individuals affected by certain investigative measures are entitled to judicial protection of their fundamental rights under the Directive [§ 101]. Article 14(1) of the Directive requires Member States to ensure that remedies are available in respect of investigative measures requested in an EIO, and that such remedies must be equivalent to those that would be available in a comparable domestic (national) case [§ 102]. If the transmission of evidence already in the possession of the executing state to the issuing state appears disproportionate in relation to the objectives of the criminal proceedings being conducted in the issuing state against the person concerned – e.g. because it constitutes a serious infringement of that person's fundamental rights, or because the investigative measure was carried out in breach of the legal provisions that would apply in a similar domestic case – then the court examining a complaint against the EIO requesting the transfer of such evidence would be obliged to draw the conclusions required under the applicable national law of the issuing state.

On the other hand, Article 14(7) of the Directive obliges Member States to ensure that, in criminal proceedings taking place in the issuing state, the evaluation of evidence obtained through an EIO guarantees the rights of the defence and safeguards the fairness of those proceedings (the right to a fair trial) [§§ 103–104]. If it is established that a party to the

proceedings is unable to properly and effectively present their position regarding evidence that may have a significant impact on the assessment of the facts, the court must find a violation of the right to a fair trial and exclude that evidence from the proceedings [§§ 105, 130–131]. According to Meyer-Mews (2024, 2025), the CJEU judgment articulates “an absolute exclusionary rule that is not subject to balancing against other competing values in the specific case” (Ger. *ein abwägungsfestes absolutes Beweisverbot*) (Meyer-Mews, 2024; Meyer-Mews, 2025).

Thus, when assessing the CJEU’s reasoning as a whole, it becomes clear that the Court separated the conditions for *issuing* an EIO from the criteria that govern how evidence obtained through such an order must be *assessed* in the issuing state. As previously mentioned, the lawfulness of issuing an EIO does not grant the issuing state the freedom to use the evidence obtained under it without limitation in its domestic criminal proceedings. The admissibility of evidence obtained under an EIO – namely, evidence already in the possession of the executing state and shared with the issuing state – depends directly on (i) the conditions and procedures under which the evidence was collected in the executing state, and (ii) whether the accused was aware of those circumstances and had the opportunity to effectively comment on them. If the accused’s knowledge of the evidence transmitted to the issuing state under the EIO does not enable them to properly and effectively express their position regarding its lawfulness, reliability, accuracy, authenticity, and other essential characteristics, such evidence – without denying or undermining the *principle of mutual recognition of judicial decisions* – cannot be used in the evidentiary process conducted in the issuing state. It is evident that knowledge of the technical details regarding how the tools used to intercept encrypted telecommunications content were designed and operated constitutes one of the *conditio sine qua non* for an effective defence.

In the context of the admissibility of evidence collected by the authorities of the executing state and subsequently transferred to the issuing state under an EIO for use in the issuing state’s criminal proceedings, the CJEU also referred to Article 31(1) and (3) of the Directive, which, among other things, aim to protect the rights of individuals (mobile network users) affected by telecommunications interception measures [§ 125]. Article 31 of the Directive is intended to safeguard not only the sovereignty of the state to which notification is given, but also the level of protection afforded under that state’s law concerning the lawfulness of telecommunications surveillance (information interception), ensuring that it is not diminished in comparison to what would apply in a purely domestic procedure. Since telecommunications surveillance (interception of information) constitutes an interference with the right to respect for private life and the confidentiality of communications enshrined in Article 7 of the Charter, Article 31 of the Directive also seeks to protect the rights of persons subjected to such measures. This objective includes safeguarding those rights in relation to the use of the intercepted data for the purposes of criminal prosecution in the notified state [§ 124].

Articles 31(1) and (3) of the Directive essentially imply that if both the intercepting state and the notified state properly fulfil their obligations under these provisions, the competent authorities of the intercepting state cannot carry out telecommunications surveillance (interception of information) on the territory of the notified state if such action would not be permitted under the national law of that state. Gebhard and Michalke (2020) rightly observe that this is not an obligation that a Member State may choose to disregard (Gebhard & Michalke, 2020). If either of the states concerned fails to properly or timely fulfil its obligations under Article 31(1) or (3) of the Directive – be it the intercepting state failing to inform the other state of the measures being implemented on its territory, or the notified state failing to prevent the unlawful interception of information (i.e. in violation of its own national law) – then

permitting the use of such evidence in the issuing state's criminal proceedings would amount to circumventing the rules and safeguards laid down in the Directive (Schmidt, 2022).

Thus, the CJEU judgment also implies a legal conclusion that, if under the domestic law of the issuing state (which, in the legal context under discussion, is the notified state) a certain measure involving access to end-user telecommunications devices – for the purpose of intercepting the flow, location, and metadata of internet-based communications – could not *in concreto* be applied on its territory, then data obtained through such a measure by the intercepting state may not be used as incriminating evidence in the criminal proceedings of the issuing state. This conclusion must be drawn regardless of whether the measure applied was lawful and legitimate under the law of the intercepting (executing) state, and irrespective of whether the obligations set out in Article 31(1) and (3) of the Directive were formally fulfilled.

## 5. CONCLUSION

The Directive does not require that an EIO seeking to obtain evidence already held by the executing state be issued by a court. However, this does not automatically imply that such an EIO may be issued by a public prosecutor. The competent authority and the conditions under which an EIO of this kind may be issued are determined by the national law of the issuing state.

When issuing an EIO seeking to obtain evidence already held by the executing state, the issuing authority must assess whether the EIO complies with: (i) the classical principles of *necessity* and *proportionality* set out in Article 6(1)(a) of the Directive; and (ii) all the “material conditions” which, under the national law of the issuing state, define the possibility of “sharing evidence” in its domestic criminal proceedings. Specifically, the issuing authority must assess the impact and legal relevance of the fact that the executing state does not disclose the technical characteristics of the measures used to infiltrate the encrypted telecommunications system. It must also compare the categories of criminal offences under investigation, as well as the specific coercive measures by which the data to be “shared” were obtained. The lawfulness of issuing an EIO seeking to obtain evidence already held by the executing state does not grant the issuing state unrestricted freedom to use the evidence obtained through that EIO in its domestic criminal proceedings. The admissibility of such evidence – already in the possession of the executing state and subsequently shared with the issuing state – depends directly on: (i) the conditions and procedures under which the evidence was collected in the executing state; and (ii) the extent to which the accused was informed about those conditions and had the opportunity to effectively respond to them. If the accused's knowledge of the evidence is insufficient to enable them to properly and effectively express their views on its validity, lawfulness, authenticity, reliability, and other essential conditions and characteristics, such evidence may not be used in the evidentiary process conducted in the issuing state.

From the perspective of Article 31(1) and (3) of the Directive, if a specific measure – namely, one involving access to end-user telecommunications devices for the purpose of intercepting the flow, location, and metadata of internet-based communications – could not *in concreto* be applied on the territory of the issuing state under its national law, then the data obtained through such a measure by the intercepting (executing) state may not be used as incriminating evidence in the issuing state's criminal proceedings.

## REFERENCES

Berlin Regional Court (Germany). (2022, October 19). Request for a preliminary ruling in the criminal case against M. N.



- <https://curia.europa.eu/juris/showPdf.jsf?text=&docid=268449&pageIndex=0&doclang=EN&mode=req&dir=&occ=first&part=1&cid=3474663> [accessed 29 March 2025].
- Charter of Fundamental Rights of the European Union. (2016). OJ C 202/02, 389–405.
- Court of Justice of the European Union. (2024, April 30). EncroChat, C-670/22. ECLI:EU:C:2024:372.
- Derin, B., & Singelstein, T. (2021). Use and exploitation of data from large-scale intrusions into information technology systems from abroad [Verwendung und Verwertung von Daten aus massenhaften Eingriffen in informationstechnische Systeme aus dem Ausland (EncroChat)]. *Neue Zeitschrift für Strafrecht*, 449 - 454. (in German)
- Directive 2014/41/EU of the European Parliament and of the Council of 3 April 2014 regarding the European Investigation Order in criminal matters. OJ L 130, 1–36.
- Federal Constitutional Court of Germany. (2024, November 1). Judgment in case No. 2 BvR 684/22. [https://www.bundesverfassungsgericht.de/SharedDocs/Entscheidungen/DE/2024/11/rk20241101\\_2bvr068422.html?nn=68080](https://www.bundesverfassungsgericht.de/SharedDocs/Entscheidungen/DE/2024/11/rk20241101_2bvr068422.html?nn=68080) [accessed 29 March 2025].
- Gebhard, A., & Michalke, R. (2020). The end does not justify the means – The EncroChat complex and the limits of the use of evidence in criminal proceedings [Der Zweck heiligt die Mittel nicht – Der EncroChat-Komplex und die Grenzen strafprozessualer Beweisverwertung]. *Neue Juristische Wochenschrift*, 655–659. (in German)
- Kipker, D.-K., & Bruns, H. (2022). EncroChat und die „Chain of Custody“. Digitale Ermittlungen als Bewährungsprobe für ein Recht auf faires Verfahren? [EncroChat and the "chain of custody": Digital investigations as a test case for the right to a fair trial?] *Multimedia und Recht*, 363–368. (in German)
- Lenk, M. (2024). The development of European evidence law in light of the "EncroChat proceedings [Die Entwicklung des europäischen Beweisrechts im Lichte der „EncroChat-Verfahren]. *Europarecht*, 51–76. (in German)
- The Code of Criminal Procedure of the Republic of Lithuania [Lietuvos Respublikos baudžiamojo proceso kodeksas] (2002). Official Gazette [Valstybės žinios], 37–1341. (in Lithuanian)
- Lödden, C., & Makepeace, J. (2023). Same same but different: SkyECC – or how European law enforcement agencies intercepted a billion messages over 21 months [Same same but different: SkyECC oder wie europäische Strafverfolgungsbehörden eine Milliarde Nachrichten über 21 Monate lang abgefangen haben]. *HRRS*, December, 384–391. (in German)
- Lödden, C., & Mania, L. (2025). No 'fear' of rule-of-law consequences of the KCanG – The limitation on use and the EncroChat decision of the Federal Court of Justice (BGH). [Keine 'Angst' vor rechtsstaatlichen Folgen des KCanG – Die Verwendungsschranke und die EncroChat-Entscheidung des BGH]. *HRRS*, January, 11–19. (in German)
- Löffelmann, M. (2022). Exclusionary rule for data transfers from abroad [Verwertungsverbot bei Datentransfer aus dem Ausland]. *Juristische Rundschau*, 9, 454–460. (in German)
- Meyer-Mews, H. (2024). EncroChat: Game, set, and match for the Berlin Regional Court. Commentary on the CJEU judgment, HRRS 2024 [EncroChat: Spiel, Satz und Sieg für das LG Berlin. Anmerkung zum Urteil des EuGH HRRS 2024] Nr. 644. *HRRS*, June, 191–197. (in German)
- Meyer-Mews, H. (2025). Some remarks on the EncroChat decision of the Federal Constitutional Court (BVerfG) [Einige Bemerkungen zum EncroChat-Beschluss des BVerfG] HRRS 2025 Nr. 1. *HRRS*, January, 19–24. (in German)
- Schmidt, A. (2022). On the admissibility in criminal proceedings of data from the surveillance of encrypted mobile phones by another EU Member State [Zur strafprozessualen

- Verwertbarkeit der Daten aus der Überwachung verschlüsselter Mobiltelefone durch einen anderen Mitgliedstaat der EU] *Juristische Rundschau*, 134(4), 982–1015. <https://doi.org/10.1515/zstw-2022-0029> (in German)
- Škulić, M. (2024). Evidentiary value of information from communication conducted via applications / modified encryption devices – such as SKY ECC and EncroChat. [Dokazni značaj informacija iz komunikacije ostvarene aplikacijama / modifikovanim uređajima za kriptovanje – kao što su SKY ECC i EncroChat]. *Crimen*, 15, 3–55. (in Serbian)
- Sommer, U. (2023). Chat about EncroChat. *Strafverteidiger Forum*, 7, 250–259. (in German)
- Sommer, U. (2024). ANOM, or: how the rule of law can produce injustice. [ANOM oder: wie der Rechtsstaat Unrecht produzieren kann]. *HRRS*, December, 394–401. (in German)
- German Code of Criminal Procedure [Strafprozessordnung] (2025, March, 29) <https://www.gesetze-im-internet.de/stpo/> (in German).
- Strate, G. (2022). EncroChat – some additional thoughts [EncroChat – einige ergänzende Gedanken]. *HRRS*, January, 15–18. (in German)
- Strate, G. (2024). The CJEU decision on EncroChat. [Die EuGH-Entscheidung zu EncroChat]. *HRRS*, July, 226–231. (in German)
- Zimmermann, F. (2022). The admissibility of foreign evidence in light of the EncroChat investigations. [Die Verwertbarkeit von Auslandsbeweisen im Lichte der EncroChat-Ermittlungen]. *Zeitschrift für Internationale Strafrechtswissenschaft*, 2, 173–190. (in German)



## OVERTOURISM AND SUSTAINABLE TOURISM

Lachi Cristina \*

*State Univeristy of Moldova, Faculty of Economic Sciences, Republic of Moldova*

**Abstract:** This document examines the phenomenon of overtourism within the global tourism landscape and proposes sustainable, data-driven solutions. The introduction outlines the rapid growth of international tourism and the resulting pressures on popular destinations. A global analysis follows, identifying overtourism hotspots through quantitative indicators and assessing their economic and social consequences. The integration of diverse datasets offers insights into the systemic nature of overtourism and the need for informed policy responses. Evidence-based approaches to sustainable tourism are then explored. These include policy interventions aimed at managing tourist flows, preserving local communities, and maintaining environmental balance. The effectiveness of these strategies is evaluated over time, with key lessons drawn from global best practices. The study also considers Moldova's current tourism profile, emphasizing the importance of diversifying tourism products to reduce future risks of overtourism. Strategic observations highlight Moldova's potential for sustainable development, provided that proactive measures are adopted. In conclusion, the paper presents a set of strategic recommendations, detailing specific initiatives to promote responsible tourism. Each recommendation is aligned with long-term sustainability goals and addresses both national and local priorities. Overall, this research contributes to the development of resilient tourism models in the face of growing global challenges.

**Keywords:** Overtourism, sustainable tourism, policy interventions, tourism development, data-driven analysis.

### 1. INTRODUCTION: THE GLOBAL TOURISM LANDSCAPE

The global tourism industry has shown remarkable resilience in the wake of the COVID-19 pandemic, exhibiting signs of recovery by returning to pre-pandemic levels by the second quarter of 2024. According to the World Travel & Tourism Council (WTTC), the sector contributed a staggering \$9.5 trillion to the global economy in 2024, accounting for approximately 10.4% of total world GDP. This resurgence highlights the growing importance of tourism as an economic driver, particularly for countries with economies heavily reliant on tourism revenues.

---

\* Corresponding author: [clachy@yahoo.com](mailto:clachy@yahoo.com)

Lachi Cristina, ORCID: 0000-0001-7768-2108

While the global tourism sector has demonstrated signs of recovery in the post-pandemic period, this resurgence has not been without significant challenges. Many popular destinations are now contending with the adverse effects of overtourism—a phenomenon characterized by visitor volumes exceeding a destination’s capacity to manage tourism in a sustainable manner (Gössling et al., 2020). It’s develop as a urban centers and heritage sites frequently experience overcrowding, which diminishes the quality of the tourist experience and adversely affects the daily lives of local residents. Also, the substantial increase in tourist numbers places excessive pressure on local infrastructure, including transportation systems, water resources, and waste management facilities, often resulting in the deterioration of essential public services. One of that important part is the growth of tourism demand, particularly in housing markets, tends to increase the cost of living, leading to the displacement of residents and the erosion of social cohesion. Natural sites are particularly vulnerable to environmental degradation caused by overuse, pollution, and habitat disruption, which threatens biodiversity and the long-term viability of these attractions (Peeters et al., 2018).

Prominent cities such as Venice, Barcelona, and Dubrovnik exemplify the complex dynamics and detrimental outcomes associated with overtourism. In contrast, emerging destinations, including the Republic of Moldova, are currently in a strategic position to design tourism policies that preemptively address these concerns. Moldova, with its distinctive cultural heritage and underexploited tourism potential, holds the opportunity to pursue a development trajectory grounded in sustainability.

This study undertakes a comprehensive examination of overtourism at a global scale, presenting both the underlying causes and the remedial strategies implemented in various international contexts. It then transitions to an in-depth analysis of Moldova’s tourism sector, assessing its current structure and identifying sustainable avenues for growth. By integrating empirical evidence and best practices from international case studies, the report formulates policy recommendations tailored to Moldova’s specific context. The overarching objective is to propose a strategic framework for tourism development that ensures long-term socio-economic and environmental benefits for both host communities and visitors (Bran et al., 1998).

## **2. GLOBAL OVERTOURISM: A DATA-DRIVEN ANALYSIS**

### **2.1. Quantitative Assessment of Overtourism Hotspots**

Overtourism has emerged as a defining challenge for destinations across the globe. With the rapid rebound of international travel, many cities and regions have seen visitor numbers soar past their sustainable thresholds. This section delves into the quantitative assessments of overtourism, presenting key metrics in tables and visual data representations that highlight current hotspots. In doing so, we examine not only the physical and infrastructural strains but also the broader economic and social consequences that are reshaping communities worldwide.

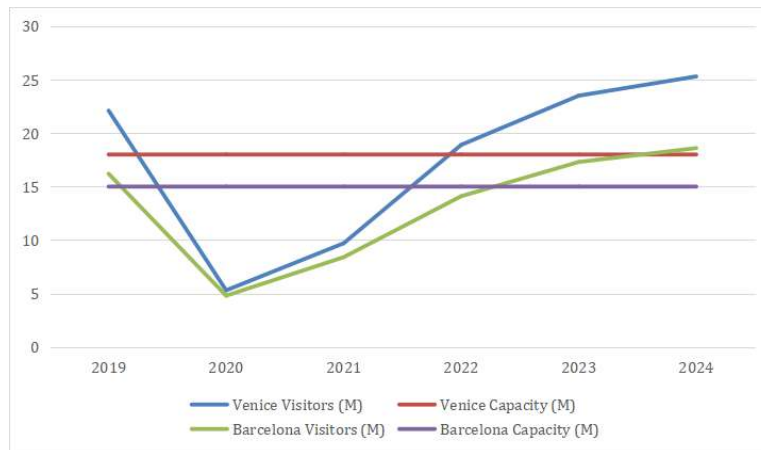
A defining metric in understanding overtourism is the visitor-to-resident ratio. This ratio provides insight into how many tourists a destination hosts relative to its local population—a critical measure that can forecast infrastructure stress and community strain. Notably, cities such as Venice, Barcelona, Dubrovnik, and Kyoto display ratios that far exceed what may be considered sustainable (Milano et al., 2019). The table below encapsulates some of the key data points for overtourism hotspots in 2024.

*Table 1. Key Metrics for Global Overtourism Hotspots (UNWTO Global Tourism Dashboard, 2024)*

Destination	Annual Visitors (M)	Resident Population	Visitor-to-Resident Ratio	Primary Pressure Points
Venice, Italy	25.3	261,905	97:1	Canal congestion, resident displacement
Barcelona, Spain	18.6	1.6M	12:1	Housing affordability crisis, infrastructure strain
Dubrovnik, Croatia	4.9	41,562	118:1	Overcrowding, degradation of historic sites
Kyoto, Japan	57.1	1.4M	41:1	Temple overcrowding, cultural dilution
Reykjavik, Iceland	2.3	140,000	16:1	Pressure on geothermal resources, environmental sensitivity

The visitor-to-resident ratios in certain historic and densely populated cities clearly indicate that tourism activity is outstripping local capacity. For instance, Dubrovnik's ratio of 118:1 symbolizes a situation where for every resident, there are 118 tourists, leading to pressures on local infrastructure and a noticeable strain on community life.

To further illustrate the dynamics of overtourism, consider the case of Venice and Barcelona. A graphical analysis over the period 2019–2024 demonstrates a divergence between the continuously rising number of visitors and the relatively fixed carrying capacities of these destinations. In this visualization (Figure 1), the blue line represents visitor numbers, while the red line indicates the carrying capacity threshold.



*Figure 1. Visitor Growth vs. Carrying Capacity (Euromonitor International, 2024)*

The graph starkly shows that by 2022, visitor arrivals at these destinations began to breach sustainable limits. This divergence has accelerated as destinations continued to welcome more tourists without proportionate expansions in local infrastructure, leading to the challenges detailed below.

## 2.2. Economic and Social Consequences of Overtourism

The implications of overtourism extend far beyond mere overcrowding. Economically and socially, affected communities bear significant costs that are not immediately visible from raw visitor statistics alone.

Overtourism imposes hidden economic burdens that can undermine local economies despite the apparent influx of tourism-related revenue. Many destinations find that the costs of managing increased tourist numbers—such as the need for enhanced public services,

transportation upgrades, and infrastructure repairs—offset the economic gains. For example, a comprehensive analysis reveals significant fiscal challenges in cities facing overtourism:

*Table 2. Economic Impacts of Overtourism on Select Destinations (OECD Tourism Economics Report, 2024)*

Destination	Annual Cost (€M)	Primary Impact	Secondary Effects
Venice, Italy	200	Flood damage and canal maintenance	Increased insurance premiums, reduced urban livability
Barcelona, Spain	150	Rising property and rent costs	Resident displacement, loss of local business diversity
Amsterdam, Netherlands	85	Rapid infrastructure wear and tear	Redistribution of tax burdens and reduced quality of public services

The table above reveals that overtourism creates a net negative economic impact for affected communities, where the ensuing costs for maintenance and public service enhancements significantly erode the revenue benefits of high visitor numbers. Such economic stress is compounded by the rising cost of living, thereby widening wealth gaps and sparking community tensions.

As visitor numbers surge, the residents' quality of life comes under threat. Overcrowded streets, long waiting times for public services, and increased noise and pollution are just a few of the issues that have directly influenced public sentiment. Surveys indicate that approval ratings among residents in overtourism hotspots have plummeted as the negative impacts on daily life become more tangible. Understanding and quantifying these shifts in public sentiment is important for devising effective policy interventions.

*Table 3. Resident Sentiment Analysis (IPSOS Global Tourism Surve, 2023-2024)*

City	2023 Resident Approval (%)	2024 Resident Approval (%)	Visitor Ratio (2024)
Venice, Italy	42	38	97:1
Barcelona, Spain	54	48	12:1
Kyoto, Japan	58	52	41:1
Reykjavik, Iceland	67	61	16:1
Dubrovnik, Croatia	39	32	118:1

This analysis vividly illustrates that higher visitor-to-resident ratios are generally accompanied by declining resident approval ratings. For instance, Dubrovnik's severe ratio of 118:1 is associated with a sharp decline in approval, reflecting escalating frustration among locals. Such discord not only erodes the social fabric but can also precipitate policy shifts that might hinder long-term tourism development if not managed appropriately.

Addressing overtourism requires policy innovation with evidence-based interventions. Multiple strategies have been implemented around the globe to mitigate the negative impacts, and a comparison of their effectiveness offers valuable insights.

Policies such as time slot admissions have shown promising results in maintaining the quality of visitor experience while ensuring that cultural heritage sites are not overwhelmed. The data suggests that combining immediate crowd-control measures with long-term sustainability investments can yield the most favorable outcomes, thereby not only restoring resident approval but also safeguarding the attractions that define these destinations.

Table 4. Sustainable Tourism Policy Matrix (WTTC, 2024)

Strategy	Implementation Details	Success Rate (%)	Key Benefits	Limitations
Tourist Taxes	Fee of approximately €5 per visitor in Venice	78	Generates revenue for urban management	Can be regressive and unpopular among tourists
Visitor Caps	Annual limitations as in Machu Picchu	85	Effective site preservation	Potential reduction in overall tourism revenue
Time Slot Admissions	Managed entry schedules, as implemented at Alhambra	92	Enhances visitor experience and protects cultural sites	Requires complex logistical management
Digital Dispersion Strategies	Use of smart data and apps to direct tourists to lesser-known areas	63	Redistributes crowd pressure across a region	Dependent on the availability and reliability of technology

A longitudinal review of policy interventions underscores the relative merits of each strategy. Graph 2 illustrates the progression of policy effectiveness over a five-year period. In this graph, the different lines represent various interventions, with the time slot admissions strategy leading to the fastest and most sustained improvement in visitor management outcomes.

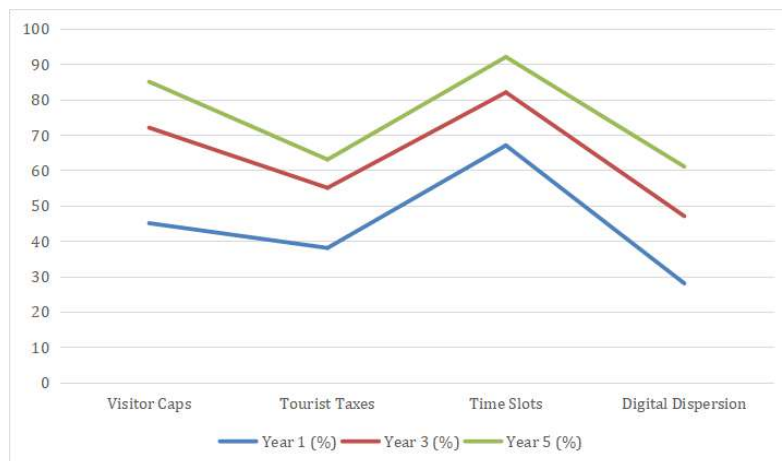


Figure 2. Policy Effectiveness Over Time (World Bank Tourism Development, 2024)

### 2.3. Integration of Data and Its Implications

The synthesis of these quantitative metrics provides a window into the multifaceted nature of overtourism. Beyond the raw numbers, two key insights emerge:

**Exceeding Physical Capacity:** Historic cities and unique cultural sites that are entrenched in legacy urban frameworks often lack the physical space required to expand infrastructure in line with growing visitor numbers (Koens et al., 2018).

This mismatch is a critical driver of the negative externalities associated with overtourism.

**Eroding Resident Sentiment:** As the burden of increased tourism becomes unsustainable, local residents begin to perceive significant quality-of-life impacts. The strong correlation between visitor-to-resident ratios and declining sentiment ratings highlights the imperative for policymakers to adopt measures that balance economic benefits with community well-being.

A higher visitor-to-resident ratio is not merely a statistic—it essentially quantifies the strain on every facet of urban life. When one community member is intermittently overwhelmed by a high volume of visitors, the consequences can include:

Overburdened public transportation systems and healthcare services can become less efficient, directly affecting both tourists and residents.

Constant influxes of external influences may jeopardize the traditional character of communities by shifting the focus towards tourist-centric economies.

As local residents witness the tangible impacts of overcrowding, tensions may rise, leading to demands for stringent regulatory measures or even outright resistance against tourism expansion.

The economic repercussions of overtourism extend well beyond immediate tourism revenues. Hidden costs such as increased maintenance, infrastructural overhauls, and corrective measures for environmental degradation can lead to a net loss for local governments. Infrastructure, such as historical buildings and transportation networks, incur accelerated wear and tear under heavy tourist traffic. In places like Venice, insurance premiums have surged to cope with the heightened risk of flood damage exacerbated by dense visitor flows (Seraphin et al., 2018). Higher living costs, driven in part by tourism-fueled demand, often lead to resident displacement, creating pockets of inequality even in otherwise vibrant communities.

#### **2.4. Data-Driven Insights for Sustainable Policies.**

The global data and analyses presented here provide critical lessons for destinations struggling with overtourism. While heritage sites and major cities wrestle with established challenges, these insights are particularly instructive for emerging markets. They demonstrate that policy interventions need to be multi-pronged—designed to control and redirect tourist flows in the short term while investing in long-term infrastructural and community resilience.

Implementing effective measures—ranging from visitor caps and timed admissions to digital strategies aimed at redistributing tourist activity—can serve as a blueprint for sustainable development. In particular, these measures highlight the importance of addressing both the visible economic indicators and the more nuanced social impacts, such as resident sentiment, that ultimately determine the success of tourism policies.

Data-driven approaches, leveraging comprehensive metrics such as visitor-to-resident ratios, resident approval ratings, and economic cost evaluations, provide a clear mandate for policymakers. While the challenges of overtourism are daunting, they also offer an opportunity to reshape tourism development frameworks to be more equitable, sustainable, and resilient in the face of fluctuating global travel trends.

By closely monitoring these metrics and adjusting policies in real time, destinations can mitigate the adverse effects of overtourism. Furthermore, the integration of cutting-edge digital tools to manage tourist flows and collect real-time data serves as an important reminder that technology can be a powerful ally in achieving sustainable tourism.

Source references for the quantitative assessments and visual data include authoritative organizations such as the UNWTO, OECD, IPSOS, Euromonitor International, and the World Bank. These data points underscore the urgent need for harmonized, globally informed policies that not only accommodate tourism growth but, more importantly, safeguard the interests of local communities and preserve the cultural and environmental assets upon which they rely.



### 3. SUSTAINABLE TOURISM SOLUTIONS: EVIDENCE-BASED APPROACHES

#### 3.1. Evidence-Based Policy Interventions

In addressing the pressing challenges of overtourism, a variety of policy interventions have emerged, illustrating a spectrum of approaches grounded in sustainability. This section provides an overview of effective strategies, encapsulated in a comprehensive policy matrix, while evaluating their efficacy through empirical data and studies.

The following table summarizes key strategies designed to mitigate overtourism and their respective outcomes:

Table 5. Sustainable Tourism Policy Matrix (WTTC, 2024)

Strategy	Implementation Details	Success Rate (%)	Key Benefits	Limitations
Tourist Tax	Fees imposed, e.g., €5 per tourist in Venice	78	Generates revenue for local infrastructure	May discourage some tourists
Visitor Caps	Set limits on annual visitors, e.g., Machu Picchu	85	Protects cultural heritage and environment	Potential revenue declines
Time Slot Admissions	Schedule visits, e.g., Alhambra	92	Improves visitor experience and site authenticity	Complex logistics for ticketing
Digital Dispersal	Apps to direct tourists to lesser-known areas	63	Reduces congestion in hotspots	Reliance on technology

#### 3.2. Evaluating Efficacy and Results

The success of these initiatives can be quantified by examining their impacts over time. Each strategy brings unique benefits coupled with specific limitations, which must be carefully considered in the context of the local environment. Implemented in destinations like Venice, this approach has proven effective in funding conservation efforts and urban infrastructure improvements. However, it risks alienating potential visitors who may feel priced out. Machu Picchu and Zion National Park serve as examples where capping visitor numbers has preserved ecological integrity and cultural identity. Yet, the resultant decrease in tourism revenue can challenge local economies. Alhambra's timed entry system demonstrates a high success rate in managing crowd flow and enhancing the visitor experience. Nonetheless, the complexity of scheduling can deter spontaneous visits and require robust management systems. Utilized in Iceland, this method effectively redistributes tourist traffic. However, reliance on tech solutions necessitates equitable access to digital resources and can lead to uneven tourist experiences.

#### 3.3. Policy Effectiveness Over Time

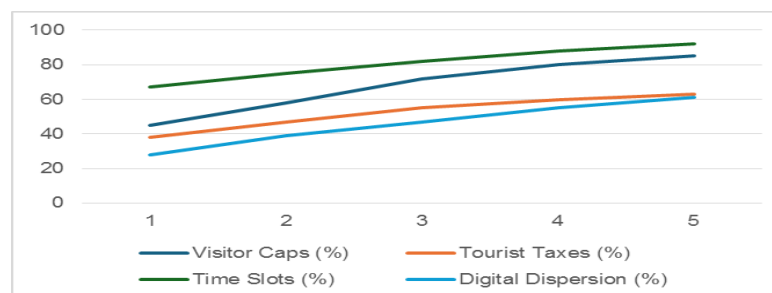


Figure 3. A longitudinal analysis of policy effectiveness accentuates the advantages of structured interventions (World Bank Tourism Development, 2024)

This visualization captures the trajectory of success rates for various strategies over a five-year span. Time slot admissions consistently lead the pack in effectiveness, establishing a robust model for both immediate management and long-term visitor satisfaction, while digital dispersal trails, emphasizing the need for continuous data collection and analysis.

### 3.4. Lessons Learned

The interplay between policy implementation and overtourism dynamics underscores the critical need for adaptive and multifaceted strategies. Each successful approach illuminates the importance of balancing tourist influx with the needs of local communities—the goal being to foster sustainable growth without compromising the cultural and environmental heritage that makes these destinations unique.

Furthermore, the data reinforces a foundational tenet: proactive, evidence-based policies that incorporate real-time metrics and community feedback mechanisms can effectively curb the detrimental impacts of overtourism. As emerging tourist markets like Moldova seek to establish themselves sustainably within the global tourism landscape, these insights serve as invaluable guidelines in crafting a resilient strategy that prioritizes both economic development and community well-being.

## 4. MOLDOVA'S TOURISM DEVELOPMENT PATHWAY

### 4.1. Current Tourism Profile

Moldova stands at a pivotal juncture within the global tourism landscape, characterized by both challenges and opportunities for growth. With an exciting blend of cultural heritage and natural beauty, Moldova is preparing to develop its tourism sector while learning from the overtourism challenges faced by more established destinations.

Recent data illustrates the trajectory of Moldova's tourism sector, highlighting key indicators for arrivals and revenue generation. The following table captures crucial statistics from 2019 to 2025, showing both current performance and projected growth.

*Table 6. Moldova Tourism Indicators 2019-2025 (Moldova National Bureau of Statistics, 2024)*

Year	Arrivals	Avg Stay (nights)	Key Markets	Revenue (€M)
2019	168,000	2.8	RO, UA	280
2023	142,000	3.1	EU, IL	310
2024*	158,000	3.3	EU, US	350
2025*	175,000	3.5	EU, AS	400

The data underscores a moderate recovery since 2020, with a steady increase in arrivals and revenue anticipated through 2025. Notably, the average length of stay is also on the rise, suggesting an increasing interest in immersive experiences among visitors.

### 4.2. Importance of Product Diversification

Despite its current focus on wine tourism—accounting for 61% of visitors—Moldova faces a pressing imperative for product diversification. The following pie chart illustrates the composition of tourism segments currently attracting visitors:

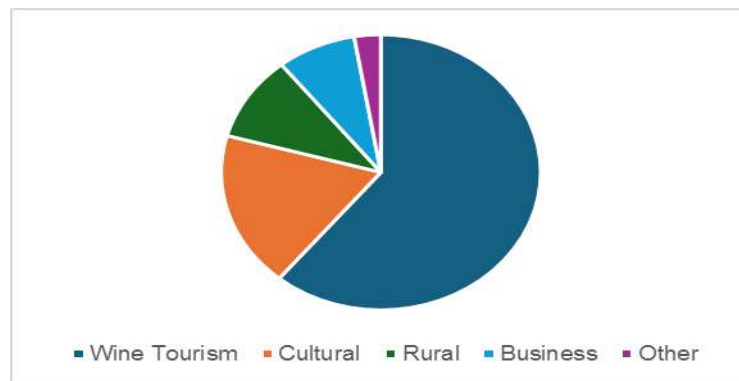


Figure 4. Distribution of Current Tourism Segments by Visitor Interest (Moldova Ministry of Economy, 2024)

While wine tours serve as a strong pillar of attraction, solely relying on a single segment poses risks. A lack of diversity could easily alienate potential tourists and lead to fluctuations driven by seasonal or economic factors. Expanding offerings to include cultural heritage, eco-tourism, and adventure tourism can provide a more balanced revenue stream and enhance destination appeal.

#### 4.3. Strategic Observations

In order to capitalize on its tourism potential in a sustainable manner, the Republic of Moldova must adopt a strategic approach that incorporates lessons derived from global experiences with overtourism and the corresponding mitigation measures.

The early adoption of sustainability frameworks is essential to prevent the negative externalities observed in over-visited destinations. Measures such as regulating tourist numbers at environmentally or culturally sensitive sites, implementing robust environmental safeguards, and promoting tourism in alignment with ecological and social carrying capacities are imperative for long-term viability.

The active involvement of local populations in tourism planning and governance processes is fundamental. Mechanisms that facilitate community input and ensure equitable distribution of tourism-related economic gains not only enhance social cohesion but also cultivate local support for sustainable development initiatives.

Digital innovation offers significant potential for enhancing tourism management and service delivery. The deployment of tools such as mobile applications for real-time visitor guidance, as well as digital platforms that connect tourists with authentic local experiences, can contribute to dispersing tourist flows and reducing pressure on high-traffic areas, thereby supporting a more balanced and responsible tourism model. Moldova's unique positioning within the Eastern European tourism milieu offers an excellent opportunity to carve a niche as a sustainable travel destination. By promoting diverse tourism products and integrating best practices from around the world, Moldova can enhance its global standing, ultimately benefiting both local communities and visitors without succumbing to the challenges of overtourism that have affected many other destinations.

## 5. STRATEGIC RECOMMENDATIONS

### 5.1. Proposed Initiatives

Moldova is poised for significant growth in its tourism sector, yet it faces the critical need for a strategic approach to avoid the pitfalls of overtourism experienced by other global destinations. To create a sustainable and resilient tourism framework, the following action plan outlines initiatives, timelines, budgets, and expected outcomes, focusing on both immediate needs and long-term sustainability.

*Table 7. Moldova Tourism Action Plan (EU Tourism Development Funds, 2024)*

Initiative	Timeline	Budget (€M)	Expected Outcome
Heritage Site Caps	2024-2025	2.5	Reduce overcrowding by 30% at key sites
Rural Tourism Development	2024-2026	8.0	Create approximately 1,200 new jobs
Digital Visitor System	2025	3.7	Improve visitor traffic flow by 40%
Eco-Tourism Initiatives	2024-2026	4.5	Enhance natural conservation efforts while boosting tourist engagement
Community Engagement Programs	2024-2025	1.0	Foster local involvement and ensure equitable benefits from tourism

### 5.2. Initiative Descriptions

To ensure the sustainable growth of Moldova's tourism sector and to prevent the adverse effects associated with overtourism, a set of strategic interventions is proposed. A regulated cap on the number of visitors permitted at key cultural and historical landmarks is essential to mitigate excessive foot traffic. Such a system would contribute to the long-term preservation of site integrity, while simultaneously improving the overall visitor experience by minimizing congestion and ensuring safer, more meaningful interactions with heritage environments.

Targeted investment in rural tourism infrastructure presents an opportunity to diversify Moldova's tourism portfolio and stimulate economic activity in underdeveloped regions. This may include the creation of new attractions, enhancement of local accommodations, and the modernization of transport and public utilities to support sustainable rural tourism practices.

The adoption of a centralized digital platform for real-time visitor tracking and traffic regulation can significantly enhance the management of tourist flows. By facilitating the spatial redistribution of visitors across multiple sites and regions, this system would reduce pressure on high-traffic areas and encourage exploration of lesser-known destinations.

The development of eco-tourism initiatives, including low-impact tours, biodiversity conservation programs, and environmental awareness campaigns, can support both environmental protection and economic development. Emphasizing ecological sustainability will reinforce Moldova's commitment to safeguarding its natural heritage while fostering long-term tourism resilience. Establishing participatory mechanisms that integrate local communities into tourism planning and decision-making processes is essential for ensuring inclusive development. Such engagement promotes local ownership, aligns tourism growth with resident interests, and enhances the sector's responsiveness to socio-cultural dynamics.

### 5.3. Importance of Recommendations

These recommendations are vital as they articulate a dual focus on immediate economic benefits, such as job creation and tourist satisfaction, while ensuring that Moldova's cultural and natural resources are preserved for future generations. Romania's approach to sustainable tourism demonstrates how early adoption of best practices can lead to resilient growth, safeguarding both local interests and tourist experiences.

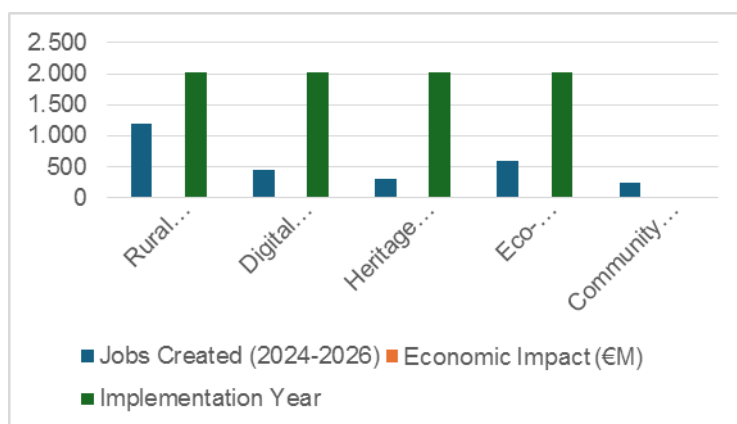


Figure 5. Projected Job Creation and Economic Impact from Initiatives 2024-2026 (Moldova Ministry of Economy, 2024)

This graph illustrates the potential job creation across various initiatives outlined in the action plan. With rural tourism development leading in job contributions, it becomes apparent that diversifying Moldova's tourism offerings is crucial for economic sustainability.

Integrating these strategies into Moldova's tourism framework not only leverages its existing strengths—such as wine and cultural tourism—but positions the nation as a leading example in sustainable travel within the regional market. In executing this action plan, Moldova can navigate the delicate balance between embracing tourism growth and ensuring a sustainable, thriving future for its cultural heritage and local communities.

## 6. CONCLUSION

The global tourism industry is at a critical juncture, balancing economic gains with increasing concerns over overtourism. In 2024, tourism contributed \$9.5 trillion to the global economy, yet the associated pressures on infrastructure, communities, and ecosystems have become unsustainable. This study explores three systemic challenges—urban infrastructure degradation, resident displacement, and environmental harm—while identifying Moldova's potential to position itself as a model for sustainable tourism by leveraging its untapped cultural and ecological assets.

### I. Global Challenges and Policy Responses

Cities like Venice and Dubrovnik suffer from excessive tourist volumes, leading to accelerated decay of historic structures. Sustainable visitor caps, rotational access models, and UNESCO-backed capacity agreements, supported by tourism levies, offer viable mitigation strategies. Also, tourism-driven housing demand has displaced local populations in cities such as Barcelona and Amsterdam. Solutions include community tourism trusts, reinvestment of tourism tax revenues into affordable housing, and resident-priority zoning policies. Natural sites face increasing ecological stress, as seen in Iceland and Bali. Adaptive measures such as carbon-

linked entrance fees, conservation-based visitor programs, and eco-passport systems could ensure environmental stewardship.

## II. Moldova's Strategic Opportunity

With 61% of arrivals focused on wine tourism, Moldova's sector remains vulnerable to market volatility. Developing thematic circuits—such as Soviet heritage trails—and promoting eco-tourism in regions like Cahul and Vulcănești can broaden its appeal. Tables represent's that, 88% of rural areas lack basic tourist infrastructure. Investment in EU-funded village hubs, digital platforms for SMEs, and the transformation of Soviet-era sanatoriums into digital nomad spaces can enhance accessibility and competitiveness.

## III. A National Framework for Action

- Short-Term (2024–2025):
  - o Introduce daily visitor limits and preservation fees at key sites (e.g., Orheiul Vechi)
  - o Freeze new short-term rentals in urban centers and allocate housing for tourism workers
- Medium-Term (2026–2030):
  - o Adopt a “Bhutan-Plus” model requiring minimum tourist expenditure, with community reinvestment
  - o Deploy AI systems for visitor flow optimization and incentive-based off-peak travel
- Long-Term (2031+):
  - o Establish Moldova as a host of the annual Overtourism Summit
  - o Become the first carbon-positive tourism destination in Europe

Without timely intervention, Moldova risks cultural dilution, economic instability, and environmental decline. A proposed “Tourism Sustainability Compact”—enshrining sustainability as a constitutional right and mandating a fixed GDP allocation for regenerative tourism—offers a transformative path forward. Moldova has the opportunity not merely to follow global best practices, but to lead.

## REFERENCES

- Bran, F., Marin, D., Simon, T. (1998). The economy of tourism and the environment. București: Editura Economică. ISBN 973-5901-35-8.
- EU Tourism Development Funds (2024). Funding allocations for Moldova's sustainable tourism initiatives. [https://ec.europa.eu/growth/sectors/tourism\\_en](https://ec.europa.eu/growth/sectors/tourism_en)
- Euromonitor International (2024). Visitor growth vs. carrying capacity data. <https://www.euromonitor.com/>
- Gössling, S., Scott, D., & Hall, C. M. (2020). Pandemics, tourism and global change: a rapid assessment of COVID-19. *Journal of sustainable tourism*, 29(1), 1-20. <https://doi.org/10.1080/09669582.2020.1758708>
- IPSOS Global Tourism Survey (2023–2024). Resident sentiment analysis in overtourism hotspots. <https://www.ipsos.com/en/tourism-impact>
- Koens, K., Postma, A., & Papp, B. (2018). Is overtourism overused? Understanding the impact of tourism in a city context. *Sustainability*, 10(12), 4384. <https://doi.org/10.3390/su10124384>
- Milano, C., Cheer, J. M., & Novelli, M. (2019). *Overtourism: Excesses, discontents and measures in travel and tourism*.
- Moldova Ministry of Economy. (2024). Tourism composition (wine, cultural, rural segments). <https://economie.gov.md/>

- Moldova National Bureau of Statistics. (2024). Tourism arrivals, revenue, and seasonal trends (2019–2025). <https://statistica.gov.md/>
- OECD Tourism Economics Report. (2024). Economic costs of overtourism (Venice, Barcelona, Amsterdam). <https://www.oecd.org/industry/tourism/>
- Peeters, P., Gössling, S., & Milano, C. (2018). Overtourism: Impact and Possible Policy Responses. European Parliament, Directorate-General for Internal Policies. [https://www.europarl.europa.eu/RegData/etudes/STUD/2018/629184/IPOL\\_STU\(2018\)629184\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2018/629184/IPOL_STU(2018)629184_EN.pdf)
- Seraphin, H., Sheeran, P., & Pilato, M. (2018). Over-tourism and the fall of Venice as a destination. *Journal of Destination Marketing & Management*, 9, 374-376. <https://doi.org/10.1016/j.jdmm.2018.01.011>
- UNWTO Global Tourism Dashboard (2024) Visitor-to-resident ratios, carrying capacity metrics. <https://www.unwto.org/tourism-data/global-and-regional-tourism-performance>
- World Bank Tourism Development. (2024). Long-term policy effectiveness trends. <https://www.worldbank.org/en/topic/tourism>
- World Travel & Tourism Council (WTTC) Policy Impact Report (2024). Success rates of tourist taxes, visitor caps, and digital dispersion strategies. <https://wttc.org/Research/Policy-Research>



## EFFECTIVE ELIMINATION OF NETWORK FAILURES IN BROADCAST SYSTEM

Jovan Zlatanovic<sup>1 \*</sup>, Ivana Milosevic<sup>2</sup>, Mirko Milosevic<sup>3</sup>

<sup>1</sup> *PE Transmitters and communication, Serbia*

<sup>2</sup> *School of Technical and Art Applied Studies Academy of Electrical and Computer Engineering, Serbia*

**Abstract:** Broadcast companies always aim to have as few interruptions and failures as possible. They have experts in the field of telecommunications and use the most modern technological solutions. However, that is not enough. It is necessary to organize continuous monitoring, and directing information to employees relevant to the part of the job and an activity plan to prevent the spread of consequences of incidents. It is also necessary to organize activities through the procedures and guidelines to avoid breakdowns. Every organization wants to improve workspace safety and efficiency and reduce costs associated with unexpected breakdowns. Preventing equipment failure should be a top priority which gives us uninterrupted work that enables user satisfaction. In this paper, one should see an organizational model that includes fault management, where every employee knows how to act to eliminate the fault promptly. Failure should last as long as possible. This procedure assigns clear roles and responsibilities to the employer. This clarity helps prevent confusion and overlap. In the event of an issue, the employee will know exactly who is responsible for addressing it, leading to quicker resolution. Broadcasting TV, radio, and mobile information is very sensitive to interruptions, so quick break resolution leads to less on-air impact.

**Keywords:** Broadcast, failures, incidents, interruption, prevent.

### 1. INTRODUCTION

Broadcasting mobile, TV, and radio information is a very complex task. In operation occur interruptions, errors, transmission losses, and breakdowns of various types of devices.

---

\* Corresponding author: jovan.zlatanovic@etv.rs

Jovan Zlatanovic, ORCID: 0000-0001-8607-8332

Ivana Milosevic, ORCID: 0009-0006-5429-8844

Mirko Milosevic, ORCID: 0009-0007-7280-6897



An interrupt is a signal emitted by hardware or software when a process or event needs immediate attention (Mc Clanahan, 2021). Unwanted interruptions can occur in any type of broadcasting equipment. The equipment needed to broadcast the signal is diverse. Head-end, NMS system, IP equipment, distribution equipment, DVB-T2 transmitters, DAB+ transmitters, FM transmitters, antennas system, RF component, UPS I DPG systems... Procedures, guidelines, and instructions would determine the tasks for the group of employees who monitor the network. Another group of employees monitor remote devices and react remotely to them. They receive information from network monitoring staff about potential incidents and the equipment and services at risk. This specific information system aims to support operation, management, and decision-making (Simon, 2013). That organization and also the way in which people interact with this technology in support of business processes (Kawalek, 2008). There are several categories that determine the teams of employees who respond to incidents in the network equipment. Those categories are: regional-geographic, by territory covered by broadcast signal, number of devices, type of devices for which employees are trained, and quality of the access road to the site. This last item is very important because the broadcast sites are located on top of hills and mountains for the best possible coverage. Only the preparation of access roads is demanding both economically and physically. All the listed factors affect the effectiveness of intervention after the incident. It is also necessary to have a good overview in terms of the stability of the high-voltage and low-voltage networks that reach the broadcast site. It is not economically justifiable to use diesel generators and UPS in all locations.

Monitoring manage teams that are on duty quickly and according to the established schedule provides quality information about the incident. Groups of intervention teams are divided geographically and by the type of device for which they are responsible (due to the large number of different types of equipment). Different types of devices include radio, television equipment, mobile phone devices, internet providers devices, police, military, and radio amateur devices.

The quality information provided by the monitoring team to the intervention teams provides inputs for quality preparation. Quality preparation includes ensuring equipment, spare parts and complete replacement devices with the team goes to the intervention. Everything mentioned is analyzed, processed, and organized to provide clients with a high degree of satisfaction. There is also the economic aspect of the agreement with clients, according to which the services delivered must have a certain level of availability. In this way, the legal framework of the agreement is not exceeded and the company does not pay penalties and punishment to creditors. Clients are radio and TV companies, mobile operators, internet providers, military police, and radio amateurs. The end users of the mentioned services are also very important and they should have all the services with minimum interruption. The level of satisfaction of the end-users depends on the telecommunication providers that offer different services as well as on the broadcast providers that enable the transmission of the signal to the final destination.

In the next section, some solutions for telecommunication systems will be presented. Then the suggested solution is described in terms of connection and cooperation of employees through procedures and instructions. In the end, the solution is analyzed with its advantages and disadvantages punishment to creditors.

Clients are radio and TV companies, mobile operators, internet providers, military police, radio amateurs. The end users of the mentioned services are also very important and they should have all the services with minimum interruption. The level of satisfaction of the end users depend on the telecommunication providers that offer different services as well as on the broadcast providers that enable transmission of the signal to the final destination.

## **2. RELATED WORKS**

Well-crafted maintenance ensures a positive user experience during downtime (Hendriksen, 2024). There are three categories of maintenance in this scenario. They maintain trust and transparency with users and provide planned maintenance. Planned maintenance activities with prior notice to users. This type of maintenance has details about the expected downtime. Emergency maintenance is required to fix critical issues. Urgent maintenance due to the causes of the problem, with subsequent notification. Unexpected downtime due to unforeseen circumstances (technical failures, cyberattacks) – unplanned maintenance. This kind of organization has shown promising results for website maintenance.

The following maintenance solution is used by IT teams. Introduced elements for analysis to make maintenance easy. Planned downtime for maintenance when many users are offline (Hartland, 2022). Communication channels are selected according to the most effective communication plan. Maintenance message includes information about affected services, expected timeframe, and contact details. In the end, up-to-date message maintenance is essential, to the maintenance progress.

The integrated Public Alert and Warning System is an integration of the nation's alert and warning infrastructure that gives public safety officials an effective way to alarm and warn (Gabbert, 2017). This system integrates an emergency alert system, a Commercial mobile alert system, and a Weather radio. The authorized local government entities can provide emergency messages affecting a large area, multiple areas, or the entire area of the state. Such a system allows for the regulation and rules by which emergency warning centres and broadcast communities work together to ensure timely emergency information to take protective actions to save lives and property. This system enables the preservation of infrastructure, equipment, and population by precisely defined procedures.

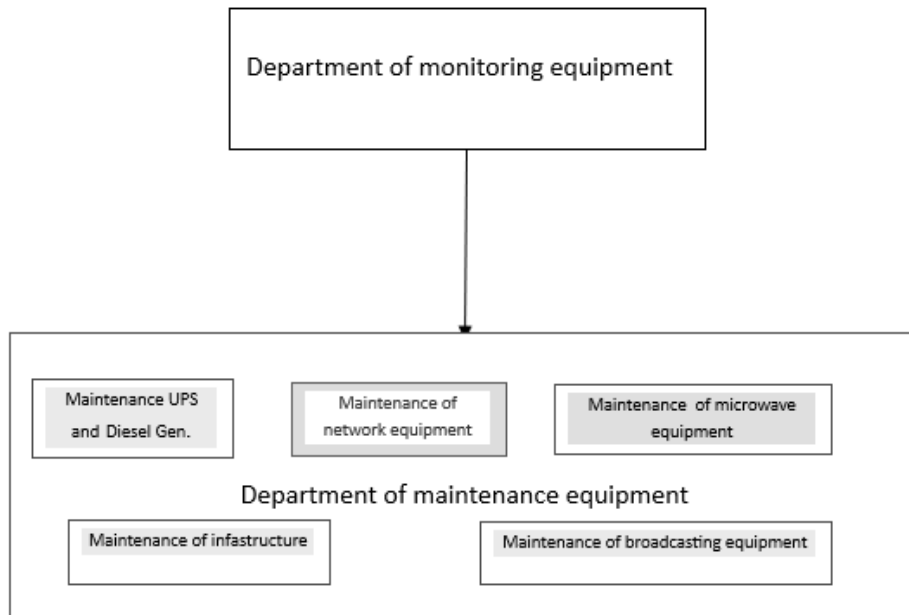
IBM developed a computerized maintenance management system (CMMS). CMMS is software that centralizes maintenance information and facilitates the processes of maintenance operations (Crain, 2021). The main function of CMMS is to provide information about automated work order generation, reserve materials and equipment, schedule and assign employees, crews, and shifts, status review, and track downtime and description and priority. CMMS systems serve in industries manufacturing, oil and gas production, power generation, construction, and transportation.

The following chapter describes the idea of the realization of maintenance in broadcast systems. Other rules and procedures are applied according to the type of work that needs to be done.

## **3. BROADCASTING MANAGEMENT SYSTEM MAINTENANCE**

The department maintenance and troubleshooting on the network works 24/7 in shifts. The responsibilities and duties of the head of the maintenance department are to determine the employees available within specific time frames. Shift must be formed so that employees are rested and focused on the problem when incidents occur. Research shows that the risk of "incidents" (accidents and injuries) is higher for the afternoon shift than for those on a morning shift, and higher still for night shifts (Folkard & Tucker, 2003) In case of unforeseen circumstances, there is a backup team of employees who take on the responsibilities according to the plan. The head of the maintenance department must assign employees according to the type of knowledge and skills to possess to work with a certain type of equipment. A monthly schedule of employees is formed for work in shifts. There are several categories of work

schedules for employees in shifts. The central shift schedule is a section for monitoring for entire equipment Figure 1.



*Figure 1. Connectivity department*

The monitoring department receives monthly employee schedules for certain types of equipment they maintain. There are multiple organizational layers in complex telecommunications systems. The first layer is crews from high-power broadcasting sites and large-area cover-ups. As the most important points of broadcasting, they have permanent crews that change in shifts. The second layer is crews that maintain a large number of low-power broadcast sites (approximately 50). Crews take turns and solve problems as needed. They also maintain the location they are responsible for. The next layer of maintenance is remote access to devices for different types of equipment. A part of this layer of maintenance is the monitoring department. The second part of this layer is made up of employees who are divided by the type of equipment they are in charge of, figure 2. Equipment is generally divided into 5 types: network equipment, transmitter, and microwave equipment, UPS and diesel generator, and infrastructure equipment. Employees need to know something about each piece of equipment. It is very difficult for employees to be trained in every type of equipment. To make it easier to resolve the incident, employees are divided according to the type of equipment they are in charge of. In this layer, it is used the computerized maintenance management system. This system has information determining which equipment requires maintenance, and which storerooms contain the spare parts they need. Also, helps management calculate the cost of machine breakdown repair versus preventive maintenance for each machine (Kishan, 2010).

The last layer is expert teams. Spare parts management is a very important procedure related to this layer. They are linked to a computerized maintenance management system with the necessary measuring equipment and spare parts. Effective demand management and inventory control for spare parts collectively referred to as spare part management, without whom the work of the expert team is unthinkable.

These layers are the most resource-intensive and innovative solutions to equipment problems.

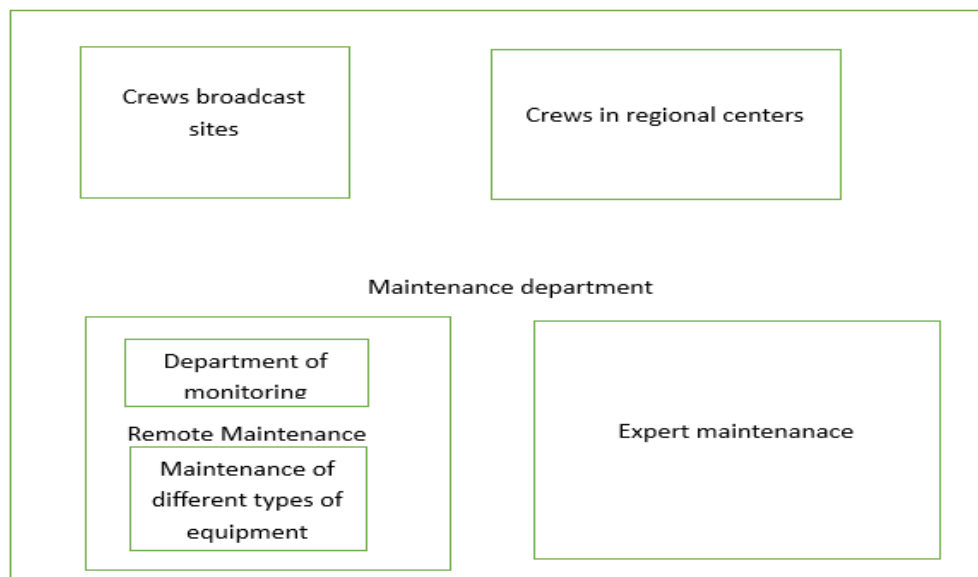


Figure 2. Maintenance department

Spare part management plays a central role in this by taking measures to achieve target service while minimizing the incurred costs (Eaves & Kingsman, 2004). In this complex telecommunication system, there are many spare parts of different equipment. Therefore, a central inventory control is needed. Central inventory control improves spare parts management. A central system allows better visibility of stock and measuring equipment across locations Figure 3. Central inventory system creates a single point of access for all inventory data.

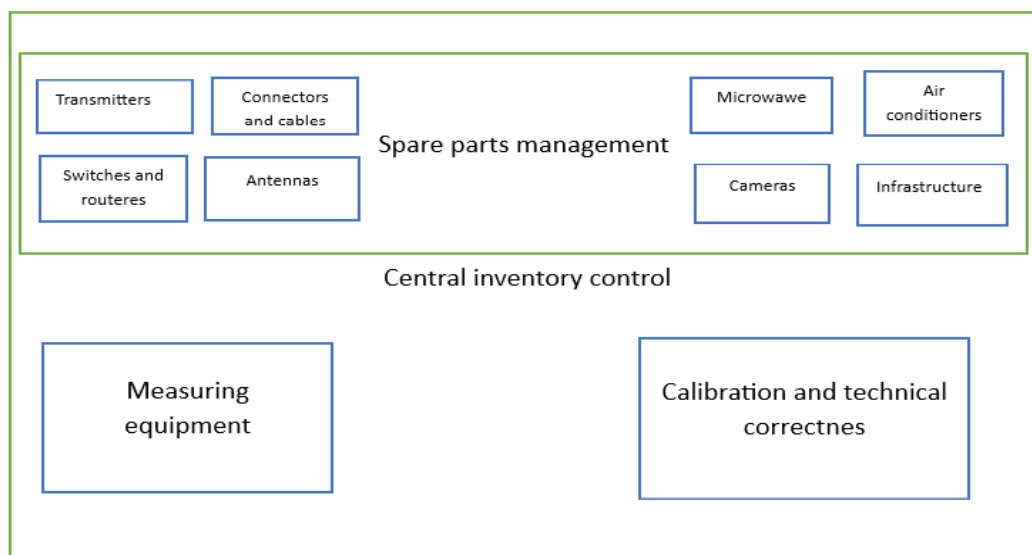


Figure 3. Central inventory control

The availability of measurement equipment for expert teams is vital in maintaining the system. Calibration ensures equipment is working as it should be. Calibration provides a safe working environment for end-users and ensures that companies are upholding their legal obligation. In this way, the central inventory system ensures the work of expert teams that know the availability and technical correctness of the equipment.

In accordance with the complex obligation, a clear plan is needed for all teams available to maintain a complex telecommunication system. Figure 4, represents part of the monthly shifts of individual teams.

Day of the month	1	2	3	4	5	6	7	8	9	10
Expert team (number)	1	2	3	4	5	1	2	3	4	5
Remote team (number)	5	4	3	2	1	5	4	3	2	1
Regional team (number)	3	1	2	4	5	3	1	2	4	5
Transmitters site team (number)	2	1	4	3	5	2	1	4	3	5
Infrastructure team (number)	4	5	1	3	2	4	5	1	3	2

Figure 4. Part of the monthly shift of different teams

Complexity and many different teams require that monthly shifts be available to managers, the monitoring department, and the maintenance department.

#### 4. PROCEDURES AND INSTRUCTION OF THE MAINTANANCE DEPARTMENT

The maintenance intervention team composition is conducted by the maintenance department manager according to the shift schedule of employees in this section. The maintenance service manager is obliged to develop a monthly plan that determines the engagement of executors (expert team, regional team, remote team, transmitter site team, and infrastructure team) in maintaining equipment with a defined type of maintenance and execution date. Based on the type of maintenance, the specifics of the location where the maintenance is conducted, the necessary equipment, and in coordination with the manager who distributes the vehicle, the type of vehicle for each expert maintenance intervention is determined.

Based on the monthly shifts prepared by the manager of the maintenance department, the maintenance service personnel are responsible for the necessary equipment to perform the defined type of maintenance, and before going to the site, it is mandatory to check the equipment's correctness according to the specification provided by the manufacturer. For performing maintenance on antenna systems, the maintenance service manager selects employees who have a valid certificate for working at heights (coordination with the occupational safety and health department). The employees check the equipment for work at heights before going to the field – the validity of the equipment's certification.

There are two types of maintenance: planned and incidental. The planned maintenance includes preventive maintenance, predictive inspection of equipment, and preventive replacement of parts on equipment. Preventive maintenance can be categorized into three groups: age reduction models, hazard rate reduction models, and a hybrid of both (Shaomin & Zuo, 2010). Preventive maintenance of the equipment includes: checking the basic parameters of the equipment, cleaning the equipment with compressed air, and checking fluids and oils. Data on primary maintenance is entered into the document primary maintenance, which is part of CMMS, table 1. Broadcast site crews and regional centers crews do primary maintenance.

Table 1. Preventive maintenance document

Preventive maintenance				
Date	Site	Equipment	Type of work	Executors

Predictive inspection of equipment is performed when there is frequent alarm. Alarms indicate that the equipment is not operating according to the equipment manufacturer's specifications, thus affecting the quality of service. Data on predictive inspection of equipment is entered into the document intervention report, which is part CMMS, table 2. Expert team does predictive inspection maintenance.

Table 2. Intervention report document

Intervention report	
Executor/work order number	
Date (departure /return time)	
Official vehicle (license plate)	
Purpose of the intervention	
Activities perform	
Resources spent	

Preventive replacement of parts on equipment is done by the expert team and regional team. Data on preventive replacement is entered document intervention report and fault report, which is part of CMMS table 3.

Table 3. Fault report document

Fault report				
Basic information				
<b>Reported prepared by</b>				
Date of report				
Equipment information				
No.	Equipment name	Equipment type	Serial no.	Site
1.				
2.				
3.				
Fault description				
Other relevant information				

In accordance with the planned intervention, there may be a procedure for changing the existing situation (new equipment, a different concept of the work network...). The board of managers must approve such activities before they are implemented.

The incidental maintenance is obtained by ticket, e-mail, phone, and from the monitoring department Figure 5.

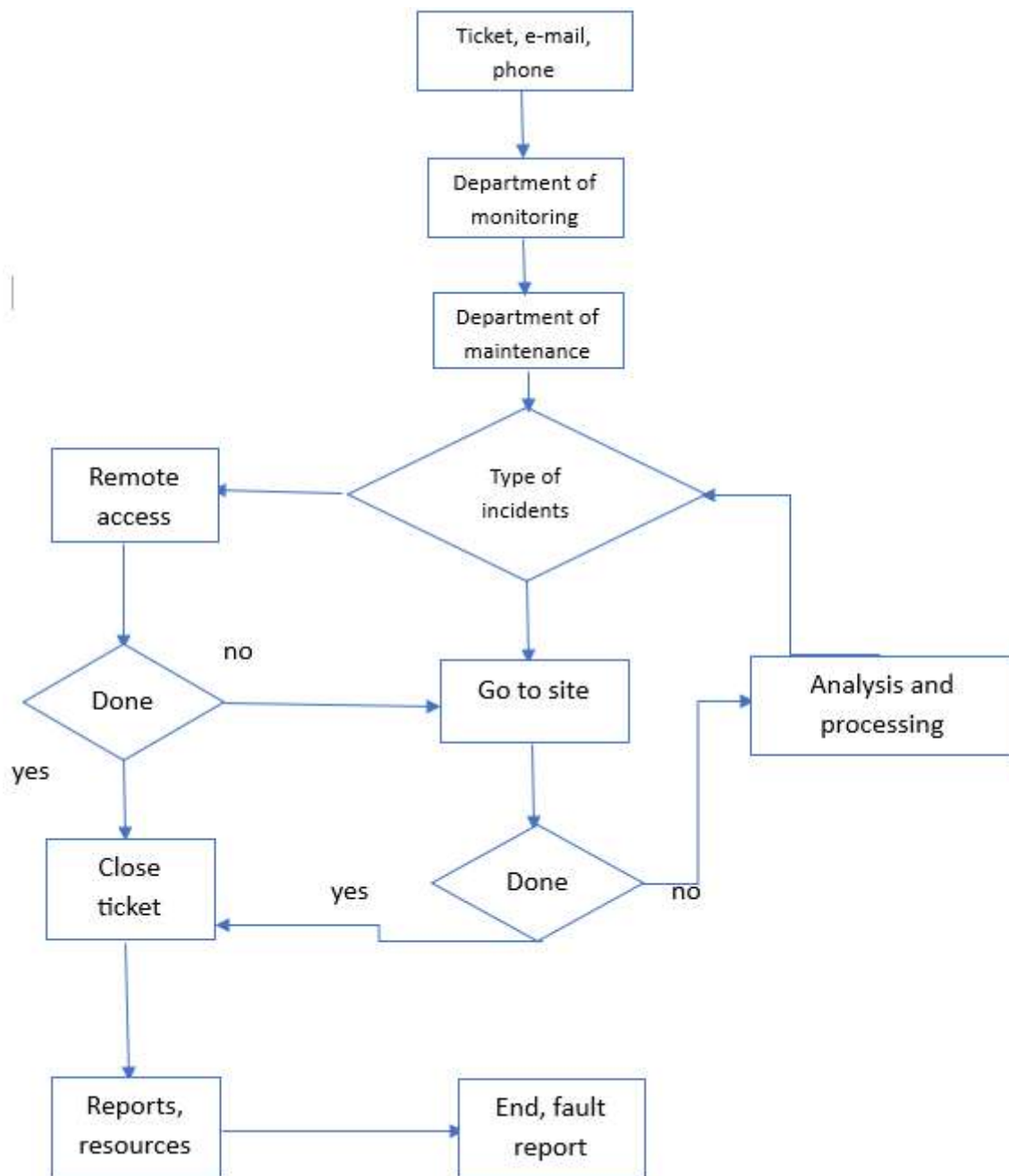


Figure 5. Incidents diagram

All teams may be doing incidental equipment maintenance. The monitoring department must be informed about the start of work on the equipment and components of the network. After the completion of the work, inform the monitoring department. The shift employee must check the correctness of the equipment on the site after the completion of the maintenance procedure. The team engaged in the maintenance of network equipment and components is of required to fill out the document intervention report after returning from the intervention.

Maintenance with the risk non-compliance in the broadcasting system are works that, in the event of a failure or error in the active equipment, could lead to service interruption on the user ( diesel generator, network equipment, transmitters...), table 4.

Table 4. Maintenance network and components

Notice on maintenance network and components			
Site	Type of maintenance	Date (time)	Executors

The team of maintenance informs the monitoring department 24 hours in advance.

## 5. CONCLUSION

Modern wireless telecommunication technologies including television, radio, and mobile telephony are online services. This content requires as few interruptions to the service as possible. The quality of service is extremely important, but modern equipment and associated protocols follow it well. This paper describes a modern maintenance system in which every step is clear. All shifts of employees and teams have assignments and guidelines monthly. The procedures are also clearly defined. The interconnection of the teams from the maintenance department exists. There is also a connection between the departments of the company. The system operates for a certain period and there is an analysis results of the implementation. It is calculated every 6 months. Every second of interruption mobile telephony, television, and radio service counts. The first steps in the development of the existing maintenance service system were carried out about 16 000 seconds. Over the years, the system has been evaluated, procedures have been improved, mistakes have been corrected, and employees have adopted a new system of work. An analysis of the maintenance system from 2024 (6 months) shows 10 000 seconds of total downtime. Significant progress has been made with the development and implementation of this maintenance system.

In the future, work should be done on further automation of the maintenance system, correction of procedures, and wider connection with central inventory control. One of the ideas of automation is the use of artificial intelligence in the processes of the work environment, spare part management, and maintenance. Employees who are interested in this would receive information about which spare parts are missing in terms of inventory.

## REFERENCES

- McClanahan, P. (2021). Operating system: 1.5 Interrupts. LibreTexts engineering. [https://eng.libretexts.org/Courses/Delta\\_College/Operating\\_System%3A\\_The\\_Basics/01%3A\\_The\\_Basics\\_-\\_An\\_Overview/1.5\\_Interrupts](https://eng.libretexts.org/Courses/Delta_College/Operating_System%3A_The_Basics/01%3A_The_Basics_-_An_Overview/1.5_Interrupts)
- Simon, B. (2013). The first phase of creating a standardised international innovative technological implementation framework/software application. *International Journal of Business and Systems Research*, 7(3), 250-265. <https://doi.org/10.1504/ijbsr.2013.055312>
- Kawalek, J. P. (2008), Rethinking Information Systems in Organizations. Taylor & Francis Group. <https://doi.org/10.4324/9780203936054>
- Hendriksen, M. (2024, May 17). Crafting Effective Maintenance Message with Examples: A Comprehensive Guide. <https://www.markhendriksen.com/maintenance-messages-with-examples/>
- Hartland, M. (2022, March 31). How to manage scheduled maintenance messages. IT and Technology. <https://www.snapcomms.com/blog/scheduled-maintenance-messages>
- Gabbert, J. (2017). Emergency alert system plan. <https://www.caloes.ca.gov/wp-content/uploads/Warning-Center/Documents/StateofCaliforniaEAS-Plan.pdf>



- Crain, M. (2021, July 5). The role of CMMS. Industrial technologies Northern digital. [https://www.plant-maintenance.com/articles/Role\\_of\\_CMMS.pdf](https://www.plant-maintenance.com/articles/Role_of_CMMS.pdf)
- Folkard, S., & Tucker, P. (2003). Shift work, safety and productivity. *Occupational medicine*, 53(2), 95-101. <https://doi: 10.1093/occmed/kqg047>.
- Kishan, B. (2010). Computerized maintenance management system made easy. ISBN 9780071491273.
- Eaves, A. H., & Kingsman, B. G. (2004). Forecasting for the ordering and stock-holding of spare parts. *Journal of the Operational Research Society*, 55(4), 431-437.
- Shaomin, W. & Zuo, M. J. (2010). Linear and nonlinear preventive maintenance models. *IEEE transactions on reliability*, 59(1), 242-249. ISSN 0018-9529.



## THE IMPACT OF THE CIRCULAR ECONOMY ON AN INDIVIDUAL'S QUALITY OF LIFE: A EUROPEAN UNION PERSPECTIVE

Ligita Gasparėnienė\*, Rita Remeikienė

*Vilnius university, Faculty of Law, Lithuania*

**Abstract:** This article explores the relationship between circular economy strategies and individual quality of life in the European Union. While the circular economy is widely promoted for its environmental and economic benefits, its social implications – particularly for everyday well-being – remain underexamined. Drawing on legal and policy document analysis, as well as comparative insights from academic and institutional sources, the study identifies how circular measures contribute to or hinder improvements in quality of life. The findings indicate that circular approaches can positively influence environmental health, job creation, and access to services, particularly when implemented through inclusive and coherent governance structures. However, uneven institutional capacity, fragmented policy implementation, and the absence of social indicators in monitoring frameworks limit the equitable distribution of benefits. The research underscores the need to move beyond material efficiency towards a socially embedded circular transition that prioritises participation, equity, and measurable well-being outcomes. It concludes that circular economy strategies must integrate quality of life considerations explicitly within their planning, funding, and evaluation processes to serve as effective tools for human-centred development across the European Union. Without such integration, the circular economy risks remaining a primarily technical or symbolic agenda, rather than a pathway to improved and more just daily life.

**Keywords:** Circular economy, European Union, Governance, Quality of life, Well-being.

### 1. INTRODUCTION

In recent years, the circular economy (CE) has emerged as a critical paradigm in the European Union's (EU) transition towards sustainable development. Beyond its role in reducing material consumption and waste generation, the CE increasingly intersects with broader societal goals, including human well-being and quality of life (QoL) (European Commission, 2020; Sekulić et al., 2022). However, while environmental and economic benefits

---

\* Corresponding author: [ligita.gaspareniene@tf.vu.lt](mailto:ligita.gaspareniene@tf.vu.lt)

Ligita Gasparėnienė, ORCID: 0000-0002-5535-6552  
Rita Remeikienė, ORCID: 0000-0002-3369-485X

of circularity have been widely acknowledged (Aguilar-Hernandez et al., 2021; Bianchi & Cordella, 2023), the social dimension – particularly its impact on everyday life – remains underexplored in both academic research and policy implementation.

The EU's political commitment to circularity, as outlined in the European Green Deal and the Circular Economy Action Plan, aims not only to decouple growth from resource use but also to foster more equitable, inclusive, and resilient communities (European Commission, n.d.-b; European Commission, 2020). National governments and local authorities have started to implement CE initiatives with potential implications for health, mobility, housing, employment, and social participation (OECD, 2025). Cities and regions such as Tallinn, Berlin, and Central Macedonia provide concrete cases for examining how these ambitions translate into individual experiences of well-being (OECD, 2023; OECD, 2024a; OECD, 2024b).

Moreover, new policy tools, such as the EU Circular Economy Monitoring Framework, aim to track circular progress at urban level, offering opportunities to integrate QoL indicators into CE assessment (Henrysson et al., 2022). Yet, the methodological and conceptual linkage between CE and QoL remains fragmented. As noted by Cramer (2020), governance models and institutional capacity greatly influence the societal outcomes of circular transitions, particularly at the regional level.

This article seeks to bridge this gap by exploring the following question: How does the implementation of circular economy strategies in the EU influence the quality of life of individuals? To answer this, the study draws on normative documents, academic literature, and comparative regional analysis to examine both the enabling and limiting factors shaping the CE–QoL nexus. In doing so, the paper contributes to an emerging body of scholarship that emphasises the human-centred dimension of sustainability (De Pascale et al., 2023; Bahers & Rosado, 2023; Pinyol Alberich et al., 2023).

The following sections provide a conceptual framework, outline the methodological approach based on legal and regulatory analysis, and present a comparative discussion of regional experiences. Emphasis is placed on policy coherence, social inclusion, and the role of governance in mediating the effects of CE on daily life.

## **2. LITERATURE REVIEW**

Establishing the connection between CE strategies and individual well-being requires a synthesis of theoretical, institutional, and legal perspectives. This section reviews how the concept of CE has evolved to encompass social dimensions, identifies key conditions for successful implementation, and examines the regulatory and policy frameworks that guide practice across the EU. It also outlines emerging approaches to evaluating CE impacts on individual and community well-being.

### **2.1. Defining Circular Economy and Social Dimensions**

The CE has evolved from early ecological visions, such as Boulding's "Spaceship Earth" concept and Stahel's work on service-based business models, into a structured framework for reducing environmental pressures while supporting economic and social resilience (Cramer, 2020). The European Commission defines CE as a system that retains the value of products, materials, and resources in the economy for as long as possible (European Commission, n.d.-a), a goal formalised in strategic initiatives like the European Green Deal and the Circular Economy Action Plan (European Commission, 2020; European Commission, n.d.-b).

Although initial policy and academic attention focused on material flows and economic gains, a growing body of research explores CE's potential social co-benefits. Sekulić et al. (2022) argue that CE can improve QoL through better air quality, access to services, and new job opportunities. Aguilar-Hernandez et al. (2021) highlight that CE, when embedded in national planning, can lead to higher employment and more equitable development. Likewise, Sanz-Torró et al., (2025) show that national CE policies are increasingly designed with social outcomes in mind.

## **2.2. Governance and Implementation Conditions**

Effective CE implementation depends not only on environmental ambition but also on the institutional capacity to align stakeholders and policy instruments. The OECD's (2025) twelve-dimensional governance checklist includes strategic vision, stakeholder engagement, regulatory coherence, and monitoring capacity. Local conditions and leadership also matter – Cramer (2020) emphasises the importance of transition brokers who coordinate regional CE processes across public, private, and non-profit sectors.

Urban case studies offer real-world insight into these dynamics. Berlin's Zero Waste strategy has integrated CE into procurement, construction, and employment planning (OECD, 2024b). Central Macedonia has used EU and regional funds to build capacity for CE in agriculture, tourism, and waste management (OECD, 2024a). Tallinn's transition benefited from a digital governance culture and stakeholder engagement across municipal departments (OECD, 2023). Despite contextual differences, each case highlights that cities with integrated and well-resourced CE strategies tend to see broader social returns.

Nonetheless, Pinyol Alberich et al. (2023) warn that policy silos and limited citizen participation still constrain many CE initiatives. Without inclusive design and multi-level coordination, efforts risk prioritising material efficiency over social value.

## **2.3. Policy, Monitoring and Legal Frameworks**

The EU supports CE transition through both regulatory and soft-law instruments. The Waste Framework Directive (Directive 2008/98/EC), Circular Economy Action Plan (European Commission, 2020), and the proposed Ecodesign for Sustainable Products Regulation (European Commission, 2022) together form the legal foundation of the EU's circular policy landscape. These instruments aim to harmonise environmental goals while leaving implementation flexibility for Member States and regions.

Monitoring tools also support CE integration with QoL considerations. Henrysson et al. (2022) applied the EU Circular Economy Monitoring Framework in Umeå municipality, linking CE actions to improvements in mobility, waste reduction, and energy efficiency. Their findings underscore the need for localised, multi-dimensional indicators when evaluating CE success.

Complementary instruments, such as the *LIFE programme*, support experimentation and project-based integration of CE and social goals (European Commission, n.d.-a). However, De Pascale et al. (2023) note that many Member States still struggle to implement EU directives coherently at the local level. As Bahers and Rosado (2023) demonstrate in their comparative study of urban metabolisms, CE transitions can inadvertently lead to increased resource use unless supported by behavioural change, institutional reform, and active citizen engagement.

### **3. METHODOLOGY**

In this research, classical methods of legal analysis were applied, as typically used in the study of regulatory and social policy frameworks. These included the logical-systematic method, legal document and policy content analysis, the comparative method, and selected approaches of legal interpretation. These methods enabled a structured examination of EU legal acts, strategic frameworks, and regional circular economy initiatives with regard to their impact on quality of life. The approach also allowed for the identification of institutional responsibilities and regulatory gaps across Member States and local authorities.

### **4. RESULTS AND DISCUSSION**

This section presents and discusses the results of the analysis, focusing on how the implementation of circular economy strategies influences individual quality of life across the European Union. The discussion is structured into four thematic sub-sections, each addressing a different dimension of the circular transition's impact on well-being.

The analysis draws on European Union legal instruments, strategic policy documents, and secondary data from academic and institutional sources. Rather than examining specific locations in detail, the discussion highlights broader patterns observed across selected cities and regions within the EU. Emphasis is placed on interpreting how governance practices, institutional arrangements, and policy coherence shape the social outcomes of circular initiatives. Each sub-section reflects on both the observed tendencies and the potential limitations of circular strategies as tools for enhancing everyday life.

#### **4.1. Measurable Impacts of Circular Economy on Quality of Life**

Circular economy strategies, when implemented coherently, can generate tangible improvements in several dimensions of individual well-being. A recurring observation across various EU cities and regions is the association between CE initiatives and enhanced environmental conditions, particularly air quality, waste reduction, and access to green public spaces. Such outcomes contribute directly to quality of life (QoL) by improving urban liveability, supporting physical and mental health, and reducing exposure to environmental hazards.

Among the most influential CE interventions are those targeting household and municipal waste. Shifting from landfill dependency to reuse, separate collection, and repair-oriented infrastructure has demonstrably reduced both physical pollution and public expenditure, while also increasing public trust in local governance systems. Furthermore, citizen-facing initiatives – such as community composting stations or second-hand material libraries – not only decrease material throughput but simultaneously promote civic participation and shared responsibility.

Another measurable benefit relates to mobility and public service provision. CE-inspired approaches to urban transport – such as bicycle reuse schemes, vehicle-sharing platforms, and electrified low-waste logistics – can contribute to more affordable, sustainable, and accessible infrastructure. These systems not only reduce congestion and pollution but also enhance social equity by enabling access to services and employment opportunities for wider segments of the population.

The food system also demonstrates strong synergies between CE principles and QoL. Local circular food networks that emphasize short supply chains, surplus redistribution, and packaging minimization not only reduce environmental impact but also address food

affordability and nutritional access. Such schemes – particularly when supported by public procurement policies – help mitigate food insecurity and strengthen community ties, especially in urban neighborhoods.

Job creation is also frequently cited as a positive outcome of the circular transition, particularly in sectors such as repair, recycling, reuse, green construction, and bio-based innovation (Aguilar-Hernandez et al., 2021; Sanz-Torró et al., 2025). These so-called “green” or “circular” jobs tend to be local, low-barrier, and skills-diverse, offering inclusive employment potential. However, questions remain about the long-term stability and social security of such positions – an area requiring further policy support and monitoring.

In some contexts, CE initiatives have extended into housing and education, where circularity is associated with redesigning service delivery models to prioritize community well-being. Citizen-led workshops, urban retrofitting, and material recovery centers offer not only functional benefits but also spaces for social interaction and learning – components increasingly recognised as contributors to subjective and collective well-being (Sekulić et al., 2022).

Nevertheless, it is important to acknowledge that not all CE strategies result in immediate or measurable improvements. Their effects often depend on scale, funding, local political will, and the degree of integration with social policy. Some initiatives, while symbolically circular, may lack sufficient follow-up or impact assessment mechanisms. This raises the need for clearer evaluation standards and QoL indicators embedded into circular transition planning (Henrysson et al., 2022; OECD, 2025).

#### **4.2. Governance and Participation as Conditions for Quality Outcomes**

The social outcomes of CE implementation are shaped not only by the design of policies, but critically by the way they are governed and communicated. A growing body of literature affirms that strong, integrated governance systems are among the most decisive factors influencing whether CE initiatives result in measurable improvements in QoL (OECD, 2025). Where institutional arrangements are coherent, cross-sectoral, and participatory, CE strategies are more likely to support equitable well-being outcomes.

One of the clearest insights from comparative case analyses is that decentralized governance – when coupled with adequate coordination – can generate more context-sensitive and socially responsive CE models. Local authorities that take ownership of CE priorities tend to be more flexible in adjusting strategies to community needs and are often more successful in activating local capacities. Conversely, top-down implementation without local agency tends to produce fragmented outcomes and low citizen engagement (Pinyol Alberich et al., 2023).

Participation mechanisms are a particularly powerful driver of QoL-enhancing CE. Initiatives co-designed with community groups or co-managed by civil society actors have demonstrated stronger longevity, legitimacy, and social resonance. Examples include collaborative reuse hubs, repair cafés, participatory budgeting for CE investments, and social enterprises based on circular practices. While these models may not scale rapidly, they often provide deeper and more lasting benefits in terms of social inclusion, knowledge exchange, and civic empowerment (Cramer, 2020).

The role of intermediaries or “transition brokers” is also notable in shaping outcomes. These actors – often non-governmental or semi-public institutions – facilitate dialogue between stakeholders, align funding and project priorities, and help bridge administrative or ideological gaps. Their presence has been linked to improved coordination across sectors and sustained CE implementation, particularly in complex governance environments.

Despite these strengths, many CE strategies still suffer from insufficient integration of participatory processes. Consultations are frequently formalistic or narrowly scoped, failing to

reach vulnerable or marginalized populations. These risks reproduce socio-spatial inequalities, particularly when circular policies affect housing, waste, or transport systems that already exhibit disparities in access and affordability. Moreover, limited transparency in how CE benefits are distributed can undermine public support, even when environmental goals are met.

The findings indicate that governance quality and participation are not supplementary features of CE success – they are core determinants of whether circular policies contribute to everyday well-being. As such, building institutional frameworks that explicitly prioritize equity, inclusion, and co-creation are not only desirable, but essential to ensuring that CE serves as a genuine pathway to improved QoL in the EU context.

#### **4.3. Equity, Inclusion, and the Risk of Uneven Benefits**

While CE policies are often promoted as inherently sustainable and socially beneficial, there is growing recognition that their impacts on QoL are not uniformly distributed. Evidence suggests that unless inclusion is embedded from the outset, CE strategies may exacerbate existing inequalities, particularly in access to services, affordability, and participation.

One key challenge lies in the unequal accessibility of CE-related infrastructure and services. Waste separation systems, for instance, often assume a level of digital literacy, transport mobility, or spatial proximity that is not shared by all citizens. Lower-income and elderly populations may face higher barriers to engaging with such systems or may bear disproportionate costs when CE measures involve user-paid schemes, deposit-refund systems, or shifts in waste tariffs. These concerns raised in the literature are that CE transitions, if left unexamined, can reinforce rather than reduce social disparities (Bahers & Rosado, 2023).

Furthermore, digital tools used to promote circular behaviour – such as repair app platforms, material tracing systems, or booking tools for shared mobility – may exclude those with limited access to technology or digital skills. In this regard, digitalization in CE should not be viewed as a neutral enabler, but as a potentially stratifying factor that calls for inclusive design and analogue alternatives (OECD, 2025).

There is also the risk that CE job creation, while positive in volume, may not guarantee quality. Circular sectors often rely on manual labour, short-term contracts, or informal economies – particularly in repair and reuse markets. Without labour protections or reskilling strategies, these jobs may replicate precarious conditions rather than offering a meaningful contribution to QoL (Aguilar-Hernandez et al., 2021).

Equity concerns also arise in the allocation of CE project funding and public-private partnerships. Regions with stronger institutional capacity or more established networks are better positioned to attract EU or national resources, while structurally weaker areas remain underserved. This institutional asymmetry may result in spatial inequalities in CE service availability and social return on investment (De Pascale et al., 2023).

Addressing these risks requires more than rhetorical commitments to inclusion. CE strategies must be systematically evaluated for their distributive effects, and proactive measures should be taken to support vulnerable groups through targeted outreach, subsidies, and participation mechanisms. Without deliberate attention to equity, CE may deliver environmental or economic efficiency at the expense of social cohesion and everyday well-being.

#### **4.4. From Strategy to Practice: Fragmentation, Policy Coherence, and Local Realities**

Despite the growing prominence of CE in European Union policy discourse, the translation of strategic goals into meaningful local implementation remains uneven. A recurring challenge is the gap between high-level ambitions – such as those outlined in the Circular Economy Action Plan – and the fragmented, sometimes inconsistent, execution at regional and municipal levels (De Pascale et al., 2023).

One key issue lies in the misalignment between different layers of governance. While national and EU frameworks often set out broad sustainability targets, local authorities are left to interpret and operationalise them with limited guidance, capacity, or coordination mechanisms. This frequently results in partial or symbolic application of CE principles, where individual projects are launched without being integrated into broader territorial strategies. Such fragmentation weakens the potential impact on quality of life (QoL), as isolated efforts tend to lack continuity, scale, and system-wide effects (Pinyol Alberich et al., 2023).

Another problem is institutional inertia. In many regions, traditional linear models are still deeply embedded in procurement rules, infrastructure planning, and budgeting procedures. Circular initiatives thus face structural resistance, requiring not only regulatory change but also shifts in organisational culture and competencies. Without institutional reform, CE risks becoming an “add-on” rather than a transformative paradigm.

Policy coherence is also undermined when environmental and social agendas are disconnected. While CE policies may succeed in improving material efficiency or waste statistics, they often fail to incorporate equity, inclusion, or well-being indicators as core objectives. This disconnect limits the extent to which circular strategies can meaningfully enhance everyday life. The use of monitoring frameworks that include social criteria remains limited and inconsistent across Member States (Henrysson et al., 2022).

Local realities further complicate implementation. Resource availability, administrative capacity, political leadership, and public awareness vary widely across EU regions. Well-funded urban areas with strong institutional networks tend to advance faster, while smaller or structurally weaker municipalities struggle to activate CE potential. This geographical disparity raises questions about fairness and cohesion in the circular transition (Sanz-Torró et al., 2025).

To bridge the strategy-practice divide, it is essential to strengthen multi-level policy coordination, embed QoL goals explicitly within CE planning, and build institutional support at the local level. Only then can circular policies evolve from abstract ambitions into lived experiences that support both environmental sustainability and social well-being.

#### **5. CONCLUSION**

This study has examined the relationship between circular economy strategies and individual quality of life within the context of the European Union. The analysis confirms that CE has the potential to deliver meaningful social benefits, particularly in areas such as environmental quality, inclusive employment, access to services, and community engagement. When designed and implemented coherently, CE initiatives can enhance everyday well-being while advancing sustainability goals.

However, the findings also highlight several limitations. The distribution of CE-related benefits remains uneven across social groups and territories. Governance quality, citizen participation, and institutional capacity are critical in determining whether circular policies translate into tangible quality of life improvements. In the absence of inclusive processes and



adequate resources, CE may unintentionally reinforce inequalities or result in symbolic rather than systemic change.

Furthermore, a disconnect persists between strategic policy objectives and practical implementation. Many initiatives still operate in isolation, without being integrated into broader social and urban development frameworks. Monitoring tools often neglect well-being indicators, limiting the capacity to evaluate CE outcomes beyond material flows.

To ensure that CE transitions genuinely contribute to human-centred development, future policy efforts must embed quality of life goals more explicitly, support inclusive governance structures, and invest in local institutional capabilities. Integrating social metrics into circular planning, funding, and evaluation processes will be essential to realise the full promise of the CE as both an environmental and social innovation pathway.

## REFERENCES

- Aguilar-Hernandez, G. A., Rodrigues, J. F. D., & Tukker, A. (2021). Macroeconomic, social and environmental impacts of a circular economy up to 2050: A meta-analysis of prospective studies. *Journal of Cleaner Production*, 278, 123421. <https://doi.org/10.1016/j.jclepro.2020.123421>
- Author, A. A., & Author, B. B. (Year). Title of the article. Name of the Periodical, volume(issue), #-#. <https://doi.org/xxxx>
- Bahers, J. B., & Rosado, L. (2023). The material footprints of cities and importance of resource use indicators for urban circular economy policies: A comparison of urban metabolisms of Nantes-Saint-Nazaire and Gothenburg. *Cleaner Production Letters*, 4, 100029. <https://doi.org/10.1016/j.clpl.2023.100029>
- Bianchi, M., & Cordella, M. (2023). Does circular economy mitigate the extraction of natural resources? Empirical evidence based on analysis of 28 European economies over the past decade. *Ecological Economics*, 203, 107607. <https://doi.org/10.1016/j.ecolecon.2022.107607>
- Cramer, J. M. (2020). The function of transition brokers in the regional governance of implementing circular economy – A comparative case study of six Dutch regions. *Sustainability*, 12(12), 5015. <https://doi.org/10.3390/su12125015>
- De Pascale, A., Di Vita, G., Giannetto, C., Ioppolo, G., Lanfranchi, M., Limosani, M., & Szopik-Depczyńska, K. (2023). The circular economy implementation at the European Union level: Past, present and future. *Journal of Cleaner Production*, 423, 138658. <https://doi.org/10.1016/j.jclepro.2023.138658>
- Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Waste Framework Directive) (2008, December, 3). *Official Journal of the European Union*, L 312, 3 - 30. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098>
- Edwards, A. A., Steacy, L. M., Siegelman, N., Rigobon, V. M., Kearns, D. M., Rueckl, J. G., & Compton, D. L. (2022). Unpacking the unique relationship between set for variability and word reading development: Examining word- and child-level predictors of performance. *Journal of Educational Psychology*, 114(6), 1242–1256. <https://doi.org/10.1037/edu0000696>
- European Commission. (2008). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Waste Framework Directive). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098>

- European Commission. (2020, April 13). Circular economy action plan: For a cleaner and more competitive Europe. [https://environment.ec.europa.eu/strategy/circular-economy-action-plan\\_en](https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en)
- European Commission. (2022). Proposal for a regulation on ecodesign for sustainable products (COM/2022/142 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022PC0142>
- European Commission. (2025, February 27). LIFE programme: Circular economy and quality of life. [https://cinea.ec.europa.eu/programmes/life/circular-economy-and-quality-life\\_en](https://cinea.ec.europa.eu/programmes/life/circular-economy-and-quality-life_en)
- European Commission. (2025, March 9). European Green Deal. [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en)
- Henrysson, M., Papageorgiou, A., Björklund, A., Vanhuyse, F., & Sinha, R. (2022). Monitoring progress towards a circular economy in urban areas: An application of the European Union circular economy monitoring framework in Umeå municipality. *Sustainable Cities and Society*, 87, 104245. <https://doi.org/10.1016/j.scs.2022.104245>
- OECD. (2023). The circular economy in Tallinn, Estonia. OECD Urban Studies, *OECD Publishing*. <https://doi.org/10.1787/06abc3de-en>
- OECD. (2024). The circular economy in Berlin, Germany. OECD Regional Development Papers, No. 98, *OECD Publishing*. <https://doi.org/10.1787/459defe7-en>
- OECD. (2024). The circular economy in Central Macedonia, Greece. OECD Regional Development Papers, *OECD Publishing*. <https://doi.org/10.1787/19f00380-en>
- OECD. (2024). The circular economy in cities and regions of the European Union. *OECD Publishing*. [https://www.oecd.org/en/publications/the-circular-economy-in-cities-and-regions-of-the-european-union\\_e09c21e2-en.html](https://www.oecd.org/en/publications/the-circular-economy-in-cities-and-regions-of-the-european-union_e09c21e2-en.html)
- OECD. (2025). The circular economy in cities and regions of the European Union. OECD Urban Studies, *OECD Publishing*. <https://doi.org/10.1787/e09c21e2-en>
- Pinyol Alberich, J., Pansera, M., & Hartley, S. (2023). Understanding the EU's circular economy policies through futures of circularity. *Journal of Cleaner Production*, 385, 135723. <https://doi.org/10.1016/j.jclepro.2022.135723>
- Sanz-Torró, V., Calafat-Marzal, C., Guaita-Martinez, J. M., Vega, V. (2025). Assessment of European countries' national circular economy policies. *Journal of Environmental Management*, 373, <https://doi.org/10.1016/j.jenvman.2024.123835>.
- Sekulić, M., Stojanović, V., Pantelić, M., Nađ, I. (2022). Impact of the Circular Economy on Quality of Life – A Systematic Literature Review. *Geographica Pannonica*, 26 (1), 78 - 91.



## MADE IN ALBANIA FOR THE WORLD: A STUDY OF EXPORT STRATEGIES AND MARKET CHALLENGES

Ariola Harizi \*, Denada Liça, Silvana Gashi

*Aleksandër Moisiu University of Durrës, Faculty of Business, Albania*

**Abstract:** The internationalization of Albanian products, under the label “Made in Albania”, presents a strategic opportunity for enhancing national economic growth, employment, and global recognition. This paper explores the findings from comprehensive surveys and four focus group discussions conducted with a total of 12 Albanian producers across key sectors such as agriculture, manufacturing, and artisanal goods. The primary aim was to assess current export practices, identify persistent barriers to internationalization, and understand producer perceptions regarding foreign markets. Data revealed that while a significant proportion of producers are active in exports, their strategies often lack formal market analysis and structured planning. Major challenges include difficulties in meeting international quality standards, high logistical costs, limited digital marketing capacities, and a weak international brand image. Producers demonstrated a strong interest in emerging regional markets and emphasized the growing demand for sustainable and culturally distinctive products. The research highlights the need for targeted policy interventions, capacity-building programs, and public-private partnerships to support export growth. Additionally, the study underscores the role of digitalization and strategic branding in enhancing Albania’s competitiveness. Findings contribute to academic discourse on SME internationalization and provide practical recommendations for stakeholders seeking to elevate Albania’s presence in global market.

**Keywords:** Export practices, international markets, Made in Albania, trade barriers.

### 1. INTRODUCTION

The expansion of Albanian products into international markets represents a critical opportunity for the country's economic modernization, export diversification, and global competitiveness. Despite Albania’s geographic proximity to key European markets and its rich cultural and natural product base, the internationalization of Albanian producers remains limited compared to regional counterparts (World Bank, 2021). Many firms continue to export

---

\* Corresponding author: [ariolaharizi@uamd.edu.al](mailto:ariolaharizi@uamd.edu.al)

Ariola Harizi, ORCID: 0000-0001-6662-5044  
Denada Liça, ORCID: 0000-0003-0504-7601  
Silvana Gashi, ORCID: 0009-0002-2941-2423

through unstructured, reactive approaches rather than proactive strategic planning, limiting both market penetration and brand development (Morgan et al., 2021; Lica & Gashi, 2024).

Empirical research shows that country-of-origin perceptions significantly affect foreign consumer behavior, impacting trust, quality assessments, and willingness to purchase (Godey et al., 2012; Costa et al., 2016; Lica et al., 2021; Liça & Gashi, 2023). Albanian products, however, suffer from low international brand awareness and sporadic marketing efforts, which hinders their potential for value-added exports. Meanwhile, trade policies and national development strategies, such as Albania's National Strategy for Development and Integration (2015–2020), emphasize the need to enhance export capacities, promote innovation, and integrate into European value chains.

Understanding the perspectives and experiences of Albanian producers is therefore crucial to designing effective interventions that support export readiness. Focus groups and comprehensive surveys, particularly involving small and medium-sized enterprises (SMEs), are essential tools to uncover the real challenges and opportunities producers face (Cuervo-Cazurra & Un, 2023). This paper presents findings from such activities, targeting the identification of current export practices, barriers to internationalization, and perceptions of foreign market dynamics.

By systematically capturing the voices of producers through structured fieldwork, this study aims not only to enrich academic understanding of SME internationalization in emerging economies but also to offer practical policy recommendations for Albania's trade development agenda. In doing so, it seeks to position "Made in Albania" as a globally recognized and competitive label.

## 2. LITERATURE REVIEW

The internationalization of small and medium-sized enterprises (SMEs) from emerging economies has been extensively studied, with researchers emphasizing the critical role of strategic planning, innovation, and brand positioning in export success (Cuervo-Cazurra & Un, 2023). In the context of Albania, however, the literature remains relatively sparse, highlighting the need for localized research to understand the unique barriers and opportunities faced by domestic producers.

One fundamental determinant of international competitiveness is the country-of-origin (COO) effect, which shapes how foreign consumers perceive product quality and trustworthiness. Studies show that a positive COO image can significantly enhance the attractiveness of products, particularly in premium segments (Arghashi & Okumuş, 2022; Costa et al., 2016). Conversely, a weak COO image, as observed with Albanian products, can become a liability, necessitating strategic branding efforts (Godey et al., 2012).

Research by Lica and Gashi (2024) suggests that Albanian firms often lack proactive internationalization strategies, relying instead on ad hoc opportunities. Their study of Albanian manufacturing firms emphasized that few businesses invest in structured market intelligence, export certification, or long-term brand development, elements found crucial by Angulo-Ruiz et al. (2022) for successful expansion into foreign markets.

Another crucial factor identified in the literature is digital transformation. The increasing relevance of digital marketing, e-commerce platforms, and online branding significantly lowers the barriers to market entry, especially for SMEs from developing economies (Dethine et al., 2020; Fahmy & Ragab, 2022). However, Albanian producers often exhibit low digital readiness, which hampers their ability to reach international customers efficiently.

Logistical barriers and infrastructure gaps also emerge as persistent challenges in emerging market contexts (Ghouse, 2020; Chaldun et al., 2024). A study by World Bank (2021) on Albania highlights the inefficiencies in transport and customs processes, which disproportionately affect SMEs aiming to export to Europe and beyond.

In addition, the regulatory environment, including complex certification processes, lack of trade facilitation services, and limited access to export financing, further constrains Albanian exporters. The importance of government intervention in simplifying export procedures and providing targeted support programs is well-documented in international best practices (Ha-Brookshire & Yoon, 2012; Chopra et al., 2024).

According to the literature, successful SME internationalization depends on a combination of factors: positive country branding, digital transformation, access to efficient logistics, regulatory support, and strong export capabilities. However, most studies call for deeper, localized field research to tailor strategies to specific national and sectoral realities, a gap this study aims to address by focusing specifically on Albanian producers' lived experiences and perceptions of international markets (Neupert et al., 2006; Bianchi & Wickramasekera, 2016; Rahman et al., 2017; Calheiros-Lobo et al., 2023).

### **3. DATA AND METHODOLOGY**

This study employed a mixed-methods research design combining quantitative surveys and qualitative focus group discussions to capture a comprehensive understanding of Albanian producers' export practices, challenges, and perceptions regarding international markets. This approach allowed for triangulation of data, enhancing the reliability and depth of the findings.

The data collection activities, were carried out between January and March 2025. During this period, both an online survey and structured focus group sessions were conducted.

An online survey was developed to gather large-scale quantitative data from Albanian producers across diverse sectors, including agriculture, textile manufacturing, handicrafts, and processed food industries. 127 producers completed the survey. The questionnaire covered areas such as current export markets, perceived market barriers, use of digital technologies, certification processes, marketing strategies, and support needs. The survey was disseminated through industry associations, chambers of commerce, and university networks to maximize reach and sectoral diversity.

To complement the survey results with deeper qualitative insights, four focus group sessions were organized. A total of 12 producers participated in the focus groups. Each session lasted approximately 90 minutes and was moderated by trained facilitators following a semi-structured guide. Participants included representatives from SMEs actively engaged in exports or seeking to enter foreign markets, ensuring a diversity of perspectives from various industries and company sizes. The focus groups explored themes such as:

- Experiences and obstacles encountered during export activities
- Strategies employed for market entry and brand development
- Perceptions of foreign market opportunities and threats
- Adoption and challenges related to digital marketing and e-commerce platforms.

Survey responses were analyzed using descriptive statistics and cross-tabulation methods to identify common patterns and sector-specific differences. Focus group discussions were audio-recorded (with participant consent), transcribed, and subjected to thematic analysis. Key themes were identified through open coding, followed by axial coding to connect and interpret relationships among emerging topics. Participants were informed about the purpose of the study, confidentiality measures, and their right to withdraw at any stage. Data was anonymized to ensure privacy and compliance with research ethics guidelines. The integration

of quantitative and qualitative approaches ensured that broad trends could be verified and contextualized with rich, narrative insights, thereby providing a holistic understanding of the Albanian producers' export landscape.

#### 4. RESULTS AND DISCUSSION

The survey indicated that 68% of responding producers currently engage in export activities; however, only 23% have a formalized export plan or dedicated personnel handling international sales. This confirms prior studies showing that SMEs in emerging markets often lack structured approaches to internationalization (Chopra et al., 2024). Focus group participants emphasized the absence of long-term planning and a heavy reliance on informal trade relationships, such as personal or diaspora networks. This pattern is consistent with research highlighting the prevalence of reactive internationalization in transitional economies (Arghashi & Okumuş, 2022).

A dominant concern raised by both survey respondents and focus group participants was the difficulty in complying with international standards, such as ISO certifications or EU food safety requirements. For many SMEs, the complexity and cost of certification processes act as major deterrents. Similar trends were observed by Chaldun et al. (2024), who found that SMEs in emerging economies face disproportionate regulatory burdens that undermine export readiness.

59% of surveyed producers reported logistical challenges, including unreliable transportation systems, delayed customs procedures, and high costs of cross-border shipping. These findings align with earlier research highlighting weak infrastructure as a recurring challenge in SME internationalization in Southeast Europe (World Bank, 2021).

While over 70% of producers acknowledged the importance of digital marketing and e-commerce, only 40% were actively using such tools. The gap is even more pronounced among firms led by older entrepreneurs, who reported low confidence in adopting online channels. This "digital divide" threatens to marginalize traditional producers in an increasingly globalized and online-driven trade environment. Studies have shown that digital readiness significantly enhances SMEs' export capacity by lowering information barriers and expanding customer reach (Dethine et al., 2020; Fahmy & Ragab, 2022).

A recurring theme in focus groups was the low international awareness and credibility of Albanian products. Several participants felt that foreign buyers perceived "Made in Albania" as a low-value label, often associating it with informal production practices or inconsistent quality. This confirms broader research on negative COO effects faced by exporters from lesser-known countries (Costa et al., 2016; Ghouse, 2020).

Despite this, producers also identified strong potential in differentiation strategies. High-quality, culturally distinct products, particularly in sectors like artisanal food, organic agriculture, and handcrafts, were seen as having untapped value in niche international markets, particularly among diaspora populations and consumers favoring authenticity.

Although the EU remains a top priority, producers expressed a strategic interest in emerging markets, especially in the Middle East and Western Balkans. These were considered more culturally accessible and less stringent in trade requirements, offering realistic short-term opportunities. This preference mirrors findings from Morgan et al. (2021) on immigrant-owned SMEs exporting to familiar markets to reduce risk.

Unanimously, participants emphasized the need for:

- Capacity-building programs on trade compliance, marketing, and digital transformation
- Access to export financing tools tailored to SMEs

- Trade fair participation, subsidized by the state or donor programs
- National branding initiatives to build international trust.

These needs are strongly aligned with policy recommendations in both Albanian national strategies and international literature advocating for stronger state–business linkages in export ecosystems (Calheiros-Lobo et al., 2023).

*Table 1.* Summary of key findings from survey and focus groups

Theme	Survey results	Focus group insights
Export Activity	68% currently export, but few have formal strategies	Export is often opportunistic and network-driven
Market Knowledge	72% lack access to structured market intelligence	Many rely on anecdotal information and informal feedback
Certification & Compliance	65% struggle with international quality standards	Need for guidance and training in certification procedures
Logistics & Infrastructure	59% report high transport costs and customs delays	Weak supply chain limits reliability and competitiveness
Digital Presence	60% do not use digital marketing or e-commerce channels	Older business owners less familiar with digital tools
Perception of Albanian Brands	74% believe Albanian products are undervalued abroad	Calls for national branding campaigns to boost recognition
Government/Policy Support	Strong demand for capacity-building programs and financial support	Desire for export promotion agencies to play a more active coordination role
Emerging Market Interest	Growing interest in diaspora and Middle Eastern markets	Cultural familiarity and easier access noted as key advantages

## 5. CONCLUSION

This study contributes to a nuanced understanding of the export behaviors, challenges, and international market perceptions among Albanian producers, based on data collected from surveys and focus groups conducted between January and March 2025. The findings confirm that while many producers are engaged in export activities, these are often unstructured, reactive, and constrained by regulatory, infrastructural, and informational barriers.

The majority of surveyed producers lack strategic export planning, rely on personal networks rather than market intelligence, and face significant difficulties complying with international quality standards. Furthermore, weak digital capabilities and a limited global perception of the “Made in Albania” brand exacerbate the challenges. However, producers demonstrated both interest and potential in diversifying into culturally proximate emerging markets, and in capitalizing on demand for sustainable, authentic products, particularly within the Albanian diaspora and niche organic sectors.

There are several limitations worth noting. First, the sample size for focus groups (12 participants) was limited, which, although sufficient for thematic analysis, may not capture the full diversity of experiences across Albania’s industries and regions. Second, the online nature of the survey may have excluded producers with low digital literacy or limited internet access. Third, the study focused exclusively on producers, without incorporating perspectives from institutional actors, policymakers, or buyers, which could have enriched the systemic analysis of export dynamics.

The findings emphasize the need for an integrated export promotion framework tailored to SMEs. Government institutions, in collaboration with universities and chambers of commerce, should prioritize:

- Training programs on certification and compliance
- Access to subsidized trade fairs and international exhibitions
- Development of digital skills for international marketing.



- Public-private branding initiatives to enhance Albania's product image globally

Support mechanisms must also be regionally inclusive, ensuring that producers in peripheral areas are not excluded from export promotion efforts. Development partners and international donors may consider supporting capacity-building and digitalization projects for export-oriented Albanian firms.

Future studies could expand the scope by:

- Conducting sector-specific deep-dives (e.g., agriculture, textiles, tourism-related goods)
- Including perspectives from institutional actors, trade advisors, and foreign buyers
- Applying longitudinal methods to track the evolution of Albanian producers' internationalization efforts over time
- Examining the impact of e-commerce platforms and B2B portals in enabling access to foreign markets.

Such research would strengthen the evidence base for policy reform and inform a more dynamic and competitive Albanian export strategy. Ultimately, aligning academic inquiry with real-world policy and entrepreneurial practice can elevate the visibility and value of "Made in Albania" products on the global stage.

## ACKNOWLEDGMENT

This study is part of the project "Promoting "Made in Albania" products in foreign markets". The authors are very grateful for the financial support of this project by Aleksandër Moisiu University of Durrës, Albania.

## REFERENCES

- Arghashi, V., & Okumuş, A. (2022). Country-of-origin image; SMEs and emerging economies—evidence from a case study of manufacturing SMEs from Turkey. *Journal of Islamic Marketing*, 13(4), 956-974. <https://doi.org/10.1108/JIMA-04-2020-0106>
- Bianchi, C., & Wickramasekera, R. (2016). Antecedents of SME export intensity in a Latin American Market. *Journal of Business Research*, 69(10), 4368-4376. <https://doi.org/10.1016/j.jbusres.2016.02.041>
- Calheiros-Lobo, N., Vasconcelos Ferreira, J., & Au-Yong-Oliveira, M. (2023). SME internationalization and export performance: A systematic review with bibliometric analysis. *Sustainability*, 15(11), 8473. <https://doi.org/10.3390/su15118473>
- Chaldun, E. R., Yudoko, G., & Prasetyo, E. A. (2024). Developing a theoretical framework of export-oriented small enterprises: A multiple case study in an emerging country. *Sustainability*, 16(24), 11132. <https://doi.org/10.3390/su162411132>
- Chopra, R., Bhardwaj, S., Baber, H., & Idris Sanusi, O. (2024). Navigating global horizons: a review of export promotion and foreign market entry strategies for small and medium enterprises (SMEs). *Journal of Business & Industrial Marketing*, 39(12), 2774-2790. <https://doi.org/10.1108/JBIM-10-2023-0610>
- Costa, C., Carneiro, J., & Goldszmidt, R. (2016). A contingent approach to country-of-origin effects on foreign products evaluation: Interaction of facets of country image with product classes. *International Business Review*, 25(5), 1066-1075. <https://doi.org/10.1016/j.ibusrev.2016.01.003>
- Cuervo-Cazurra, A., & Un, C. A. (2023). Beauty in the eyes of the beholders: How government- and consumer-based country-of-origin advantages and disadvantages drive host country



- investment dynamics. *Management International Review*, 63(2), 285-312. <https://doi.org/10.1007/s11575-022-00497-8>
- Dethine, B., Enjolras, M., & Monticolo, D. (2020). Digitalization and SMEs' export management: Impacts on resources and capabilities. *Technology Innovation Management Review*, 10(4), 18-34. <http://doi.org/10.22215/timreview/1344>
- Fahmy, M. M., & Ragab, N. E. (2022). Enhancing enterprise competitiveness and sustainability using EWOM: The case of Egypt. *Corporate and Business Strategy Review*, 3(1), 29–38. <https://doi.org/10.22495/cbsrv3i1art3>
- Ghouse, S. M. (2020). Impact of export barriers on micro, small and medium enterprises internationalisation: an Indian perspective. *International Journal of Export Marketing*, 3(4), 370-388. <https://doi.org/10.1504/IJEXPORTM.2020.109529>
- Godey, B., Pederzoli, D., Aiello, G., Donvito, R., Chan, P., Oh, H., Singh, R., Skorobogatykh, I. I., Tsuchiya, J., & Weitz, B. (2012). Brand and country-of-origin effect on consumers' decision to purchase luxury products. *Journal of Business Research*, 65(10), 1461–1470. <https://doi.org/10.1016/j.jbusres.2011.10.012>
- Ha-Brookshire, J., & Yoon, S.-H. (2012). Country of origin factors influencing US consumers' perceived price for multinational products. *Journal of Consumer Marketing*, 29(6), 445–454. <https://doi.org/10.1108/07363761211259250>
- Liça, D., & Gashi, S. (2023). Motivations and challenges: An analysis of manufacturing firms in the fashion industry internationalizing to Albania. *International Journal of Economics, Commerce and Management*, 11(11), 126–137. <https://ijecm.co.uk/>
- Lica, D., & Gashi, S. (2024). Internationalization of firms: The impact of “Made in Albania” on strategic decisions. *Corporate & Business Strategy Review*, 5(2), 175–185. <https://doi.org/10.22495/cbsrv5i2art15>
- Lica, D., Di Maria, E., & De Marchi, V. (2021). Co-location of R&D and production in fashion industry. *Journal of Fashion Marketing and Management*, 25(1), 133–152. <https://doi.org/10.1108/JFMM-02-2020-0023>
- Morgan, H. M., Sui, S., & Malhotra, S. (2021). No place like home: The effect of exporting to the country of origin on the financial performance of immigrant-owned SMEs. *Journal of International Business Studies*, 52, 504-524. <https://doi.org/10.1057/s41267-020-00360-8>
- Neupert, K. E., Baughn, C. C., & Thanh Lam Dao, T. (2006). SME exporting challenges in transitional and developed economies. *Journal of small business and enterprise development*, 13(4), 535-545. <https://doi.org/10.1108/14626000610705732>
- Rahman, M., Uddin, M., & Lodoros, G. (2017). Barriers to enter in foreign markets: evidence from SMEs in emerging market. *International Marketing Review*, 34(1), 68-86. <https://doi.org/10.1108/IMR-10-2014-0322>
- Republic of Albania, Ministry of Finance and Economy. (2015). National Strategy for Development and Integration 2015–2020. [https://neighbourhood-enlargement.ec.europa.eu/system/files/2019-04/albania\\_erp\\_2018-2020.pdf](https://neighbourhood-enlargement.ec.europa.eu/system/files/2019-04/albania_erp_2018-2020.pdf)
- World Bank. (2021). Albania Country Economic Memorandum: Boosting Competitiveness to Grow the Economy. <https://documents1.worldbank.org/curated/en/099845001312232607/pdf/P1752090e8141b05a08afc06ea6bc385da3.pdf>



## THE MODERATING EFFECT OF STAKEHOLDERS' INFLUENCE ON THE RELATIONSHIP BETWEEN SUCCESSION MANAGEMENT AND HUMAN RESOURCE OUTCOMES IN PRIVATE UNIVERSITIES, KENYA

Hilderlith Amimo-Ogut<sup>1\*</sup>, Fred Walumbwa<sup>2</sup>, Vincent Ogutu<sup>1</sup>, Simon Ndiritu<sup>1</sup>

<sup>1</sup> Strathmore University, Business school, Kenya

<sup>2</sup> Florida International University, USA

**Abstract:** The growing number of private universities in Kenya continues to increase opportunities for higher education, in tandem with elevating competition, as each institution strives to attract quality employees for competitive services. Thus, retention of experienced academic administrators is increasingly becoming a key challenge in many universities, with implications on leadership stability and performance. Some universities are responding to this challenge through Succession Management (SM) and stakeholder engagement programmes, hoping to improve Human Resource (HR) outcomes. However, little is known in academia about the effect of such programmes on HR outcomes. This study sought to establish the moderating effect of Stakeholders' Influence (SH) on the relationship between SM and HR outcomes in the private universities. Using the cross-sectional data, sourced from 253 academic administrators, the study found that SM accounted for 31% of variance in HR outcomes, while the interaction term between SM and SH explained up to 51% of the variance: with a positive and significant effect (Beta = 0.718,  $p < 0.000$ ). This led to rejection of the research hypothesis for being untrue, and the conclusion that SH had a significant moderating effect on the relationship between SM and HR outcomes in private universities, in Kenya.

**Keywords:** Stakeholders, succession management, human resource, private universities

### 1. INTRODUCTION

Human Resource Management (HRM) embodies all the activities associated with selection, recruitment, training, development, performance management, mentorship of employees, among others; collectively described as HR practices (Marescaux et al., 2013;

---

\* Corresponding author: [hilderlith@gmail.com](mailto:hilderlith@gmail.com)

Hilderlith Amimo-Ogut, ORCID: 0000-0002-9343-0784

Fred Walumbwa, ORCID: 0000-0002-8038-3608

Vincent Ogutu, ORCID: 0000-0002-0801-1615

Simon Ndiritu, ORCID: 0000-0002-8463-3758

Koster & Brenda, 2020; O’Riordan, 2017). While HR practices are designed to create value by enhancing efficiency and professionalism, HRM optimizes the value created to improve organisational performance (Ekpa, 2021; Koster & Brenda, 2020). HR practices can be favourable or unfavourable depending on the extent to which, and how soon they address employees’ needs (Marthalia, 2022).

The success of HRM manifests through measurable HR outcomes, which Jiang et al. (2012) classified as: employee-related, organisational, and business-related. While, employee-related outcomes address individual experiences and behaviors, organisational outcomes focus on overall operations and performance. Business-related outcomes include top-level impacts, such as growth in sales or return on investment, among other performance metrics (Jiang et al., 2012). This study focused on employee-related outcomes, including job security and pay equity (Ekpa, 2021; Koster & Brenda, 2020). The relationship between HRM and HR outcomes is increasingly becoming important across all sectors, with a considerable number of studies focusing on underlying factors such as leadership transition (Marescaux et al., 2013).

Succession Management (SM) involves carefully selecting appropriate individuals from internal talent pools, retaining and developing them to assume senior management and leadership roles. Its purpose is to ensure that vacant positions are filled by the right people, at the right time to avoid leadership gaps, loss of knowledge and expertise in the event that staff exit for various reasons (Nyagudi, 2020). SM process involves forecasting the need for future senior managers and leaders, assessing the list of potential candidates, planning for talent development, and communicating to employees about career paths and opportunities (Wonnia, 2021). It benefits organisations by preparing them for planned and unplanned departures, breaking the cycle of homo-social reproduction at the workplace, propagating diversity, minimising conflicts during leadership transitions, and enhancing organisational competitiveness. SM also boosts employee morale, enhances retention and motivates performance (Wonnia, 2021). In universities, SM ensures leadership continuity and organisational stability, both of which are critical for performance. Therefore, an organisation that fails to prioritise SM gradually impairs its operations, business culture and competitiveness (Chakraborty & Biswas, 2020).

A stakeholder is any individual or group with vested interests in an organisation. Thus, a stakeholder can influence, or be influenced by the decisions and operations of an organisation (Boutilier, 2024). Stakeholders can be external such as investors, shareholders and suppliers; or internal like managers and employees (Boutilier, 2024; Sahal & Bett, 2022). Stakeholders’ Influence (SH) is becoming a common phenomenon in organisations, as stakeholders adopt various strategies to entrench their interests in organisational decisions (Darškuvienė & Bendoraitienė, 2014). Consequently, organisations have a crucial task of maintaining good relations with stakeholders, for positive reputation and optimal performance (Boutilier, 2024). In this study, although stakeholders contribute towards the success of private universities, little is known about the effect of SH on processes such as SM and HRM.

In 2022, Kenya had 36 private universities, having increased from 30 in 2015 (Cowling, 2023). Among other dynamics, the growing number of private universities has created more opportunities for the academic administrators, and intensified competition in the sub-sector. Thus, every university strives to attract and retain quality employees for competitive services. However, retention of experienced employees is gradually becoming an inevitable challenge to most institutions (Amburi et al., 2024). Although some institutions are increasingly responding to the challenge through programmes such as SM and stakeholder engagement, to prepare employees for higher management and leadership positions, little is known about the effect of such programmes on HR outcomes in academia. Furthermore, the relationship between SM and HR outcomes has attracted substantial research; however, the effect of SH on SM and HR

outcomes remains under-investigated. This study sought to establish the moderating effect of SH on the relationship between SM and HR outcomes.

## 2. LITERATURE REVIEW

The study was anchored on the stakeholder theory (Freeman, 1984) and the institutional theory (Meyer & Rowan, 1977). Whereas the stakeholder theory explained the relationship between SH and SM, as well as between SH and HR outcomes; institutional theory was used to elaborate the relationship between SM and HR practice, especially how organisations compete for legitimacy and survival.

A review of previous studies revealed relations between SM and HR outcomes, SH and SM, as well as SH and HR outcomes, but which were either contextually irrelevant or conceptually inadequate to fully address the research gap. For example, Nyagudi (2020) established a positive and significant relationship between SM and employee retention in mobile telecommunication companies; and concluded that improving SM was likely to influence HR outcomes positively. Rotich and Kiiru (2021) revealed that succession planning had a strong, positive and significant effect on employee performance. However, the study's simple conceptual configuration limited the extent to which it addressed the research gap.

Bassam et al. (2020) highlighted the importance of SI vis-à-vis SM, by influencing organisational decisions to perpetuate their interests. However, no hypotheses were tested to determine the relationship between SH and SM, which limited the study's contribution. Boutilier (2024) highlighted the importance of SH in relation to leadership transitions. It also revealed that SH was a critical factor in leadership transition processes; thereby, hinting at its potential moderating role on the relationship between SM and HR outcomes.

While citing a study conducted by the Society for Human Resource Management, Vorecol (2024) indicated that companies prioritising stakeholder engagement in HR projects were 40% more likely to meet their project objectives compared to those not doing so. Besides, organisations with high levels of stakeholder engagement in HR initiatives experienced a 21% increase in project success rates. Though the cited reports highlight the importance of SH in relation to HR outcomes, they were more than five years old, and were confined to the corporate sector; thereby, limiting their contextual relevance to private universities.

In conclusion, the literature review revealed shortage of studies focusing on the nexus between SM, SH and HR outcomes, particularly in private universities. Therefore, by investigating the moderating effect of SH on the relationship between SM and HR outcomes, this study addressed a valid research gap. The conceptual framework presented in Figure 1 indicates the hypothesised relationship between SM, SH and HR outcomes in private universities in Kenya.

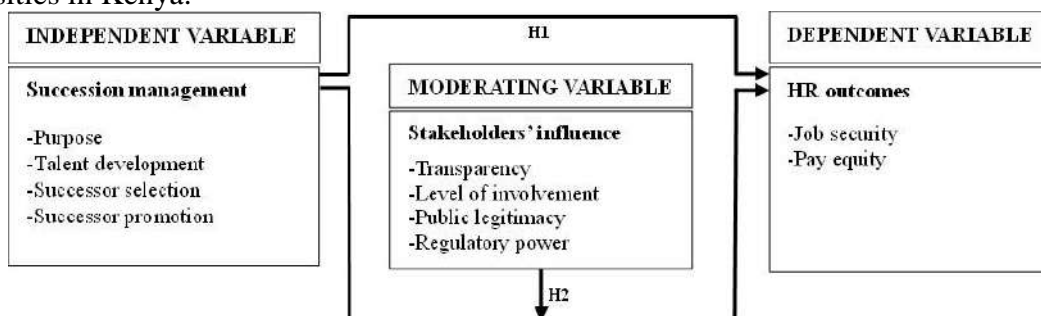


Figure 1. Conceptual framework

Based on the conceptual framework linkages, this study tested two research hypotheses: H1: SM has no significant influence on HR outcomes in private universities in Kenya; and H2: SH has no significant moderating effect on the relationship between SM and HR outcomes in private universities in Kenya.

### 3. DATA AND METHODOLOGY

The study anchored on pragmatist philosophy and employed a cross-sectional design. The design was chosen due to its cost-effectiveness and efficiency (Hunziker & Blankenagel, 2024). The study targeted academic administrators in all the 36 private universities (CUE, 2022). The target population was 316 academic administrators, including 158 deans and 158 directors. Based on the census principles, all the 316 respondents were involved. The sampling frame was stratified into two groups of deans and directors, who were sampled purposively. Primary data were sourced using a self-administered questionnaire. The questionnaire was pre-tested, its validity was determined using the Kaiser-Meyer-Olkin and Bartlett's test of sphericity; while its reliability was computed using the Cronbach's alpha ( $\alpha$ ) (Shrestha, 2021).

Descriptive and inferential analyses were used to address study objectives. Descriptive analysis included computation of composite Likert scale scores for each variable, to identify central limit tendencies and variability. Likert scale composite scores represent participants' overall perceptions towards the constructs being measured. Depending on the scale, lower scores indicate negative perceptions, while higher scores show positive perceptions or agreement (Alkharusi, 2022). This study used a scale of 1-5, calibrated as 'not at all (1)', 'small extent (2)', 'some extent (3)', 'moderate extent (4)' and 'great extent (5)'. Inferential analysis was performed using Pearson's Correlation Coefficient, simple linear and multiple regression. The model can be expressed in terms of the equation:

$$Y = \beta_0 + \beta_1 X_1 + \beta_{2m} X_{2m} + \beta_{3i} X * Z_{3i} + \varepsilon. \quad (1)$$

Where:  $Y$  is the dependent variable (HR outcomes);  $\beta_0$  is the intercept;  $X_1$  is independent variable (SM);  $\beta_1$  is the regression coefficient measuring effect of SM on HR outcomes;  $X_{2m}$  is the moderating variable (SH);  $\beta_{2m}$  is the regression coefficient indicating effect of SH;  $X * Z_{3i}$  is the interaction term between the SM and SH;  $\beta_{3mi}$  is the regression coefficient indicating effect of  $X * Z_{3i}$ ; while  $\varepsilon$  is the error term. The stepwise iteration method was used to determine the moderating effect of SH on the relationship between SM and HR outcomes (Ruengvirayudh & Brooks, 2016). Both simple linear regression and multiple regression equations were used to test the research hypotheses. The results were interpreted from the standardised regression coefficients ( $Beta$ ), adjusted coefficient of determination ( $R^2$ ), and the significance of F statistic (Morgan et al., 2007). The study was guided by the framework of ethical principles for social science research to protect participants. The researcher sought respondent's informed consents to ensure voluntary participation. Participants were also assured about the privacy, anonymity and confidentiality of their information (Praveen & Showkat, 2017). The researcher also sought ethical clearance from the Strathmore University Ethics Committee, and a research permit from the National Commission for Science, Technology and Innovation ahead of data collection.

### 4. RESULTS AND DISCUSSION

The results are presented under two broad themes, including descriptive and inferential results. Whereas the descriptive results focus on participants' socio-demographic characteristics, inferential results involve correlation and regression analyses.

#### 4.1. Descriptive results

The study captured information on participants' attributes, including gender, age, highest academic qualification, academic rank, years of work at the institution, and managerial training, among others. Of the 253 participants, 154 (60.9%) were males, suggesting that administrative positions were dominated by men. The participants were aged between 26 and 72, with a mean age of 47 years ( $SD = 9.647$ ). Besides, 152 (60.1%) respondents had PhD education or its equivalent, while 95 (37.6%) indicated master's degrees. Cumulatively, 97.7% of the participants had at least a master's education, suggesting specialized knowledge and potentially informed perspectives on SM, SH and HR outcomes in their institutions. Ninety-seven (38.4%) participants were lecturers, 79 (31.2%) were senior lecturers, while 55 (21.7%) were assistant lecturers. Regarding years of work at the institution, the analysis obtained a mean of 9.5 years, ( $SD = 9.000$ ). Furthermore, 120 (47.4%) participants had accessed some certified managerial training; making them better placed to perform managerial duties. Notably though, more than one-half, 133 (52.6%) participants had not accessed any training. Despite this, up to 241 (95.3%) participants performed both academic and administrative duties, raising curiosity about the quality of leadership in private universities in Kenya.

The study covered 36 chartered private universities at the time; of which 22 (61.1%) were non-profit, suggesting a focus on mission-driven objectives. Six (16.7%) institutions are profit-oriented, while another 6 (16.7%) reported a blend of profit and non-profit. The ownership status of private universities may have some influence on the institutional culture around SM, SH and HR practices. Twenty-three 23 (62.5%) institutions were faith-based, suggesting that SM, SH and HR practices may be founded on religious values. However, 14 (37.5%) universities were classified as secular, with distinct SM, SH and HR practices. The population of students in private universities ranged between 120 and 60,000, with a mean of 8,403 students ( $SD = 12,042$ ). Out of 36 institutions, 10 (27.8%) operated on annual budgets of less than KES 500 million, suggesting that about one-third of the private universities may be constrained in funding SM and HR practices, considering that about two-thirds were non-profit oriented. Six (16.7%) institutions operated on budgets of KES 502-999 million, while 4 (11.1%) stated budgets of KES 1-50 billion. However, 15 (41.7%) institutions did not disclose their annual budget, suggesting a gap in financial disclosure and transparency.

More still, 35 (96.0%) institutions adhered to CUE guidelines on promotions, suggesting that promotions were based on established standards; thereby, encouraging appropriate succession practices. Regarding the gender of most recent appointees to deanship positions, 16 (44.4%) institutions had appointed males, while 4 (11.2%) indicated females, suggesting that the proportion of women holding leadership positions in private universities falls below the one-third constitutional requirement. Notably though, 16 (44.4%) institutions were unclear on the gender of most recent appointees to the deanship positions. About the models used in most recent appointments to deanship positions, in 12 (32.0%) institutions the appointments followed the insider relay model, 5 (14.2%) indicated the insider non-relay model, another 5 (14.2%) stated the outside succession model, while 10 (27.7%) hinted the use of a mixture of succession models. Despite this, 4 (11.9) lacked appropriate succession plans, which may impact SM, SH and HR practices. Furthermore, Table 1 indicates the composite Likert scale scores for each study variable.

*Table 1. Likert scale composite scores*

Constructs	N	Minimum	Maximum	Mean	Std. Deviation
HR outcomes	253	1	5	3.62	0.933
SH	253	1	5	3.98	0.872
SM	253	1	5	3.49	0.962
Interaction factor between SM & SH	253	1	25	15.74	6.349
Valid N (listwise)	253				

Participants expressed positive perceptions about the constructs of the study, including SM, SH and HR outcomes. The perceptions ranged from 3.49 for SM to 3.98 for SH. Thus, participants were more positive towards SH than SM, with the extent of agreement ranging from ‘some extent’ to ‘moderate extent’. This information was used to establish whether or not the constructs were significantly correlated.

#### **4.2. Inferential results**

Correlation analysis was performed to establish whether the predictor variables (SM and SH) had significant correlations with HR outcomes. Correlation analysis is an essential precedent for linear and multiple regression analysis. Its purpose is to determine whether linear relationships exist between predictor and predicted variables, in line with a fundamental assumption of linear regression analysis. Correlation analysis was achieved using Pearson's Correlation Coefficient ( $r$ ) and the results showed that SM had a direct positive and significant correlation with HR outcomes ( $r = 0.547$  &  $p < 0.000$ ). This means that SM and HR outcomes in private universities had a linear relationship, such that as SM improved, HR outcomes also improved proportionately. This affirmed that SM could be regressed against HR outcomes. The analysis revealed a direct, positive and significant correlation between SH and HR outcomes ( $r = 0.633$  &  $p < 0.000$ ); suggesting a linear relationship between the two variables. Regarding the interaction term between SM and SH, the analysis revealed a direct, positive and significant linear relationship with HR outcomes ( $r = 0.718$  &  $p < 0.000$ ). Furthermore, the interaction term had the strongest positive correlation with HR outcomes, followed by SH and SM in that order. Despite this, the results suggested that all the variables used in the study fulfilled the assumption of linear relationship with the outcome variable; thereby, justifying the application of linear and multiple regression to test the research hypotheses.

Regression analysis generated three models: Model 1 fitted SM against HR outcomes; Model 2 regressed SM and SH against HR outcomes; while Model 3 regressed the interaction term against HR outcomes. Table 2 shows regression analysis results.

Table 2. Regression analysis results

Model Summary									
	R	R Square	Adjusted R Square	Std. Error	Change statistics				
					<i>R Square Change</i>	<i>F Change</i>	<i>df1</i>	<i>df2</i>	<i>Sig. F Change</i>
1	0.562 <sup>a</sup>	0.315	0.313	0.774	0.315	115.590	1	251	0.000***
2	0.641 <sup>b</sup>	0.411	0.407	0.719	0.411	87.332	2	250	0.000***
3	0.718 <sup>c</sup>	0.516	0.514	0.651	0.516	267.298	1	251	0.000***
ANOVA									
		Sum of Squares	df	Mean Square	F	Sig.			
1	Regression	69.234	1	69.234	115.590	0.000***			
	Residual	150.339	251	0.599					
	Total	219.573	252						
2	Regression	90.310	2	45.155	87.332	0.000***			
	Residual	129.263	250	0.517					
	Total	219.573	252						
3	Regression	113.239	1	113.239	267.298	0.000***			
	Residual	106.334	251	0.424					
	Total	219.573	252						
Regression Coefficients									
Model		Unstandardized Coefficients		Standardized Coefficients	t	p-value			
		<i>B</i>	<i>Std. Error</i>	<i>Beta</i>					
1	(Constant)	1.577	0.196		8.040	0.000***			
	SM	0.545	0.051	0.562	10.751	0.000***			
2	(Constant)	1.284	0.188		6.833	0.000***			
	SM	0.164	0.076	0.169	2.163	0.031**			
	SH	0.456	0.071	0.500	6.385	0.000***			
3	(Constant)	1.959	0.110		17.886	0.000***			
	$X*Z_{3i}$	0.106	0.006	0.718	16.349	0.000***			
Dependent Variable: HR outcomes									
a Predictors: (Constant), Succession management									
b Predictors: (Constant), Succession management, SH									
c Predictors: (Constant), $X*Z_{3i}$									

\*\* & \*\*\* shows significance at  $p < 0.05$  and  $p < 0.01$ , respectively.

The analysis was conducted to investigate the moderating effect of SH on the relationship between SM and HR outcomes. Collinearity tests were interpreted from the Variable Inflation Factor (VIF), which formed part of the output. The analysis generated VIF values ranging between 1 and 1.419, which according to Zach (2019) signals moderate levels of Collinearity between the predictor variables. The summary models show that Model 1 with SM as the predictor variable obtained the adjusted R square of 0.313, which suggest that the model explained 31.3% of variance in HR outcomes. The model's goodness-of-fit is supported by the R Square Change of 0.315 from the default model and an F-statistic of 115.590, which is significant ( $p < 0.000$ ). These results suggest that inclusion of SM in the regression equation created a robust model explaining variance in HR outcomes in private universities. In addition, Model 1 shows that SM had a positive influence on HR outcomes that was also significant (Beta = 0.562,  $p < 0.000$ ). This suggests that a unit change in the standard deviation from the mean



for SM, influenced up to 0.562 of change in HR outcomes. Based on this, the research hypothesis stating that *SM has no significant influence on HR outcomes in private universities in Kenya* is rejected for being inconsistent with empirical findings. SM influences HR outcomes by creating pipelines for internal talent development, with clear career progression paths, growth opportunities, and employee engagement, which collectively reduce uncertainty about future job dynamics. Helping employees to feel more secure in their positions and confident about ascending to positions with greater responsibilities, is not only crucial for job satisfaction, but also for improving individual performance. SM in private universities also contributes to better HR outcomes by propagating merit in the compensation of workers, which are essential for motivation, satisfaction and performance.

The results in Table 2 show that Model 2, which incorporated SM and SH, obtained the adjusted R square of 0.407, suggesting that the model accounted for 40.7% of variance in HR outcomes. The model's explanatory power is further indicated by the R Square Change of 0.411 and the F-statistic change of 87.332, which is significant ( $p < 0.000$ ). The results suggest that addition of SH and SM in the regression equation generated a robust and significant model to explain variance in HR outcomes in private universities. Model 2 further shows that SM and SH had positive influence on HR outcomes, individually, and the effect of each was statistically significant (Beta = 0.169,  $p < 0.000$ ) for SM and (Beta = 0.500,  $p = 0.031$ ). In relation to the results of Model 1, the results obtained by Model 2 suggest that addition of SH in the regression equation usurped the influence of SM on HR outcomes, meaning that SH had more power in explaining HR outcomes compared to SM. This means that stakeholders have a critical role to play in SM in private universities. Most private universities in Kenya depend on stakeholder funding, and these stakeholders often influence HR decisions. Thus, enhancing stakeholder engagement can have a greater impact on HR outcomes than SM alone, as it introduces diverse perspectives and expertise to shape HR practices.

Model 3, with the interaction term as the predictor variable, generated the adjusted R square of 0.514, suggesting that it accounted for 51.4% of variance in HR outcomes. Thus, inclusion of the interaction term in the equation significantly boosted the model's explanatory power. This further reflects with the R Square Change of 0.516 and the F-statistic change of 267.298, which was significant ( $p < 0.000$ ). The results suggest that the interaction term between SM and SH was the most effective in explaining variance in HR outcomes in private universities. Besides, effect of the interaction term on HR outcomes was not only positive, but also significant (Beta = 0.718,  $p < 0.000$ ). This means that inclusion of SH in the equation boosted the relationship between SM and HR outcomes. Consequently, the research hypothesis claiming that *SH has no significant moderating effect on the relationship between SM and HR outcomes in private universities in Kenya* was rejected for being untrue. While SM develops future leaders and promotes stability, SH ensures succession plans reflect institutional values and funds their implementation. Optimizing SH in SM is key to aligning HR practices with organizational goals for improved performance.

## 5. CONCLUSION

The objective of the study was to determine the moderating effect of SH on the relationship between SM and HR outcomes. The study demonstrated that SM and HR outcomes had a significant and positive relationship. However, addition of the interaction term between SM and SH improved the model's robustness and explanatory power. Therefore, SH had a significant moderating effect on the relationship between SM and HR outcomes in private universities in Kenya. Improving SH is likely to improve the strength of the relationship between SM and HR outcomes. This may be achieved by improving stakeholder involvement

in institutional decision-making processes focusing on SM and HRM programmes. Stakeholder involvement may also be enhanced through consistent and transparent communication, interactive engagement forums, leveraging on their professional experience and perspectives; in addition to expeditious response to their concerns.

## REFERENCES

- Alkharusi, H. (2022). A descriptive analysis and interpretation of data from Likert scales in educational & psychological research. *Indian Journal of Psychology & Education*, 12 (2), 13-16.
- Amburi, G.O., Odollo, L. & Njeje, D. (2024). Balanced score card and performance of private chartered universities in Kenya. *The Journal of Business and Economics*, 1 (2), 1-12.
- Bassam, F., Rida, E., de Clercy, C. & Glenn, R.W. (2020). Leadership succession in different types of organisations: What business and political successions may learn from each other. *The Leadership Quarterly*, 31 (1), 1-21.
- Boutilier, R.G. (2024). *Understanding stakeholders and their influence*. <https://www.researchgate.net/publication/378963389>. DOI: [10.4337/9781802208870.00029](https://doi.org/10.4337/9781802208870.00029)
- Chakraborty, D., & Biswas, W. (2020). Articulating the value of human resource planning (HRP) activities in augmenting al performance toward a sustained competitive firm. *Journal of Asia Business Studies*, 14 (1), 62-90. DOI:10.1108/JABS-01-2019-0025
- Commission for University Education (CUE) (2022). *University Statistics 2022/2023*. Nairobi: CUE.
- Cowling, N. (2023). *Number of public and private universities in Kenya 2015-2022*. <https://www.statista.com/statistics/1237787/number-of-public-and-private-universities-in-kenya/>
- Darškuvienė, V. & Bendoraitienė, E. (2014). Stakeholder expectations and influence on company decisions. *Taikomoji Ekonomika*, 8 (2), 84-96. <http://dx.doi.org/10.7220/AeSr.2335.8742.2014.8.2.5>
- Ekpa, I.H. (2021). Career management and human resource outcomes: A review. *International Journal of Management and Commerce Innovations*, 9 (2), 517-528.
- Freeman, R.E. (1984). *Strategic Management: A Stakeholder Approach*. Pitman, Boston.
- Hunziker, S. & Blankenagel, M. (2024). Cross-Sectional Research Design. In: *Research Design in Business and Management*. Springer Gabler, Wiesbaden.
- Jiang, K., Lepak, D.P., Hu, J. & Baer, J.C. (2012). How does human resource management influence organisational outcomes? a meta-analytic investigation of mediating mechanisms. *Academy of Management Journal*, 55 (6), 1264–1294. <http://dx.doi.org/10.5465/amj.2011.0088>
- Koster, F. & Benda, L. (2020). Innovative human resource management: measurement, determinants and outcomes. *International Journal of Innovation Science*, 12 (3), 287-302. <https://doi.org/10.1108/IJIS-03-2020-0027>
- Marescaux, E., De Winne, S. & Sels, L. (2013). HR practices and HR outcomes: The role of basic need satisfaction. *Personnel Review*, 42 (1), 4-27. DOI 10.1108/00483481311285200
- Marthalia, L. (2022). The importance of human resources (HR) management in company. *Journal of World Science*, 1 (9), 700-705. DOI: 10.36418/jws.v1i9.89

- Meyer, J., & Rowan, B. (1977). Institutionalized Organizations: Formal Structure as Myth and Ceremony. *American Journal of Sociology*, 83, 340-363. <http://dx.doi.org/10.1086/226550>
- Morgan, G.A., Leech, N.L., Gloeckner, G.W. and Barrett, K.C. (2007). *SPSS for Introductory Statistics: Use and Interpretation*. 3rd Edition. New York: Psychology Press.
- Nyagudi, W. O. (2020). Succession management and employee retention in mobile telecommunication companies in Kenya. *The Strategic Journal of Business and Change Management*, 7(3), 166-185.
- O’Riordan, J. (2017). *The practice of human resource management: Research Paper 20*. Institute of Public Administration.
- Praveen, H., & Showkat, N. (2017). Research ethics. *ResearchGate*. [https://www.researchgate.net/publication/318912804\\_Research\\_Ethics](https://www.researchgate.net/publication/318912804_Research_Ethics)
- Rotich, J.L., & Kiiru, D. (2021). Effect of succession planning on employee performance in the Ministry of ICT, Innovation and Youth Affairs in Nairobi City County, Kenya. *International Academic Journal of Human Resource and Business Administration*, 3 (10), 112-128.
- Ruengvirayudh, P. & Brooks, G.P. (2016). Comparing stepwise regression models to the best-subsets models, or, the art of stepwise. *General Linear Model Journal*, 42 (1), 1-14.
- Sahal, I.D. & Bett, S. (2022). Influence of stakeholder involvement on performance of Kenyan parliamentary service commission. *International Journal of Management and Commerce Innovations*, 10 (1), 326-332.
- Shrestha, N. (2021) Detecting multicollinearity in regression analysis. *American Journal of Applied Mathematics and Statistics*, 8, 39-42. <https://doi.org/10.12691/ajams-8-2-1>
- Vorecol (2024). *Importance of stakeholder engagement in HR projects*. <https://vorecol.com/blogs/blog-importance-of-stakeholder-engagement-in-hr-projects-10059#>
- Wonnia, L.K. (2021). Succession management in public universities in Ghana: Context, prospects and success factors - A review of literature. *UDS International Journal of Development*, 8 (2), 688-697.
- Zach, (2019). *A guide to multicollinearity and VIF in regression*. Retrieved on 20/07/2022 from <https://www.statology.org/multicollinearity-regression/>



## **SOCIAL RESOURCE ORCHESTRATION AND GROWTH OF SMALL AND MEDIUM ENTERPRISES: A SYSTEMATIC REVIEW**

**Loise Oburu<sup>\*</sup>,<sup>1</sup>Joseph Onyango, Ann Ndirangu**

*Strathmore University, Strathmore University Business School, Kenya*

**Abstract:** Small and Medium Enterprises (SMEs) are crucial in global economic growth, job creation, and innovation. However, many SMEs, particularly in developing regions, continue to face challenges that hinder their growth, and the contribution of social resource orchestration to SME growth has not been adequately investigated. This systematic review synthesises the research stream to clarify the impact of social resource orchestration on SME growth and its mechanisms. The studies were evaluated using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Results indicate that most studies were conducted in the Global South, particularly in Africa and Asia. The studies consistently highlight the importance of social resource orchestration in shaping SME growth. Social networks, including relationships with customers, partners, and financial institutions, positively influence various SME outcomes, such as business growth, innovation, and economic performance, with effect sizes showing moderate to strong positive associations. However, direct links to SME growth were implied rather than explicitly stated. This analysis signals that while social networks are valued for improving performance metrics, the pathway to sustained growth through social resource orchestration requires further research. Addressing this gap could clarify how specific orchestration strategies support SMEs' growth.

**Keywords:** SME Growth, Social Capital, Social Resource Orchestration, Systematic Review

### **1. INTRODUCTION**

Many Small and Medium Enterprises (SMEs) struggle to outgrow their smallness and could benefit from social resources (Ibrahim et al., 2020). As the economic backbone of many developing countries (Okeke et al., 2021), the dynamics of their growth have become a topic of enduring intellectual interest, and their orchestration of social resources is no exception (Liu et al., 2022). Social resource orchestration – the ability to mobilize and coordinate resources

---

<sup>\*</sup> Corresponding Author: [loburu@strathmore.edu](mailto:loburu@strathmore.edu)

<sup>\*</sup>Loise Oburu, ORCID: 0009-0005-5397-2342

Joseph Onyango, ORCID: 0000-0003-3070-2014

Ann Ndirangu, ORCID: 0000-0003-3539-6482

within one's networks – is increasingly becoming crucial for SMEs reliant on institutional, business, and social networks to access vital resources (Andrade-Rojas et al., 2022). Social resources must still be orchestrated like any other production factor to create growth value (Bals et al., 2023). Social resource orchestration, however, is an emergent concept in literature, and knowledge production is still evolving. In this regard, a systematic review methodology is ideal for examining its nexus to SME growth because it enables a comprehensive and unbiased synthesis of existing research (Hiebl, 2023). While research has explored resource orchestration within large firms and specific sectors, such as finance and technology, there is a limited comprehensive analysis of how social resources – such as networks, partnerships, and alliances – are coordinated to foster growth within SMEs in developing economies. An interesting finding from a systematic literature review by Gamage et al. (2020) focuses on social capital and SMEs from 1999 to 2020. Their results provided insights into social capital and SME performance rather than social resource orchestration and SME growth.

This systematic review is grounded in the need to understand how SMEs, particularly in developing economies, can optimize social resource allocation, structuring, and coordination to achieve sustained growth. Their ability to orchestrate social resources is especially critical due to limited access to capital, infrastructure, and skilled labor, which are typical constraints SMEs particularly face (Narada Gamage et al., 2020). The systematic review seeks to address the gap in the literature by specifically focusing on the role of social resource orchestration in SMEs, a topic that has been largely neglected in earlier systematic reviews. Three research questions guided the systematic review.

1. What are the key characteristics of studies examining the relationship between social resource orchestration and SME growth?
2. What theoretical frameworks underpin the studies, and what were the findings?
3. What is the risk of bias in studies exploring the impact of social resource orchestration on SME growth, and how does it affect the reliability of their findings?

## **2. DATA AND METHODOLOGY**

This study adopted a systematic review to investigate the relationship between social resource orchestration and SME growth to provide a comprehensive and unbiased synthesis of existing knowledge. A systematic review methodology adopts an unequivocal, orderly approach to assemble and synthesize the results of studies that state questions (Page et al., 2021). By systematically collecting, appraising, and analyzing studies, this approach ensures a rigorous examination of the current body of knowledge, reducing the likelihood of selection bias and providing a transparent, replicable framework for identifying patterns, gaps, and the quality of evidence (Lim et al., 2022). Three open-source databases, namely, CrossRef, PubMed, and Google Scholar were selected to ensure a wide-reaching capture of the field of knowledge across business, management, and social sciences. The PRISMA 2020 emphasizes transparency of systematic reviews to ensure the review contributes to scholarship (Page et al., 2021). In this regard, the use of open-source databases fosters transparency by allowing unrestricted access to the search strategy, data sources, and research articles, thereby promoting replication and verifiability of findings (Lyon, 2016). Including three databases also increased the likelihood of capturing diverse studies, reducing publication bias.

The inclusion criteria were all SMEs regardless of industry or geographical location, so long as the articles classified them as such. Eligible articles were those based on primary research, whether quantitative, qualitative, or mixed-methods studies, as long as they were peer-reviewed and published in English, undertaken between 2014 and 2024, and focused on SMEs. Non-empirical studies, unpublished articles, and those conducted before 2014 were thus excluded. A search was done for “Social Resource” or “Social Capital” and “Orchestration” or

“Resource Orchestration” and “SMEs” or “SME growth.” The search was conducted in October 2024. A total of 114 articles were identified. This comprised 45 articles from CrossRef, 49 from PubMed, and 20 from Google Scholar. A total of 60 articles remained after removing duplicates. A two-stage manual screening process followed this. Firstly, the titles and abstracts were reviewed to exclude irrelevant articles such as those based on systematic literature review, meta-analysis, scoping reviews, or meta-synthesis. As a result, 39 articles were retained. Secondly, a full-text assessment was performed on the eligible articles to confirm their conformity to the pre-defined eligibility criteria. This process led to the removal of eight articles that were not focused on SME development or growth. A total of 31 articles fulfilled the requirement for this systematic review. Figure 1 provides a flow diagram illustrating the identification, screening, eligibility, and inclusion process.

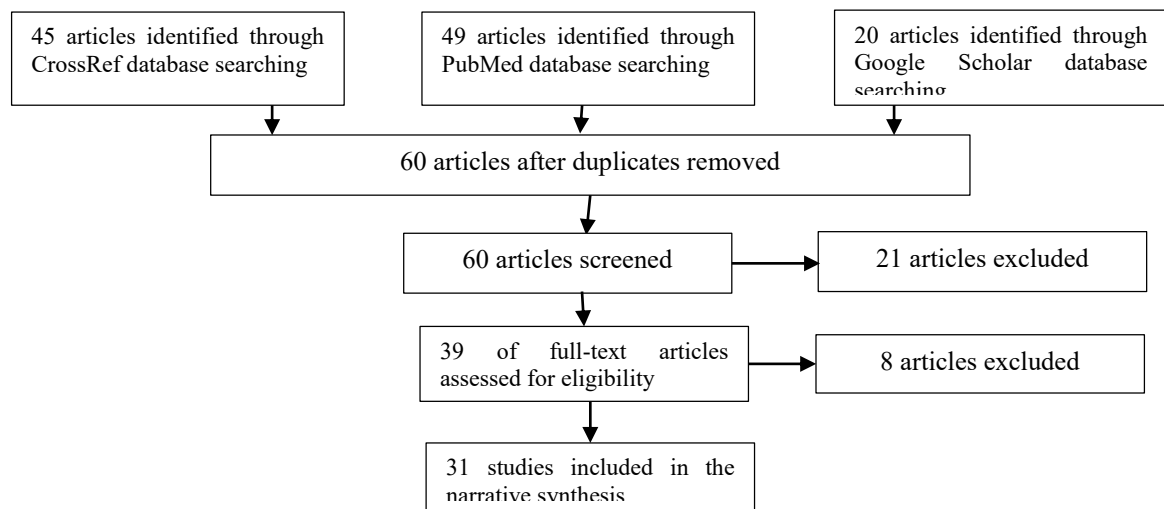


Figure 1. Study selection flow diagram

A standardized data extraction form was used to ensure consistency and completeness. The researcher independently collected the data from each article manually. Extracted data included study characteristics such as authors and year of publication, geographical location/country, industry type, specific social resource orchestration and SME growth variables, research design, methodology, and key findings. The collected data were then subjected to risk of bias assessment in line with the PRISMA 2020 checklist (Page et al., 2021). Because none of the studies were experimental or longitudinal, relevant biases included selection and detection biases, as classified by the Cochrane Collaboration’s tool for assessing risk of bias (Cumpston et al., 2019). Narrative synthesis method was used to map the patterns, themes, and relationships across the studies. Findings were compared based on study location. Narrative synthesis was suitable since the outcomes were presented differently across studies. The findings were presented descriptively, with any notable inconsistencies contextualized within the broader evidence base.

### 3. RESULTS

Table 1 summarizes the study characteristics, theoretical frameworks and key findings

**Table 1.** Study characteristics, theoretical frameworks, and key findings

Author & year	Location	Type of SME/ Industry	Variables	Research design	Theory	Key Findings	Effect estimates
<b>AFRICA</b>							
Adegbile et al. (2024)	Nigeria	Agricultural ventures	Resource mobilization, venture performance, bricolage, social capital, resource orchestration	Quantitative	Resource orchestration	Entrepreneurs' social resource affect the value of resource orchestration	$b = 0.28, p \leq 0.01$
Ademola et al. (2020)	Nigeria	Cross sector	Social networks, resource-based entrepreneurship	Quantitative	Network approach and RBV	Social networks had a significant and positive influence on the performance of women entrepreneurs.	$r=0.4631, p<0.01$
Agyapong et al. (2018)	Ghana	Hotel industry	Innovation capability, external social network relationship, business performance	Quantitative	Social network and resource-based view	Social network relationships have a slight inclination to have a positive effect on business performance.	$\beta=0.124, t=-2.056, p<0.01$
Bekanwah et al. (2020)	Nigeria	Manufacturing firms	Relational resource, business relational capital, social capital, structural growth	Quantitative	Open systems theory	A positive correlation was obtained between relational capital and business growth.	$r=.946, p<0.01$ ; $r=.895, p<0.01$ ;
Asamoah et al. (2020)	Ghana	Service and manufacturing SMEs	Social network relationship Supply chain resilience	Quantitative	Social capital theory and RBV	Both internal and external social networks can be orchestrated to improve supply chain resilience	$r= 0.582, p<0.01$
Munyanyi and Poee (2021)	Zimbabwe	Tourism SMEs	Knowledge sharing Social capital Production innovation	Quantitative	Social capital theory	Inter-organizational trust and social reciprocity contribute to improving product innovation.	$R^2=.487, p<.01$
Gamba (2017)	Tanzania & Rwanda	Food processing SMEs	Social capital	Quantitative	None	Country differences were established in social capital richness, with potential influence on the economy	$M= 1.5958$ ; $SD= .27723$
Olafenwa (2024)	Nigeria	Manufacturing SMEs	Social capital, human capital, business reputation, risk-taking propensity	Quantitative	Resource dependence	Social capital, along with human capital and risk taking propensity positively influenced business growth	$\beta =.487, p<0.01$

Table 2. Study characteristics, theoretical frameworks, and key findings (*Continued*)

Author & year	Location	Type of SME/ Industry	Variables	Research design	Theory	Key Findings	Effect estimates
Omoni and Ngugi (2018)	Kenya	Dairy Cooperative societies	Opportunity exploitation, resource gap, social capital, risk taking	Quantitative	Need for achievement and RBV	A strong, positive correlation was obtained between social capital and business performance	$r=.547, p<0.01$
Ghalwash and Ismail (2022)	Egypt	Social enterprises	Resource mobilization Social bricolage Social capital	Qualitative	Resource based theory	Results revealed six social bricolage themes	n/a
<b>EUROPE</b>							
Andersen (2021)	Sweden	Manufacturing SMEs	Resource orchestration, entrepreneurial orientation, human capital, firm performance	Quantitative	Human capital theory and resource-based view	Resource orchestration does not independently impact the relationship between firm-specific human capital and firm performance.	$r= 0.28, p<0.01$
Partanen et al. (2020)	Finland	-	Network identity Network resources Performance	Quantitative	Network resources, relationship identity theory	Reputable partners help establish credibility during initial growth phases thorough commit to and invest in the relationship.	$r=.032, p<0.01$
<b>ASIA</b>							
Anwar and Ali Shah (2020)	Pakistan		Managerial networking Business model innovation	Quantitative	Social network theory and innovation diffusion theory	Financial networking, business networking, and political networking contributed positively to business model innovation.	$r=0.427, p<0.01.$ $r=0.522, p<0.01.$
Gunawan, & Koentjoro, (2023).	Indonesia	Commodity (footware) industry	Human capital resources, social capital resources, empowerment of authority, coordination of authority	Qualitative	Resource orchestration theory	Expanding knowledge resources alone is not enough to promote resource orchestration or ensure the sustainability of family businesses.	n/a
Hussain et al. (2023)	Pakistan	Social enterprises	Business networking, access to finance, financial performance, social enterprises	Quantitative	RBV and signalling theory	Business networking was significantly correlated to financial performance of social enterprises	$\beta= 0.234. p<0.01$



Table 3. *Study characteristics, theoretical frameworks, and key findings (Continued)*

Author & year	Location	Type of SME/ Industry	Variables	Research design	Theory	Key Findings	Effect estimates
Jeong et al. (2019)	South Korea	Manufacturing SMEs	Social networks, Business networks, Business performance	Quantitative	Resource-based theory	Social networks only enhanced marketing capabilities but did not directly contribute to international business performance	$r = 0.24, p < .01$
Muafi et al. (2024)	Indonesia	Fashion MSMEs	Offline social capital, online social capital, Digital Innovation	Quantitative	Social capital theory	The study demonstrated that social capital positively influences business sustainability in SMEs	C.R.=10.471, $p < .01$
Nasution et al. (2021)	Indonesia	Retail SMEs	Social capital, social network ties, proactive entrepreneurial behaviour	Quantitative	Resource-based view and social capital theory	Retail business success increased with increased social network ties.	$\beta = 0.889, p < .01$
Pratono (2018)	Indonesia	-	Firm performance, social networks, pricing capability, selling capability, trust	Quantitative	Social capital theory	Social media use in management processes alone does not enhance firm performance.	$\beta = 0.097, p > 0.05$
Qamariah and Muchtar (2022)	Indonesia	Female owned SMEs	Human capital, social capital, Entrepreneurial opportunities Business performance	Quantitative	Resource-based view and entrepreneurial theory	Social capital played a vital role as a key resource to entrepreneurs with implications on business success	$t = 2.745, p < .01$
Qamariah, & Muchtar (2019).	Indonesia	Female owned SMEs	Social capital, Human capital, Entrepreneurial opportunity recognition	Case study	Human capital and social capital theory	Social capital and human capital determinants of the entrepreneurial possibilities' recognition.	$\beta = 403, p < .01$
Sulistyo and Ayuni (2019)	Indonesia	Handicraft SMEs	Social capital, Entrepreneurial orientation Competitive advantage. Performance	Quantitative	Social capital theory	Entrepreneurial orientation and social capital play a crucial role in shaping innovation.	$r = 0.28, p < .01$
Sutikno et al. (2022)	Indonesia	Convection SMEs	Social capital, Entrepreneurial competence Performance	Quantitative	Resource-based theory	Resource orchestration competence mediated social capital's impact on the performance of MSMEs.	$t = 6.728, p < .01$

Table 4. *Study characteristics, theoretical frameworks, and key findings (Continued)*

Author & year	Location	Type of SME/ Industry	Variables	Research design	Theory	Key Findings	Effect estimates
Syabena (2023)	Indonesia	Ground coffee SMEs	Human capital, social capital, Government role, SME performance	Mixed method	Human capital and social capital theory	Ground coffee SMEs had high social capital, which facilitated knowledge exchange about business performance	M=2.84
Udimal et al. (2021)	China	Farming SMEs	Network reliance, external networking behaviour, entrepreneurial orientation	Quantitative	Dynamic capabilities theory	Network reliance influences entrepreneurial performance both directly and indirectly	t=2.447. p< 0:05.
Xie et al. (2024)	Chine	Chinese Manufacturing SMEs	Network embeddedness, resource orchestration capability, and innovation	Quantitative	Social network and resource orchestration	Both market and technology network embeddedness significantly improve green innovation performance	r=0.182, p<0.01. r=0.234,p<0.01
Yunani (2022)	Indonesia	Four sectors	Social norms. Effective leadership. Institutional cooperation. Social capital	Quantitative	Social capital theory	Strong leadership, and institutional collaboration are positively linked to the social capital of SMEs	$\beta=0.432$ , P<0.01
<b>MIDDLE EAST</b>							
Temouri et al. (2022)	United Arab Emirates	Tradingand manufacturing,	Human capital, social capital, exploratory growth, exploitative growth	Quantitative	Resource-based theory	SMEs that leverage a firm's current firm-specific advantages to exploit existing product and service markets	R <sup>2</sup> =0.46, P<0.01
<b>AMERICAS</b>							
Clarke et al. (2015)	Brazil	Commodity – based single industry	Structural, Social, cognitive relationa capitals, Internationalization Competitiveness	Quantitative	None	Brazilian SMEs in this sector have relatively low social capital and limited awareness of how leveraging social capital	$\beta=0.889$ , p<0.01

The first research question was: what are the key characteristics of studies examining the relationship between social resource orchestration and SME growth? Most of the studies (13, 42%) examined SMEs in the manufacturing sector, while 12 (39%) focused on the service sector—particularly clothing and design, hospitality, and tourism – and four (13%) on agriculture and food processing. Geographically, 12 studies (39%) were conducted in Africa and another 12 (39%) in Asia. Most studies (61%) examined social resource orchestration, with 39% focusing on social capital orchestration. Regarding outcomes, 58% of the studies addressed business performance and 42% focused on business growth. Methodologically, 84% used quantitative designs, 13% qualitative, and 3% mixed methods. Conceptually, 48% focused on social capital, 39% on resource orchestration, and 13% on entrepreneurial factors. The second research question was what theoretical frameworks underpin the studies and what were

the findings? As shown in Table 1, the studies consistently emphasize the significance of social resource orchestration in shaping SME outcomes across various contexts. Social networks positively influence business growth, innovation, and financial performance, with multiple studies (Ademola et al., 2020) reporting strong correlations between social capital and business success. Effect sizes frequently indicate moderate to strong positive impacts, such as Adegbile et al. (2024) reporting  $b = 0.28$  and Hussain et al. (2023) reporting  $\beta = 0.234$ . The third research question was: what is the risk of bias in studies exploring the impact of social resource orchestration on SME growth, and how does it affect the reliability of their findings? Table 2 reports the risk of bias analysis.

*Table 5. Risk of bias assessment*

Source	Non-response bias	Sampling bias	Self-selection bias	Self-report bias
Adegbile et al. (2024)	-	+	?	+
Ademola et al. (2020)	?	-	-	+
Agyapong et al. (2018)	-	-	-	+
Andersen (2018)	+	-	-	+
Anwar and Ali Shah (2020)	-	+	?	+
Asamoah et al. (2020)	-	+	+	+
Bals et al. (2023)	?	-	-	+
Bekanwah et al. (2020)	-	+	?	+
Clarke et al. (2015)	-	+	+	+
Gamba (2017)	-	+	?	+
Ghalwash and Ismail (2022)	?	+	-	+
Gunawan, & Koentjoro, (2023).	-	+	-	+
Hussain et al. (2023)	-	+	+	+
Jeong et al. (2019)	+	+	+	+
Muafi et al. (2024)	-	+	?	+
Munyanyi and Pooe (2021)	-	?	?	+
Nasution et al. (2021)	-	?	?	+
Olafenwa (2024)	-	?	?	+
Omoni and Ngugi (2018)	-	-	-	+
Partanen et al. (2020)	+	+	+	+
Pratono (2018)	+	-	-	+
Qamariah and Muchtar (2022)	?	+	?	+
Qamariah, & Muchtar (2019).	?	+	?	+
Sulistyo and Ayuni (2019)	-	+	-	+
Sutikno et al. (2022)	?	+	?	+
Syabena (2023)	?	?	?	+
Temouri et al. (2022)	+	-	-	+
Udimal et al. (2021)	-	-	+	+
Wang et al. (2020)	-	-	+	+
Xie et al. (2024)	-	?	?	+
Yunani (2022)	?	+	-	+

A positive sign (+) indicates high risk of bias, a negative sign (-) denotes a low risk of bias, and a question mark (?) symbolizes unclear risk of bias in line with Drucker et al. (2016). Non-response bias was high for response rates below 50%, sampling bias was high for all non-random samples, self-selection bias was high for convenient samples and online survey-based samples, and self-report bias was high for all non-experimental studies. The highest risk was found in detection bias, as all 31 studies (100%) relied on self-reported data without experimental designs, leading to consistently high potential self-report bias. Sampling bias ranked second, with high risk evident in 17 (55%) studies due to non-random sampling,

impacting generalizability, followed by self-selection bias with 16 studies (52%) exhibiting self-selection bias risks.

#### **4. DISCUSSION**

The key characteristics of studies examining the relationship between social resource orchestration and SME growth reveal that great scholarly attention has been accorded to SMEs in the global south. The findings agree with Andrade-Rojas et al. (2022), who emphasize the importance of social resource orchestration in developing economies. The concentration of studies on these regions reflects the need for SMEs to leverage social networks due to limited access to financial and technical resources, as noted by Okeke et al. (2021). Additionally, the prominence of social capital and resource orchestration in the findings aligns with Marjański et al. (2019) and Narada Gamage et al. (2020), who highlight the strategic importance of social networks and human capital in driving SME growth. Regarding the theoretical underpinnings of the studies and resulting findings, this systematic review supports growing evidence on the importance of social capital and social resource orchestration theories for explaining SME growth. This is particularly significant for overcoming challenges such as limited access to financing, technology, and managerial expertise. The concepts of social resource and social resource orchestration – encompassing resource mobilization and coordination within networks, are emerging as a crucial capability for SMEs that depend on institutional, business, and social connections to access vital resources (Andrade-Rojas et al., 2022). The systematic review exposed several risks of bias in the exploration of the impact of social resource orchestration on SME Growth. Most notably, the prevalence of reporting bias suggest that future research should address biases through more rigorous methodologies, as emphasized by Gamage et al. (2020), who call for a more systematic and unbiased approach to SME research.

#### **5. CONCLUSION**

The studies on social resource orchestration and SME growth primarily focused on the manufacturing and service sectors, focusing less on agriculture and niche industries. Most research was conducted in developing regions, particularly Africa and Asia. Quantitative methods were dominant. The risk of bias in the studies presented several key concerns that affected the reliability of the findings. The highest risk was detection bias, as all studies relied on self-reported data without experimental designs. Theoretical implications of this systematic review emphasize the nuanced role of social capital and resource orchestration theories in explaining SME performance and growth. For SME owners, this review underscores the strategic value of cultivating diverse social networks and leveraging relational capital. Policymakers can draw from this systematic review to promote policies that facilitate networking opportunities and support collaboration platforms. Although the evidence supports the positive impact of social resource orchestration on SME performance, the gap in research around direct growth impacts suggests a need for further studies that clarify mechanisms and measure long-term growth outcomes across diverse economic contexts.

#### **REFERENCES**

Ademola, A. O., Adegboyegun, A. E., & Adegoke, K. A. (2020). Does social networking enhance the performance of women entrepreneurs in Nigeria? *Asian Journal of Economics, Finance and Management*, 10-20.

- Andrade-Rojas, M. G., Li, S. Y., & Zhu, J. J. (2024). The social and economic outputs of SME-GSI research collaboration in an emerging economy: An ecosystem perspective. *Journal of Small Business Management*, 62(2), 656-699.
- Bals, L., Huang, F. K., Tate, W., & Rosca, E. (2023). Creating social value at the bottom of the pyramid: Elaborating resource orchestration via social intermediaries. *Journal of Business Research*, 168. <https://doi.org/10.1016/j.jbusres.2023.114209>
- Cumpston, M., Li, T., Page, M. J., Chandler, J., Welch, V. A., Higgins, J. P., & Thomas, J. (2019). Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *The Cochrane database of systematic reviews*, 2019(10).
- Drucker, A. M., Fleming, P., & Chan, A. W. (2016). Research techniques made simple: assessing risk of bias in systematic reviews. *Journal of Investigative Dermatology*, 136(11), e109-e114.
- Gamage, S. K. N., Prasanna, R. P. I. R., Jayasundara, J. M. S. B., Ekanayake, E. M. S., Rajapakshe, P. S. K., GAKNJ, A., ... & Nedelea, A. M. (2020). Social capital and SME: A systematic literature review and research directions. *Ecoforum Journal*, 9(3).
- Hiebl, M. R. (2023). Sample selection in systematic literature reviews of management research. *Organizational research methods*, 26(2), 229-261.
- Hussain, A., Ahmad, S. A., Mia, S., Ahmed, F., & Prommee, P. (2023). Relationship between business information, business networking, access to finance and financial performance of social enterprises: Perspective of resource-based view and signalling theory. *Cogent Business & Management*, 10(1), 2285062. <https://doi.org/10.1080/23311975.2023.2285062>
- Ibrahim, N., Rizal, A. M., Hee, O. C., Baskaran, S., & Sahimi, M. (2020). Resource allocation between exploration and exploitation strategies: a case study of a Malaysian SME family firm. *International Journal of Entrepreneurial Venturing*, 12(4), 355-375.
- Liu, A., Gu, J., & Liu, H. (2022). The fit between firm capability and business model for SME growth: a resource orchestration perspective. *R&D Management*, 52(4), 670-684.
- Lyon, L. (2016). Transparency: The emerging third dimension of open science and open data. *LIBER Quarterly: The Journal of the Association of European Research Libraries*, 25(4), 153-171.
- Marjański, A., Sułkowski, Ł., Marjańska-Potakowska, J., & Staniszevska, K. (2019). Social capital drives SME growth: A study of family firms in Poland. *German Journal of Human Resource Management*, 33(3), 280-304.
- Naradda Gamage, S. K., Ekanayake, E. M. S., Abeyrathne, G. A. K. N. J., Prasanna, R. P. I. R., Jayasundara, J. M. S. B., & Rajapakshe, P. S. K. (2020). A review of global challenges and survival strategies of small and medium enterprises (SMEs). *Economies*, 8(4), 79.
- Okeke, P., Odey, J. O., & Akaegbobi, G. (2021). Dynamic Capability and Sustainability of SMEs in South-East Nigeria: The Nexus. *International Journal of Management & Entrepreneurship Research*, 3(10), 349-358.
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *bmj*, 372.



## EMPOWERING CONSUMERS IN THE CIRCULAR ECONOMY: STRATEGIES FOR SUSTAINABLE AGRI-FOOD SYSTEMS IN THE REPUBLIC OF NORTH MACEDONIA

Katerina Bojkovska \*

*University "St. Kliment Ohridski", Faculty of Biotechnical Sciences, North Macedonia*

**Abstract:** The transition to a circular economy (CE) in North Macedonia's agri-food sector is essential for achieving sustainability and resource efficiency. This study explores consumer-centric strategies that emphasize reducing, reusing, and repairing (3Rs) to minimize waste and promote sustainable consumption. Using a mixed-methods approach, the research integrates quantitative consumer surveys (n=500) with qualitative interviews (n=30) and case studies of successful CE initiatives. Secondary data from government reports and industry publications were also analyzed. Findings reveal moderate consumer awareness of CE principles, with 72% familiar with local food systems but only 50% aware of reuse and repair strategies. While 35-40% of consumers are willing to pay up to a 5% premium for sustainable products, economic constraints limit broader adoption. Key barriers include lack of awareness (40%), higher costs of sustainable products (30%), and limited availability (25%). Regression analysis confirms that consumer awareness ( $\beta = 0.58$ ,  $p = 0.002$ ) and economic incentives ( $\beta = 0.42$ ,  $p = 0.01$ ) significantly influence CE adoption. The study highlights the need for affordable solutions, education campaigns, and stronger policy frameworks to encourage consumer participation. A multi-stakeholder approach, engaging consumers, businesses, and policymakers, is vital for advancing a sustainable agri-food sector in North Macedonia.

**Keywords:** Circular economy, consumer-centric strategies, agri-food sector, sustainability, food waste reduction.

### 1. INTRODUCTION

The agri-food sector is one of the most resource-intensive industries, significantly impacting the environment through food waste, excessive packaging, and inefficient resource use. As global concerns over sustainability grow, the transition toward a circular economy (CE) has become a priority for many countries, including North Macedonia. The circular economy model promotes reducing, reusing, and repairing (3Rs) as core principles to minimize waste,

---

\* Corresponding author: [katerina.bojkovska@uklo.edu.mk](mailto:katerina.bojkovska@uklo.edu.mk)

Katerina Bojkovska, ORCID: 0000-0002-8651-4621

maximize resource efficiency, and extend product lifecycles. Unlike the traditional linear economy model of "take, make, dispose," a circular economy emphasizes closing the loop through sustainable practices, thereby creating a regenerative system that minimizes environmental impact.

In North Macedonia, where agriculture contributes significantly to the economy and employment, integrating circular strategies into the agri-food sector presents both opportunities and challenges. The sector is a cornerstone of the country's economy, supporting rural development, food security, and livelihoods. However, it also faces pressing issues such as inefficient resource use, high levels of food waste, and limited infrastructure for sustainable practices. Traditional linear consumption patterns—characterized by production, use, and disposal—must shift toward more sustainable practices that involve consumers as active participants. This transition requires a combination of consumer awareness, supportive policies, and business innovations to encourage responsible consumption, waste reduction, and product longevity.

Consumer behavior plays a pivotal role in driving the transition to a circular economy. As end-users of agri-food products, consumers have the power to influence production and consumption patterns through their choices and practices. However, achieving this shift requires a deep understanding of consumer attitudes, awareness, and willingness to adopt sustainable behaviors. This paper focuses on consumer-centric strategies that prioritize reducing, reusing, and repairing as key pillars of a circular economy in North Macedonia's agri-food sector.

The primary objectives of this research are to:

- assess the current state of circular economy practices in North Macedonia's agri-food sector,
- identify barriers and opportunities for implementing consumer-centric CE strategies, and
- propose actionable solutions to engage consumers in sustainable practices.

By addressing these objectives, this study aims to contribute to the growing body of knowledge on circular economy implementation in developing economies, with a specific focus on the agri-food sector.

This paper explores consumer-centric strategies that facilitate the adoption of CE principles in North Macedonia's agri-food sector. It examines how consumers can drive sustainability through behavioral changes, product choices, and engagement in circular practices such as food waste reduction, sustainable packaging, and local food systems. Additionally, it evaluates existing policy frameworks, industry efforts, and barriers to implementation. Through case studies and empirical analysis, this study provides actionable insights into fostering a more resilient and resource-efficient food system.

The study employs a mixed-methods approach, combining qualitative and quantitative research. Data were collected through surveys, interviews with key stakeholders (farmers, consumers, policymakers, and business representatives), and case studies of successful CE initiatives in the region. Secondary data from government reports and industry publications were also analyzed to provide context.

The results reveal significant potential for reducing food waste, reusing packaging materials, and repairing agricultural equipment through consumer engagement and education. Key findings include the need for stronger policy frameworks, increased awareness campaigns, and incentives for businesses to adopt circular practices. The study concludes that a collaborative approach involving consumers, businesses, and policymakers is essential for fostering a sustainable and resilient agri-food system in North Macedonia.



By focusing on the role of consumers in the circular economy, this research contributes to the broader discourse on sustainable development in North Macedonia. It highlights the necessity of multi-stakeholder collaboration, incentives for circular business models, and targeted education campaigns to enhance consumer participation. Ultimately, the findings aim to support policymakers, businesses, and consumers in transitioning toward a more sustainable and circular agri-food sector.

By exploring the potential of consumer-centric strategies for a circular economy in North Macedonia's agri-food sector, this research seeks to pave the way for sustainable development, environmental preservation, and economic resilience in the region.

## **2. LITERATURE REVIEW**

### **2.1. The Concept of Circular Economy in the Agri-Food Sector**

The circular economy (CE) has emerged as a key framework for sustainable development, particularly in resource-intensive sectors such as agriculture and food production. According to the Ellen MacArthur Foundation (2013), the CE model seeks to minimize waste and maximize resource efficiency by emphasizing the principles of reducing, reusing, and recycling. In the agri-food sector, this involves strategies such as food waste prevention, by-product utilization, composting, and sustainable packaging (Kirchherr et al., 2017). Studies highlight that integrating circular principles into agriculture can improve environmental sustainability while also enhancing food security and economic resilience (Geissdoerfer et al., 2017).

The agri-food sector is one of the most resource-intensive industries, significantly impacting the environment through food waste, excessive packaging, and inefficient resource use. The transition to a circular economy is critical for addressing these challenges, as it promotes closing material loops, preserving natural capital, and fostering resilience through innovation (Ellen MacArthur Foundation, 2015). In North Macedonia, where agriculture contributes significantly to the economy and employment, integrating circular strategies into the agri-food sector presents both opportunities and challenges.

### **2.2. Consumer Behavior and Circular Economy Adoption**

Consumer engagement is critical for the successful implementation of circular economy practices in the agri-food sector. Research indicates that consumers play a vital role in waste reduction by making informed purchasing decisions, supporting sustainable packaging, and participating in food-sharing initiatives (van Loon et al., 2020). However, studies also reveal several behavioral and psychological barriers, such as limited awareness, convenience preferences, and skepticism toward sustainable alternatives (Kanter et al., 2020).

In North Macedonia, consumer attitudes toward sustainability remain underexplored, making it essential to assess public perceptions and willingness to adopt CE practices. Research by Hobson and Lynch (2016) emphasizes the importance of consumer awareness, education, and engagement in fostering sustainable practices. However, barriers such as lack of information, convenience, and affordability often hinder the adoption of circular behaviors.



### **2.3. Food Waste Reduction and Consumer Participation**

Food waste is a significant challenge in the global agri-food system, with studies estimating that nearly one-third of all food produced is wasted (Food and Agriculture Organization [FAO], 2019). Consumer habits, including improper food storage, over-purchasing, and lack of awareness about expiration dates, contribute to this issue (Aschemann-Witzel et al., 2015). Interventions such as educational campaigns, digital tools for food tracking, and incentives for responsible consumption have proven effective in other contexts (Gustavsson et al., 2018).

In North Macedonia, localized strategies that align with cultural and economic factors could enhance consumer participation in food waste reduction efforts. For example, campaigns that raise awareness about portion control, proper storage, and creative use of leftovers can significantly reduce food waste at the consumer level (Stenmarck et al., 2016).

### **2.4. Sustainable Packaging and Reuse Initiatives**

Packaging waste, particularly from plastic materials, poses a significant environmental threat. Research underscores the importance of sustainable packaging solutions, including biodegradable materials, reusable containers, and zero-waste shopping models (Napper & Thompson, 2019). Consumer willingness to adopt these alternatives is influenced by factors such as cost, availability, and perceived convenience (Dilkes-Hoffman et al., 2019).

In the European Union, regulatory frameworks promoting eco-friendly packaging have driven innovation, but North Macedonia still faces challenges in policy enforcement and infrastructure development (European Environment Agency, 2021). Reusable packaging, returnable containers, and secondary use of by-products (e.g., converting food waste into animal feed or bioenergy) are effective ways to close material loops (Mourad, 2016).

### **2.5. Policy Frameworks and Business Innovations in North Macedonia**

Effective policy interventions and business models play a crucial role in facilitating the transition to a circular agri-food system. Studies show that government incentives, tax benefits, and extended producer responsibility (EPR) programs encourage businesses to invest in circular practices (Borrello et al., 2020). In North Macedonia, initiatives such as sustainable agriculture programs and waste management policies are gradually gaining traction, but gaps remain in enforcement and consumer participation (United Nations Development Programme [UNDP] North Macedonia, 2022).

Case studies from other European nations suggest that public-private partnerships and consumer-driven innovations, such as food-sharing platforms and community-supported agriculture, could be instrumental in advancing circular strategies. Additionally, EU integration efforts provide a platform for aligning North Macedonia's policies with broader European sustainability goals, including the European Green Deal and the Circular Economy Action Plan (Petrevska et al., 2020).

### **2.6. Challenges and Future Directions**

Despite growing recognition of the circular economy's benefits, several challenges hinder its widespread adoption in North Macedonia's agri-food sector. Key barriers include lack of awareness, insufficient infrastructure, regulatory gaps, and resistance to behavioral change (Jurgilevich et al., 2016). Future research should focus on developing localized

solutions that address these obstacles while leveraging digital technologies, behavioral incentives, and policy innovations to enhance consumer participation.

The literature review highlights the critical role of consumer engagement in advancing the circular economy within North Macedonia's agri-food sector. While existing studies provide valuable insights into sustainable food systems, further research is needed to tailor circular strategies to the country's specific socio-economic context. Strengthening policy frameworks, fostering business innovation, and enhancing consumer awareness will be essential to achieving a sustainable and resilient food system.

### **3. DATA AND METHODOLOGY**

This study employs a mixed-methods approach to comprehensively assess consumer-centric circular economy (CE) strategies in North Macedonia's agri-food sector. The research integrates both quantitative and qualitative methods to provide a well-rounded analysis of consumer behavior, industry practices, and policy frameworks related to reducing, reusing, and repairing in the sector.

#### **3.1. Research Design**

The research design combines qualitative and quantitative data collection methods to explore the current state of circular economy practices, barriers, and opportunities for consumer engagement in North Macedonia's agri-food sector. The mixed-methods approach ensures a holistic understanding of the topic by triangulating data from surveys, interviews, case studies, and secondary sources.

#### **3.2. Data Collection Methods**

##### **3.2.1. Primary Data Collection**

###### **- Consumer Surveys**

A structured questionnaire was distributed to 500 consumers across urban and rural areas of North Macedonia to assess awareness, attitudes, and practices related to circular economy principles. The survey covered topics such as:

- Awareness of food waste reduction, sustainable packaging, and repair initiatives,
- Willingness to pay for sustainable products,
- Barriers to adopting circular behaviors,
- Perceptions of government policies and business initiatives.

Respondents were selected using stratified random sampling, ensuring representation across different demographics (age, gender, income, and education levels).

###### **- Stakeholder Interviews**

Thirty semi-structured interviews were conducted with key stakeholders, including:

- Farmers and producers (10): Insights into sustainable farming, food waste management, and packaging reuse,
- Policymakers (5): Discussion on existing CE regulations, incentives, and challenges,
- Business representatives (10): Adoption of circular business models, barriers to sustainable practices,

- Consumer advocacy groups (5): Role of education and awareness campaigns in promoting sustainability.

Interviews were analyzed using thematic analysis to identify common challenges and opportunities in implementing consumer-centric CE practices.

- Case Studies

Three case studies of successful CE initiatives in the agri-food sector were examined:

- A local farm cooperative implementing food waste reduction strategies,
- A startup focused on reusable packaging solutions,
- A community-supported agriculture (CSA) program promoting sustainable consumption.

### 3.2.2. Secondary Data Collection

- Government Reports & Policy Documents

Analysis of reports from the Ministry of Agriculture, Forestry, and Water Economy of North Macedonia was conducted to assess national strategies for sustainable agriculture. Additionally, EU integration documents related to CE policies in North Macedonia were reviewed.

## 3.3. Data Analysis Methods

### 3.3.1. Quantitative Analysis

Data from the consumer survey were analyzed using SPSS and Excel. The following statistical techniques were applied:

- Descriptive statistics (mean, median, mode) to summarize consumer awareness and behaviors,
- Chi-square tests to assess relationships between consumer demographics and CE adoption,
- Regression analysis to evaluate the impact of awareness and economic incentives on willingness to participate in circular economy practices.

### 3.3.2. Qualitative Analysis

Thematic analysis was used to interpret interview and case study data, identifying key themes such as policy gaps, economic barriers, and consumer engagement strategies. Content analysis of policy documents and government reports was conducted to assess regulatory frameworks supporting circular economy initiatives.

## 4. RESULTS AND DISCUSSION

This section presents the findings from the consumer survey, stakeholder interviews, and case studies. Data is summarized in tables and graphs, followed by a discussion of key themes related to consumer engagement in circular economy (CE) practices within North Macedonia's agri-food sector.

#### 4.1. Consumer Awareness and Behavior Toward Circular Economy Practices

*Table 1. Consumer Awareness of Circular Economy Practices (n=500)*

CE Practice	Aware (%)	Not Aware (%)	Somewhat Aware (%)
Food waste reduction	65%	20%	15%
Sustainable packaging	58%	25%	17%
Repairing/reusing equipment	50%	30%	20%
Local food systems	72%	18%	10%

72% of respondents are aware of local food systems, the highest awareness level among CE practices.

Only 50% are aware of repairing and reusing agricultural tools and food packaging, indicating a need for more education on these aspects.

Food waste reduction has a moderate awareness level (65%), suggesting that campaigns have had some impact but need further reinforcement.

#### 4.2. Willingness to Pay for Sustainable Products

To assess consumer demand for CE-friendly products, respondents were asked about their willingness to pay a premium for sustainably packaged or locally produced food.

*Table 2. Willingness to Pay for Sustainable Products (%)*

Extra Cost Willing to Pay	<5% Price Increase	5-10% Price Increase	>10% Price Increase	Not Willing
Sustainable Packaging	35%	10%	5%	50%
Locally Produced Food	40%	15%	5%	40%

35-40% of consumers are willing to pay up to a 5% premium for sustainably packaged and locally produced food, reflecting economic constraints.

Only 5-10% would pay more than a 10% premium, confirming affordability as a major concern.

50% of consumers are unwilling to pay any premium for sustainable products, emphasizing the need for cost-effective and incentive-based solutions.

#### 4.3. Barriers to Adopting Circular Economy Practices

Survey respondents and interviewees identified key barriers to CE adoption.

*Table 3. Major Barriers to Consumer Adoption of CE Practices (%)*

Barrier	% of Consumers Identifying as a Challenge
Lack of awareness	40%
Higher cost of sustainable products	30%
Limited availability of sustainable options	25%
Lack of government incentives	20%

40% of consumers cite lack of awareness as the biggest barrier, confirming the need for educational initiatives.

30% point to higher costs of sustainable products, suggesting that affordability plays a significant role in adoption rates.

Limited availability (25%) and lack of government incentives (20%) also hinder widespread adoption.

#### 4.4. Stakeholder Perspectives on Circular Economy Practices

Insights from interviews with farmers, policymakers, and business representatives highlight systemic challenges and opportunities.

Table 4. Key Themes from Stakeholder Interviews

Stakeholder Group	Key Insights
Farmers (10)	Need better incentives for food waste reduction and packaging reuse. Some have started composting but require financial support.
Policymakers (5)	Lack of enforcement mechanisms for existing CE policies. Integration with EU regulations remains a challenge.
Businesses (10)	High initial costs deter investment in sustainable packaging. Consumer demand for sustainability is rising, but infrastructure is lacking.
Consumer Groups (5)	Educational campaigns are critical to shifting consumer behavior. Current awareness levels are still low.

Farmers and businesses emphasize the need for financial and policy incentives to invest in CE-friendly practices.

Policymakers acknowledge regulatory gaps and the slow pace of CE policy implementation.

Consumer advocacy groups stress education as a key driver in changing behavior.

#### 4.5. Case Study Analysis

Three case studies were examined to illustrate successful circular economy initiatives.

Table 5. Summary of Case Studies

Case Study	Circular Economy Strategy	Impact
Local Farm Cooperative	Converts food waste into compost, reducing landfill waste.	Increased soil fertility, lower waste costs.
Reusable Packaging Startup	Offers refillable containers for bulk foods.	30% reduction in plastic packaging waste.
Community-Supported Agriculture (CSA)	Connects consumers directly with local farmers, reducing supply chain waste.	More consumer engagement and reduced food miles.

Examined case studies shows that successful models exist but require policy and financial support to scale up.

Local initiatives demonstrate the viability of food waste reduction and packaging reuse.

Consumers respond positively when given access to circular economy solutions.

#### 4.6. Regression Analysis: Impact of Awareness and Economic Incentives on CE Adoption

A regression analysis was conducted to measure how awareness and incentives influence CE adoption.

Regression Model: Willingness to Engage in Circular Practices =  $\beta_0 + \beta_1$  (Awareness) +  $\beta_2$  (Economic Incentives) +  $\varepsilon$

Variable	Coefficient ( $\beta$ )	p-value
Awareness Level	0.58	0.002**
Economic Incentives	0.42	0.01*

(\*\*p < 0.05 significant, \*\*p < 0.01 highly significant)

Awareness has the strongest impact ( $\beta = 0.58$ ,  $p = 0.002$ ), meaning better-informed consumers are more likely to adopt CE behaviors.

Economic incentives also play a significant role ( $\beta = 0.42$ ,  $p = 0.01$ ), supporting the need for financial policies to encourage sustainability.

#### 4.7. Chi-Square Test: Relationship Between Demographics and CE Adoption

A chi-square test was conducted to assess the relationship between key demographic factors (age, income, and education) and willingness to adopt circular economy (CE) practices in North Macedonia's agri-food sector.

Table 6. Chi-Square Test Results

Demographic Factor	Chi-Square Value	p-value	Significance
Age	12.45	0.002**	Highly significant ( $p < 0.01$ )
Income Level	8.76	0.01*	Significant ( $p < 0.05$ )
Education Level	6.34	0.05*	Marginally significant ( $p = 0.05$ )

(\*\*p < 0.05 significant, \*p < 0.01 highly significant)

#### 4.8. Key Findings and Discussion

- Age and CE Adoption:
  - Younger consumers are significantly more likely to adopt CE behaviors ( $p = 0.002$ ), likely due to higher environmental awareness and digital exposure to sustainability campaigns.
  - However, purchasing power may be limited in this group, meaning their support for CE initiatives does not always translate into economic action (e.g., buying sustainable products).
- Income Level as a Determining Factor:
  - Higher-income consumers are more likely to engage in CE practices ( $p = 0.01$ ), possibly due to their greater ability to afford sustainable products, packaging alternatives, and waste-reduction efforts.
  - Middle- and lower-income consumers may support CE in principle but struggle financially to participate, reinforcing the need for subsidies, discounts, and affordability-focused initiatives.
- Education's Limited but Relevant Influence:
  - While education level is marginally significant ( $p = 0.05$ ), suggesting that higher education levels contribute to greater CE awareness, it is not as strong a predictor as age and income.
  - This indicates that awareness campaigns should target all education levels, not just highly educated consumers, to ensure broad engagement in CE practices.
- Implications for CE Strategies:
  - Target younger demographics with low-cost, accessible CE initiatives (e.g., student-led sustainability programs, digital campaigns).

- Implement financial incentives (subsidies, tax breaks) to make CE adoption feasible for middle- and lower-income groups.
- Expand CE education efforts across all demographics, ensuring accessibility regardless of prior educational background.
- Discussion and Policy Implications
  - Consumer-Centric Strategies for Circular Economy
  - The results highlight a moderate to high awareness of CE practices, yet there is a disconnect between knowledge and action. Awareness campaigns and educational programs should be expanded to bridge this gap.
- The Role of Policy and Business Innovation
  - Policymakers must introduce incentives (tax breaks, subsidies) to encourage businesses and farmers to adopt circular practices.
  - Businesses should innovate in packaging and product design to meet growing consumer demand for sustainability.
- Strengthening Infrastructure for CE Implementation
  - Waste management systems should be upgraded\*\* to support food waste reduction and recycling efforts.
  - Investment in sustainable supply chains (e.g., local food networks) can enhance consumer participation.
- Future research directions

Further studies should explore:

- The impact of digital tools (e.g., food waste tracking apps) on consumer behavior.
- Long-term behavioral shifts resulting from CE education programs.

This research results confirm that consumer engagement is essential for advancing a circular economy in North Macedonia's agri-food sector. While awareness is growing, significant barriers such as cost, availability, and policy gaps remain. A multi-stakeholder approach, combining consumer education, business innovation, and policy support, is needed to drive CE adoption.

## 5. CONCLUSION

This study highlights the critical role of consumer engagement in advancing a circular economy (CE) in North Macedonia's agri-food sector. While the findings reveal moderate to high awareness of CE principles, particularly in areas like local food systems, significant gaps remain in consumer knowledge and willingness to adopt sustainable practices, especially when economic constraints are a factor. The research underscores the importance of addressing key barriers such as affordability, limited availability of sustainable options, and insufficient policy support to foster widespread adoption of CE practices.

The study emphasizes the need for a multi-stakeholder approach that integrates consumer education, business innovation, and policy interventions. Affordable solutions are essential to make sustainable products accessible to all consumers, particularly in a context where economic challenges are prevalent. Education and awareness campaigns can bridge the gap between knowledge and action, empowering consumers to embrace reducing, reusing, and repairing practices. Additionally, stronger policy frameworks are needed to provide financial incentives, improve waste management infrastructure, and align with EU sustainability directives.

The success of local initiatives, such as food waste reduction, reusable packaging, and community-supported agriculture, demonstrates the potential for scalable and impactful CE

solutions. By fostering collaboration among consumers, businesses, and policymakers, North Macedonia can transition toward a more resilient, resource-efficient, and environmentally sustainable agri-food system.

In conclusion, this research contributes to the broader discourse on sustainable development by highlighting the importance of consumer-centric strategies in driving the circular economy. The recommendations provided aim to support North Macedonia in achieving its sustainability goals while addressing the unique challenges of its socio-economic context.

## ACKNOWLEDGMENT

The author would like to express the sincere gratitude to the COST Action CA22124 - EU Circular Economy Network for All: Consumer Protection through reducing, reusing, repairing (ECO4ALL) for their invaluable support in conducting this research. The financial and intellectual contributions provided by ECO4ALL were instrumental in enabling this study to explore consumer-centric strategies for advancing the circular economy in North Macedonia's agri-food sector.

## REFERENCES

- Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., & Oostindjer, M. (2015). Consumer-related food waste: Causes and potential for action. *Sustainability*, 7(6), 6457–6477. <https://doi.org/10.3390/su7066457>
- Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S., & Cembalo, L. (2020). Consumers' perspective on circular economy strategy for reducing food waste. *Sustainability*, 12(3), 912. <https://doi.org/10.3390/su12030912>
- Dilkes-Hoffman, L. S., Lane, J. L., Grant, T., Pratt, S., & Lant, P. A. (2019). Environmental impact of biodegradable food packaging when considering food waste. *Journal of Cleaner Production*, 180, 325–334. <https://doi.org/10.1016/j.jclepro.2018.01.169>
- Ellen MacArthur Foundation. (2013). Towards the circular economy: Economic and business rationale for an accelerated transition. Ellen MacArthur Foundation.
- Ellen MacArthur Foundation. (2015). Growth within: A circular economy vision for a competitive Europe. Ellen MacArthur Foundation.
- European Environment Agency. (2021). Packaging waste and recycling in Europe. <https://www.eea.europa.eu>
- Food and Agriculture Organization [FAO]. (2019). The state of food and agriculture 2019: Moving forward on food loss and waste reduction. FAO. <https://openknowledge.fao.org/server/api/core/bitstreams/11f9288f-dc78-4171-8d02-92235b8d7dc7/content>
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- Gustavsson, J., Cederberg, C., & Sonesson, U. (2011). Global food losses and food waste: Extent, causes, and prevention. FAO. <https://openknowledge.fao.org/server/api/core/bitstreams/10388b16-5f1a-45d0-b690-e89bb78d33bb/content>
- Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: Radical social transformation in a resource-scarce world. *Futures*, 82, 15–25. <https://doi.org/10.1016/j.futures.2016.05.012>



- Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., & Pietikäinen, J. (2016). Transition towards circular economy in the food system. *Sustainability*, 8(1), 69. <https://doi.org/10.3390/su8010069>
- Kanter, D. R., Walls, H. L., Tak, M., Harwatt, H., & Robalino, J. (2020). Food system transitions in Vietnam: The case of pork and vegetable networks. *Sustainability*, 12(3), 1123. <https://doi.org/10.3390/su12031123>
- Kirchherr, J., Reike, D., & Hekkert, M. (2017). Circular economy: A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- Mourad, M. (2016). Recycling, recovering, and preventing food waste: Barriers and opportunities. *Journal of Cleaner Production*, 112, 1–12. <https://doi.org/10.1016/j.jclepro.2015.06.080>
- Napper, I. E., & Thompson, R. C. (2019). Environmental deterioration of biodegradable, oxo-biodegradable, compostable, and conventional plastic carrier bags in the sea, soil, and open-air over a 3-year period. *Environmental Science & Technology*, 53(9), 4775–4783. <https://doi.org/10.1021/acs.est.8b06984>
- Petrevska, B., Dimitrov, N., & Kotevska, A. (2020). Circular economy in agriculture: A case study of North Macedonia. *Sustainability*, 12(5), 2001. <https://doi.org/10.3390/su12052001>
- Stenmarck, Å., Jensen, C., Quedstedt, T., & Moates, G. (2016). Estimates of European food waste levels. IVL Swedish Environmental Research Institute. <https://edepot.wur.nl/378674>
- United Nations Development Programme [UNDP] North Macedonia. (2022). Sustainable agriculture and rural development in North Macedonia. UNDP. <https://www.undp.org/north-macedonia>
- Van Loon, P., Teunissen, M., & Almeida, C. (2020). Consumer behavior in the circular economy: A review of the literature. *Journal of Cleaner Production*, 246, 118953. <https://doi.org/10.1016/j.jclepro.2019.118953>



## IMPLEMENTATION OF THE NEW INFORMATION SYSTEM FOR FINANCIAL MANAGEMENT (ERP SYSTEM) AT ŽRS A.D. DOBOJ

Siniša Urumović\*, Nikola Simić

*Željeznice Republike Srpske a.d. Doboj, Bosna i Hercegovina*

**Abstract:** It has been observed that most business processes and activities at ŽRS are based on paper documentation or are only partially automated. With a view to eliminating the existing shortcomings, it has been proposed that the new information system should be one from a group of modern ERP systems (Enterprise Resource Planning System) which, with their functionalities, enable the connection of business processes and organizational units that execute those processes into a single system. The advanced capabilities of modern ERP systems enable support for the business processes of individual companies - members of the holding, but also of the holding as a whole. ERP systems are modularly designed, with each module supporting a group of related business functions. The implementation of the ERP system brings numerous benefits, the most significant of which are: integration, standardization, optimization and automation of business processes, increased efficiency, recording of changes in real time, single input and single database. The implementation of the ERP system brings major changes: existing software solutions are abandoned and new ones are introduced, there is a change/redesign of existing business processes and the methods the organization functions as a whole.

**Keywords:** information system, ERP system, implementation at ŽRS a.d. Doboj.

### 1. INTRODUCTION

Two approaches are possible when acquiring and developing an information system: the traditional approach ("on-premise"), which implies local implementation of software on equipment that is owned and located at the company's location, and the cloud computing approach ("cloud") in which the system is located at a remote location (very often outside the country's borders), on the supplier's equipment and is accessed via an Internet browser or specialized client software. Our analysis of the estimated implementation costs shows that the traditional approach has the advantage. Also, it is a fact that even after the reorganization from

---

\* Corresponding author: [sinisa.urumovic@gmail.com](mailto:sinisa.urumovic@gmail.com)

Siniša Urumović, ORCID: 0009-0008-8134-1275  
Nikola Simić, ORCID: 0009-0003-3057-0012

a single company to a holding structure, the majority owner of the capital of the RS Railways will be the Government of Republika Srpska, and the provisions of the Regulation on information security measures for state-owned companies prevent the complete implementation of an information system for financial management using "cloud computing" technology.

Based on the analysis of business processes and the adopted future organizational structure of RS Railways, which will be implemented in the form of a holding within which four companies will exist, it was proposed to introduce an integrated information system that would consist of the following modules:

- General ledger.
- Accounts receivable accounting.
- Liability accounting.
- Fixed assets accounting.
- Capital investment management.
- Sales management.
- Procurement and inventory management.
- Cost and income management.
- Management of receivables and payables upon maturity.
- Management of personnel records.
- Salary calculation.

The implementation of a module that meets these requirements would replace the majority of existing software solutions that are outdated and unintegrated, eliminate the need for multiple entries of the same data in different applications, reduce the number of records that are kept only in paper form, and improve business processes, automation of data processing, quality of planning, control and reporting.

## **2. TECHNICAL SPECIFICATION OF THE SOFTWARE SYSTEM ERP**

The objective of introducing a new organizational structure is, in addition to compliance with the requirements of the European Union that regulate the field of rail transport, the establishment of RS Railways as an efficient and sustainable market-oriented business entity (Rodić, 1998).

The new organizational structure is based on the following key principles that are valid for all legal entities within the future holding organization of the RS Railways:

- Market orientation.
- Customer orientation.
- Profit orientation.
- Executive responsibility and comprehensive responsibility.
- Horizontal hierarchies.
- Transparency in decision-making processes (Rodić, 2003).

The implementation of the new information system for financial management should be implemented in the new organizational structure of RS Railways. However, its establishment is not a simple process, and for this reason, the transition to a new organizational structure - holding, through two phases, was proposed:

- Preparatory phase - which should last 12 months, i.e. it would ideally start 12 months before the establishment of the new organizational structure. The goal of the preparatory phase is to present the new structure to all employees and psychologically prepare them for the new structure so that their "transition" to the new holding organization will be successful.

- The transition phase - which begins with the official order of introduction of the new structure and will last an additional 12 months.

### **3. SOFTWARE LICENSES**

In the process of acquiring a new information system for financial management, it is necessary to request:

- An application package of ERP solutions that supports business processes that take place in RS Railways and that fulfill all required functionalities for 140 users.
- The application package of ERP solutions should enable the calculation of wages for 2,100 employees (total for 4 companies).
- Licenses for system administration – for four users.
- Database software license.
- Integration Software License.

Regarding the right of use (license), the offered information system should enable the creation of users of different levels of access, namely:

- User with full access – has access to all system functionalities.
- A user with limited access – has the ability to view all data, but limited data input and modification capabilities.

Along with the offered software, it is necessary to submit the manufacturer's technical documentation. It should contain all the necessary data for access, management and maintenance of the system (technical description of the configuration, database, process, interface, maintenance instructions, etc.).

The bidder is obliged to submit the Form of technical characteristics for the hardware platform for all hardware and infrastructure that is necessary for the operation of the ERP solution according to the methodology of the software manufacturer. This includes defining the environment (development, test and production) according to the methodology, defining the specification and number of servers, client workstations and all necessary interconnections between servers, storage systems, backups and connections to the LAN network. This information is needed so that the RS Railways can decide whether the existing hardware resources are sufficient or need to be increased (Advantis broker, 2017).

### **4. FUNCTIONAL REQUIREMENTS OF THE NEW INFORMATION SYSTEM FOR FINANCIAL MANAGEMENT IN RS RAILWAYS**

The new financial management information system of RS Railways should be one of the modern ERP business systems (Enterprise Resource Planning System). Such business-information systems enable the connection of various business processes and organizational units that execute those processes into a single system. This leads to consistent operation of all sectors of the company - sales, procurement, storage, distribution, finance and accounting. Since in one business organization (especially a large one) there can be a very large number of business processes that intertwine with each other and often cross functional or organizational boundaries, the conclusion is that they are difficult to monitor and analyze (Advantis broker, 2017).

In that case, the ERP system, as a unique information system, has a very important role because with its integration and various functionalities, it can significantly facilitate the management of the organization. This feature of the ERP system is particularly important in the light of the future organizational structure of RS Railways holding. The implementation of the ERP system should enable process management and provide information for making business decisions both at the level of future companies that will be established and at the level of the holding as a whole.

One of the basic characteristics of modern ERP systems is that they are predefined software solutions to support business processes that are based on the best world experiences and practices. Also, ERP systems of the newer generation are significantly flexible and their functionalities can be adapted to the specific needs of each organization. In this way, the implementation of the ERP system leads to the improvement of the existing business processes in the organization, increases the efficiency of the organization and ensures the optimal use of resources.

Before the emergence of the ERP system in the nineties of the 20th century, individual business functions were supported by individual software applications that were more or less connected, while the ERP system implies the complete integration of those applications into a single information system for business support.

Today, ERP systems are implemented in a large number of companies, especially large ones, and the key advantages of using these systems are:

- Integration of business processes.
- Standardization and optimization of business processes.
- Increasing efficiency.
- Improvement of work performance and productivity level.
- Recording of business changes in real time.
- High level of automation in data processing and reduction of errors.
- Unique data entry.
- Unique database.
- The possibility of creating quality reports for the needs of the Administration.
- Improvement and facilitation of the planning and control process.
- Increased security.
- Improving service and ultimate customer/client satisfaction.

Modern ERP systems consist of several modules or subsystems, each of which is intended for one group of business functions. How many ERP system modules will be installed in a certain company depends on its size, the type of activity it performs, the number of employees and other factors, but the following modules and their functionalities are common for ERP systems since they reflect the basic business functions common to most business entities: procurement and warehousing, sales management, finance and accounting, asset management, human resources.

Based on the analysis of the business processes taking place in RS Railways and the future organizational structure-holding, we conclude that RS Railways needs the introduction of an integrated information system that would consist of the following mutually integrated modules:

- General ledger.
- Accounts receivable accounting.
- Liability accounting.
- Fixed assets accounting.
- Capital investment management.
- Sales management.
- Procurement and inventory management.
- Cost and income management.
- Management of receivables and payables upon maturity.
- Management of personnel records.
- Salary calculation.

The successful implementation of the above-mentioned modules would significantly improve the existing IT environment in RS Railways and, as a result, eliminate the observed shortcomings:

- Use of outdated and non-integrated applications.
- Weak support of business processes by applications in use.
- Multiple entry of the same data in different applications.
- Lack of automatic data processing and control.
- Out-of-date reporting.
- A large number of records exclusively in paper form.

## **5. RISKS AND ASSUMPTIONS OF THE IMPLEMENTATION OF THE NEW INFORMATION SYSTEM IN RS RAILWAYS**

The implementation of a new information system is, as a rule, a complex, long-term and extensive project, associated with many risks. Practice has shown that these are expensive projects that have a significant failure rate (consulting company Gartner made an assessment in 2017 that showed that even up to 75% of all ERP system implementations do not achieve all the set goals). The implementation of a new information system brings big changes - in addition to abandoning the existing software solution and introducing a new one, there is also a change/redesign of existing business processes and a change in the way the organization functions as a whole (Advantis broker, 2017).

The process of implementing a new information system represents a project of strategic importance for the company, during which its stakeholders face a large number of different problems, from the technical and organizational aspects. In order to avoid bad practices and common mistakes, it is very important to identify implementation risks and adequately address them.

The identification of implementation risks and measures to mitigate them becomes particularly important when it is taken into account that the implementation is being carried out in the conditions of the entire restructuring of RS Railways, which in itself represents a significant aggravating circumstance for successful implementation.

The main technical risks of implementation are:

- Adequacy of the selected information system.
- Complexity of information system implementation and maintenance.
- Inadequate data migration.
- Technological unpreparedness of the organization.
- Inadequate integration with other applications / subsystems in use.

The basic measure for mitigating the technical risks of implementation is clearly and precisely defined hardware and functional requirements that the information system must satisfy in order to fully support business processes, and based on such defined requirements, the selection of the optimal software solution.

## **6. CONCLUSION**

The new financial management information system of RS Railways should be one of the modern ERP business systems (Enterprise Resource Planning System). Such business-information systems enable the connection of various business processes and organizational units that execute those processes into a single system. This leads to consistent operation of all sectors of the company - sales, procurement, storage, distribution, finance and accounting. Since in one business organization (especially a large one) there can be a very large number of

business processes that intertwine with each other and often cross functional or organizational boundaries, the conclusion is that it is difficult to monitor and analyze them.

In that case, the ERP system, as a unique information system, has a very important role because with its integration and various functionalities, it can significantly facilitate the management of the organization. This feature of the ERP system is particularly important in the light of the future organizational structure of RS Railways - holding. The implementation of the ERP system should enable process management and provide information for making business decisions both at the level of future companies that will be established and at the level of the holding as a whole.

The implementation of a new information system is, as a rule, a complex, long-term and extensive project, associated with many risks. Practice has shown that these are expensive projects that have a significant failure rate (consulting company Gartner made an assessment in 2017 that showed that even up to 75% of all ERP system implementations do not achieve all the set goals). The implementation of a new information system brings big changes - in addition to abandoning the existing software solution and introducing a new one, there is also a change/redesign of existing business processes and a change in the way the organization functions as a whole.

The process of implementing a new information system represents a project of strategic importance for the company, during which its stakeholders face a large number of different problems, from the technical and organizational aspects. In order to avoid bad practices and common mistakes, it is very important to identify implementation risks and adequately address them.

## REFERENCES

- Advantis broker a.d. Banja Luka (2017). Analysis of potential steps in restructuring of Republika Srpska Railways jsc. Doboj, Advantis broker a.d. Banja Luka, Banja Luka.
- Rodić, J. (1998). Financial restructuring of companies, Second Symposium, SRRRS, Teslić.
- Rodić, R. (2003). Privatization of state capital of the companies in Republika Srpska - a problem or a prerequisite for solving the problem, Finrar, SRRRS, Banja Luka.



## BRIDGING THE ESG AWARENESS GAP: CHALLENGES AND OPPORTUNITIES FOR SMEs IN NORTH MACEDONIA

Vladimir Petkovski\*, Irina Piperkova, Elizabeta Djambaska, Aleksandra Lozanoska

*Ss. Cyril and Methodius University in Skopje, Institute of Economics - Skopje, Republic of North Macedonia*

**Abstract:** The growing emphasis on Environmental, Social, and Governance (ESG) principles highlights the need for SMEs to integrate sustainable practices into their operations. However, ESG adoption in SMEs remains a challenge due to limited awareness, financial constraints, and lack of standardization and regulation. This study investigates ESG awareness among SMEs in North Macedonia based on a comprehensive survey assessing their knowledge, attitudes, and practices. The survey explores key ESG dimensions, including environmental responsibility, social impact, and corporate governance, as well as barriers to implementation. Findings indicate varying levels of ESG awareness, with gaps in knowledge about regulatory requirements, measurement of carbon emissions, and ethical governance practices. The study also examines the willingness of SMEs to adopt ESG strategies, including participation in ESG training, ethical sourcing, and renewable energy investments. Additionally, the research highlights the role of policy incentives, industry support, and stakeholder engagement in fostering ESG compliance. By analyzing the impact of ESG integration on business competitiveness and sustainability, the study provides practical recommendations to enhance ESG adoption in SMEs. Strengthening ESG awareness and implementation will contribute to responsible business conduct and long-term economic growth in North Macedonia.

**Keywords:** ESG, SMEs, sustainability, corporate governance, North Macedonia.

### 1. INTRODUCTION

In recent years, the world has witnessed a significant transformation in how societies and economies view their impact on the environment. This shift has put sustainability in the forefront of public discourse and policy-making. As the consequences of climate change and

---

\* Corresponding author: [vladimir@ek-inst.ukim.edu.mk](mailto:vladimir@ek-inst.ukim.edu.mk)

Vladimir Petkovski, ORCID: 0000-0001-9733-4901

Irina Piperkova, ORCID: 0000-0003-2680-9556

Elizabeta Djambaska, ORCID: 0000-0002-4812-5166

Aleksandra Lozanoska, ORCID: 0000-0003-2496-8553



the depletion of natural resources become increasingly evident, governments are introducing a range of initiatives and comprehensive regulations designed to encourage environmentally responsible behaviour and foster a culture of accountability and innovation, thereby embedding sustainability into economic development. Businesses are considered to be relevant actors in this shift. Consumers, investors, and employees alike are demanding transparency and ethical conduct, making sustainability increasingly important element of corporate strategy and performance. As a result, businesses are directing their efforts towards investing in renewable energy sources and green technologies, implementing environmental management practices and integrating Environmental, Social, and Governance (ESG) principles into their decision-making processes. However, this sustainability quest is complex and multifaceted. While policymakers push forward ambitious environmental agendas, and consumers and investors have rising demands for corporate transparency and ethical business practices, companies face numerous challenges in adapting to the sustainability transition. Integrating ESG principles into corporate strategy is one of the key challenges for businesses.

Aligning environmental, social, and governance factors with strategic goals primarily requires strong commitment to sustainability from management, as well as significant investments and changes in operations and supply chains. In addition, businesses must address the complexities of measuring and reporting ESG factors. Aligning financial and sustainability objectives, as well as managing complex regulations, market pressures, and the costs of transformation, presents considerable challenge for businesses. Therefore, achieving significant progress in sustainability- at both the business and state levels- requires more than individual efforts. Close cooperation between governments, businesses, and civil society is essential to scale these initiatives into widespread sustainability. Moreover, achieving a carbon-neutral EU by 2050 is not possible without the full commitment and active engagement of SMEs. In this context, gaining an in-depth understanding of the SMEs' awareness of ESG factors, as well as the challenges they face, is crucial for developing effective policy and support mechanisms. This research contributes to the emerging body of literature on ESG practices in SMEs, where studies remain scarce.

## **2. LITERATURE REVIEW**

The increasing emphasis on sustainability has led to the development of policies and incentives aimed at encouraging improved environmental business practices. In this context, the Environmental, Social, and Governance (ESG) framework, originally introduced as tools for sustainable investing, has assumed a central role in corporate strategy, risk management and long-term business objectives. Its popularity reflects both the growing concern about climate change and stakeholders' expectations for ethical business conduct, accountability, and transparency. In recent years, the EU has taken significant steps to promote ESG through a comprehensive regulatory framework and establish mechanisms for the effective implementation of ESG requirements. In line with this, the EU Taxonomy Regulation (EU Regulation 2020/852) was introduced to enhance sustainability and transparency in business practices. In addition to the Taxonomy Regulation, the Corporate Sustainability Reporting Directive (CSRD) (EU Directive 2022/2464) came into effect in 2024, requiring all large companies, as well as listed SMEs, to disclose detailed sustainability information in their annual reports on the company operations. Indirectly, however, this directive will also affect other firms within the supply chain. Although SMEs comprise 99% of all businesses in EU, they are currently exempt from ESG reporting requirements under the EU Taxonomy Regulation. Nevertheless, voluntary ESG reporting could provide SMEs with several advantages, such as enhanced visibility towards investors and customers, improved access to finance, and

opportunities to benchmark their performance against sustainable targets or competitors, among others. As Moeslinger et al. (2022) indicate, considering the predominant share of SMEs within Europe and across supply chains, it is paramount to support and prepare SMEs for ESG reporting and ensure their access to sustainable finance, while taking into account their specific needs and constraints.

## **2.1. THE IMPACT OF ESG PRACTICES ON FIRM PERFORMANCE**

Recent research has supported the importance of incorporating ESG factors into the business strategy and business operations. ESG performance was found to enhance firm's market value, particularly through operational capacity (Zhou et al., 2022). Corporate ESG initiatives are also found to enhance green innovation performance in firms (Liu et al., 2023). A 2024 global survey (Selig, 2024) revealed that SMEs enhanced their business reputation, increased business differentiation, met customer expectations and won new customers as a result of their environmental efforts. However, a significant 84% of SMEs have not received any financial incentives to support emission reduction efforts, and over 70% indicated a need for additional funding to start or accelerate their climate efforts. Examining the impact of environmental investments on economic performance, measured by firms' net profits in over 6000 firms, Pekovic et al. (2018) found that too little or too much environmental effort can be detrimental to a firm's economic performance. They argue that there is an optimal level of environmental investment and that the ability to manage the tension between green investments and the pursuit of profitability, though complex and costly, can be the key determining whether the chosen level of green investments will enhance or hinder firm's economic performance.

In the social dimension of ESG, Albuquerque et al. (2019) presented empirical evidence of the positive impact of corporate social responsibility (CSR) on firm value, particularly in firms with high product differentiation. CSR activities targeting employees, customers, and society have also been found to positively impact the financial performance of SMEs in Germany (Hammann et al., 2009). Analysing 812 listed European firms, Qureshi et al. (2020) revealed positive impact of ESG disclosure and board gender diversity on firm value. Additionally, firms in sensitive industries tend to achieve stronger social and governance performance, whereas firms with greater female board representation show significantly better overall ESG performance. Similarly, Xie et al. (2019) found that governance information disclosure has the strongest positive link with corporate efficiency, followed by social and environmental disclosure. Other studies have found negative correlation between gender diversity on boards and voluntary ESG disclosure (Cucari et al., 2018). A study on the benefits of CSR in SMEs (Bielawska, 2022) showed that all enterprises gained at least one benefit from CSR. However, most entrepreneurs fail to recognize many of the opportunities CSR offers and tend to act intuitively, implementing CSR initiatives sporadically rather than strategically. This lack of understanding about the meaning, objectives, and potential benefits of CSR prevents entrepreneurs from identifying and appreciating all the achievable benefits of CSR.

## **2.2. BARRIERS TO ESG IMPLEMENTATION IN SMEs**

The green transition offers significant opportunities for SMEs, yet it remains a low priority for many. Unlike large companies, SMEs often face considerable barriers to adopting sustainable practices, mainly as a result of limited access to financing, technology and relevant skills. In this regard, SMEs often face challenges in adopting ESG practices primarily due to limited understanding of ESG practices and awareness of its relevance, skills gaps in incorporating ESG principles in business operations and ESG performance reporting, lack of

funding and access to necessary tools to implement ESG principles in their operations (ESCAP, 2024). Analysing the 50 most cited articles, Álvarez Jaramillo et al. (2019) identified 175 barriers to sustainability for SMEs, with the most frequently cited being lack of resources, high initial capital cost of implementing sustainability measures, and lack of expertise. A qualitative research conducted among UK SMEs (UK Finance, 2024) reveals that they have undertaken initial sustainability measures, with as much as 96% of the SMEs taking at least one action towards carbon reduction. Most businesses, however, have yet to implement comprehensive sustainability measures. Lack of resources, expertise, and policy clarity are the main barriers hindering their sustainability efforts. Through meta-analyses and literature reviews of empirical studies conducted over the past decade in developed countries, Rudžionienė & Brazdžius (2023) have found that sustainability reporting can yield significant benefits for companies, both financial – such as improved financial performance, better access to capital, and reduced cost of capital – and non-financial, including enhanced reputation, increased employee motivation, and improved risk management. While the costs associated with sustainability practices and reporting can be substantial and may lead to short-term negative impacts for businesses, the long-term benefits generally outweigh these disadvantages. The benefits were found to be particularly pronounced for SMEs, as sustainability initiatives can boost their competitiveness, facilitate access to capital, and strengthen stakeholder engagement. By incorporating ESG practices into their operations, SMEs can proactively anticipate future challenges and fully leverage the potential benefits of sustainability.

### **3. DATA AND METHODOLOGY**

The purpose of the research is achieved through the use of the survey method, using a survey questionnaire as an instrument. The previously constructed questionnaire was forwarded to a randomly selected sample of SME's in different industries via the data base of the Economic Chamber of North Macedonia. In the period of April 2025, the survey questionnaire was forwarded mainly in digital version, electronically (email and social networks) using the google survey platform.

The questionnaire consists of 25 survey questions, closed type, with the possibility to choose one or in some cases more of the offered answers. The data obtained from the survey research are analyzed on a univariate, bivariate and multivariate level by applying appropriate statistical procedures in excel and they are interpreted textually and visually, usually through graphs. In order to enrich and detail the findings and knowledge, the basic data obtained from the survey is structured into 3 different parts, each obtaining knowledge of the awareness and implementation of the key ESG dimensions, including environmental responsibility, social impact, and corporate governance, as well as barriers to implementation. Furthermore, the survey investigates ESG awareness among SMEs in North Macedonia based on a comprehensive survey assessing their knowledge, attitudes, and practices.

The limitations that appeared during the realization of the empirical research are as follows: limited response rates due to varying levels of interest or understanding of ESG topics among SMEs; potential bias introduced by self-reported data; difficulties in reaching micro-enterprises without active digital presence; and uneven industry representation despite efforts to randomize the sample through the Economic Chamber database.

Despite these limitations, the research provides valuable insights into the ESG awareness, attitudes, and practices of SMEs in North Macedonia, highlighting both progress

and gaps in understanding and implementation across the environmental, social, and governance dimensions.

#### 4. RESULTS AND DISCUSSION

The growing global emphasis on sustainable business practices has brought ESG (Environmental, Social, and Governance) principles to the forefront of economic development discourse. While multinational corporations often lead in ESG implementation due to regulatory pressure and stakeholder demand, the role of small and medium-sized enterprises (SMEs) is no less critical. This study presents an in-depth analysis of ESG awareness and practices among SMEs in North Macedonia based on the findings of a nationwide survey conducted during April 2025. The survey targeted a randomized sample of SMEs across various industries, utilizing digital distribution channels via the Economic Chamber database. Several of the survey questions closely related to the topic of this paper are hereby analysed. The results reveal a broadly positive trend in ESG awareness among SMEs. A significant 80% of respondents stated that they had heard of the term ESG, while only 10% had not, and another 10% expressed uncertainty. This level of awareness is a positive indicator, suggesting that ESG discourse has penetrated the SME sector to a considerable extent. When asked to self-assess their understanding of ESG principles, the majority of respondents rated their knowledge as moderate (40%) or high (35%), while only 12% rated it as very high. These findings suggest that while awareness is high, depth of understanding remains a challenge. Approximately 13% of respondents admitted to having low or very low understanding, signalling the need for more targeted educational initiatives and capacity-building programs to move SMEs from awareness to informed implementation (See Figure 1).

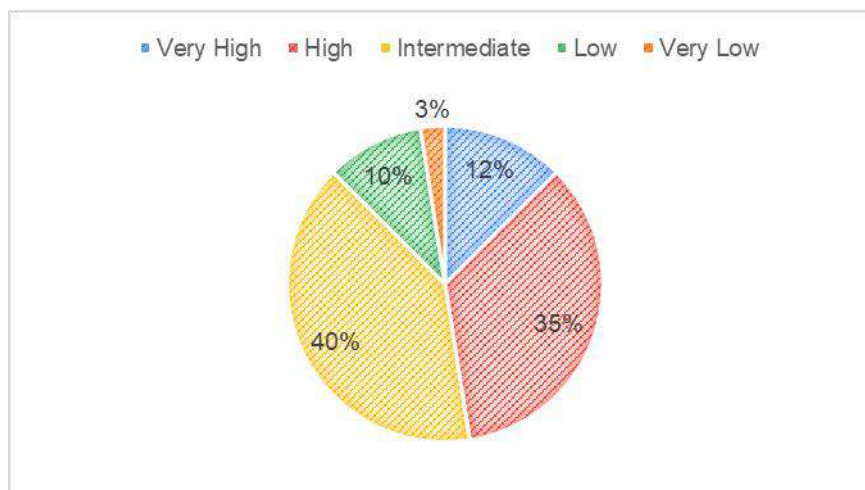


Figure 1. Level of understanding of ESG principles

Environmental sustainability appears to be a high priority for many SMEs according to the survey. When asked whether companies should be held accountable for their environmental impact, an overwhelming 95% of respondents either agreed or strongly agreed, with 65% choosing the strongest level of agreement. This indicates a strong normative commitment to environmental responsibility within the SME sector. Moreover, when it comes to internal practices, 70% of SMEs reported having set specific environmental goals, with 42% also tracking their progress through indicators. An additional 18% have set goals but are not yet measuring progress. Only 7.5% stated that they had not considered environmental goals at all, while another 17.5% are planning to do so in the near future. These findings suggest that

environmental awareness is translating into practical action for a significant share of SMEs, although there remains a need for improved monitoring mechanisms and clearer metrics for impact evaluation (See figure 2).

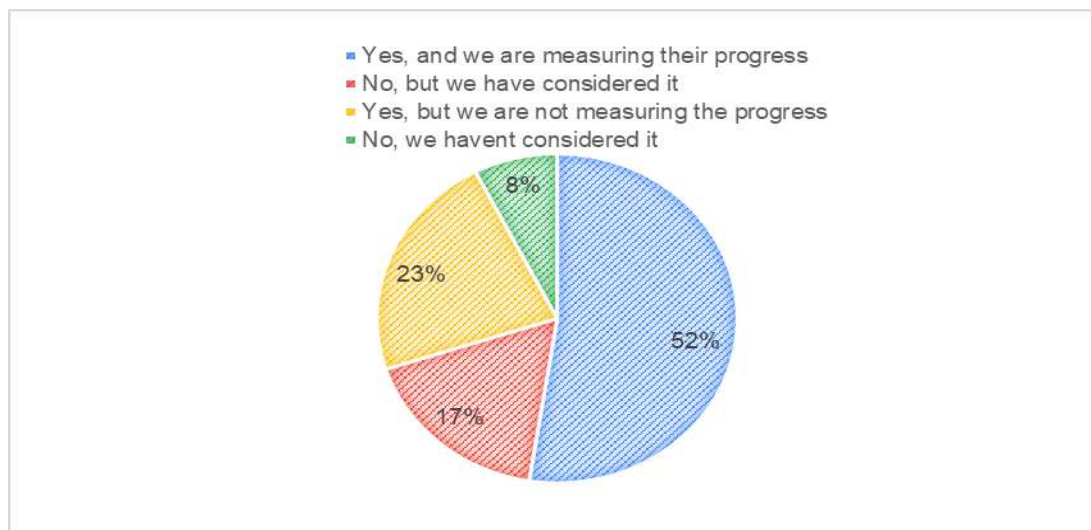


Figure 2. ESG goals and measuring progress

Governance, particularly in the area of business ethics and anti-corruption, is another area where SMEs appear to be progressing. The survey shows that 80% of respondents confirmed having a policy of zero tolerance toward corruption, bribery, and unethical conduct. This is a positive sign of institutionalization of ethical standards in governance structures, a crucial component of the "G" in ESG. However, 10% of SMEs indicated that they do not have such policies, and another 10% were unsure, which may reflect smaller or less formalized businesses that lack structured compliance mechanisms. This uncertainty points to a potential gap in internal communication or the formal documentation of governance practices, which could be addressed through training and policy standardization. More so the majority of SMEs do not know any other government factors that influence ESG scores, even further confirming the knowledge gap in the governance part. Furthermore on the social part they do not always work with partners which prioritize their social responsibility (See figure 3).

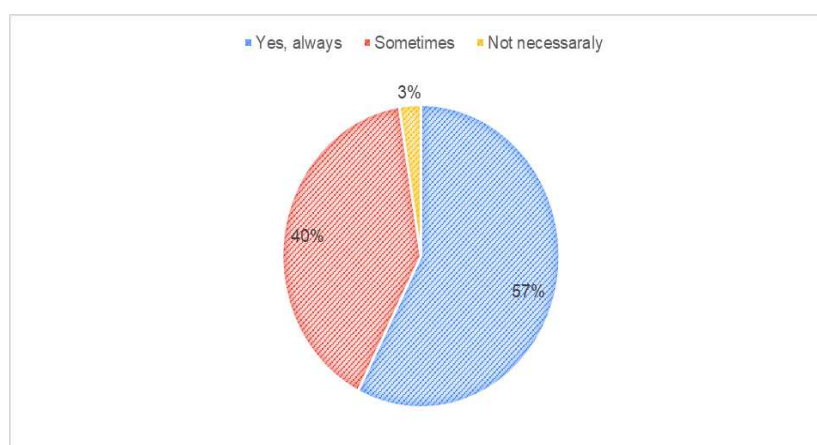
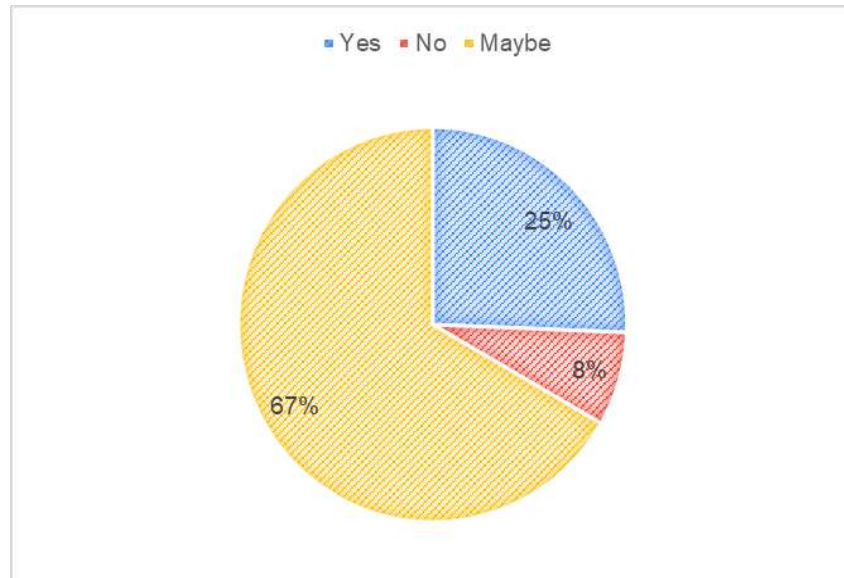


Figure 3. Collaboration only with socially responsible partners

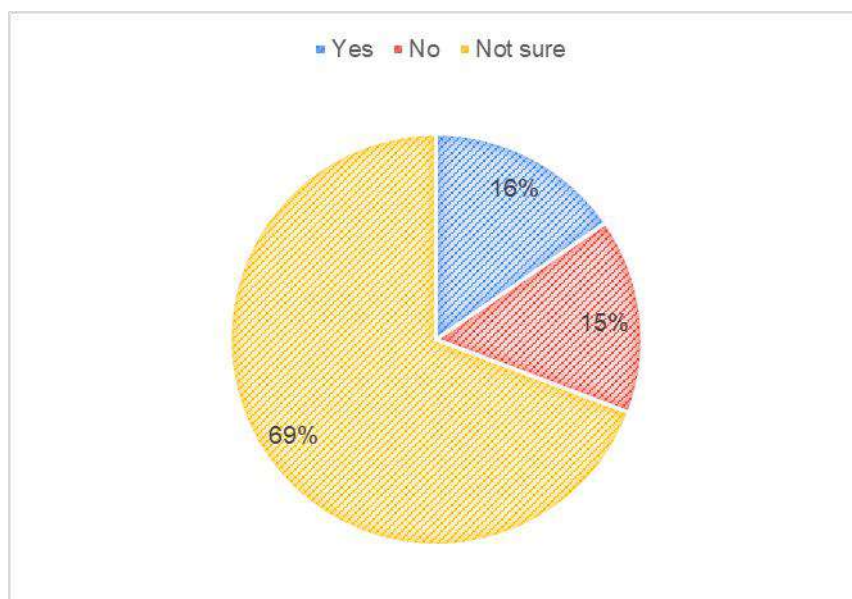
The survey also explored consumer and market behaviour related to ESG. When asked whether they would be willing to pay a premium for products or services from companies with

strong ESG commitments, the most common response (65%) was "maybe." A smaller group (25%) responded affirmatively, while only 8% indicated unwillingness. These responses reflect a moderate but growing consumer consciousness around sustainable business practices and the value they bring (See figure 4).



*Figure4.* Willingness to pay more for products or services that are made regarding the ESG principles

The hesitancy among some respondents to commit to paying more for ESG-aligned goods and services suggests that price sensitivity remains a significant barrier, especially in price-competitive markets. This finding reinforces the importance of policy incentives and market-based mechanisms that can help reduce the cost burden of ESG compliance for SMEs, while making ESG products more competitive.



*Figure5.* Opinion on whether the ESG related benefits exceeds costs

The most striking insight is that over two-thirds of respondents are unsure about whether ESG investments pay off (See figure 5). This points to a significant knowledge gap or lack of information about the tangible benefits of ESG practices. It also signals hesitation or confusion among SMEs in assessing ESG value. Among those who had a definitive opinion, responses are nearly evenly split between those who think ESG costs outweigh the benefits and those who believe the opposite. This division suggests there is no strong consensus on ESG as a business advantage. The high level of uncertainty underscores the need for targeted awareness campaigns and real-world case studies showing the return on investment (ROI) of ESG initiatives, especially for SMEs.

## 5. CONCLUSION

This study offers critical insights into the level of ESG (Environmental, Social, and Governance) awareness, implementation, and barriers among small and medium-sized enterprises (SMEs) in North Macedonia. The findings reveal a promising degree of general awareness, with a majority of SMEs having heard of ESG principles and acknowledging their importance. However, despite this awareness, significant gaps remain in the depth of understanding, particularly regarding regulatory requirements, carbon emissions measurement, and governance-related practices.

While environmental responsibility is widely embraced by SMEs—evidenced by goal-setting and increasing use of environmental indicators—this momentum does not fully extend to the social and governance dimensions. Many SMEs still lack formalized policies, especially in ethical governance and responsible supply chain partnerships. Moreover, limited collaboration with socially responsible partners and insufficient understanding of governance impact on ESG scoring further highlight the need for targeted capacity-building.

Barriers to implementation—such as limited financial resources, lack of standardized ESG frameworks tailored to SMEs, and a general need for policy clarity—remain considerable. The willingness of SMEs to adopt ESG-aligned practices is evident, particularly in areas like ethical sourcing and environmental goal-setting, but these efforts are often fragmented and informal due to structural limitations and a lack of external support.

To improve ESG integration in the SME sector, the study recommends a multipronged approach:

- Policy makers should introduce tailored incentives and simplified regulatory guidelines that reflect the operational scale of SMEs.
- Public institutions and business chambers should consider developing decision-support tools or financial incentives to reduce the perceived risk and cost burden of ESG implementation.
- Industry bodies and chambers of commerce should lead targeted training programs to close knowledge gaps and support the development of ESG reporting tools suited for SMEs.
- Financial institutions should facilitate easier access to green financing instruments, helping SMEs overcome initial investment barriers.
- Civil society and academic institutions should support awareness campaigns and provide technical assistance to promote ESG best practices.

Ultimately, strengthening ESG adoption in SMEs is not only a matter of compliance but a strategic opportunity for competitiveness, innovation, and long-term sustainability. As North Macedonia aligns with broader European Green Deal goals, empowering SMEs to navigate and embrace ESG principles will be vital for inclusive and resilient economic growth.



## ACKNOWLEDGMENT

This research was conducted in cooperation with the Economic Chamber of North Macedonia and the participating small and medium-sized enterprises that are members of the Chamber. We gratefully acknowledge their support and collaboration.

## REFERENCES

- Albuquerque, R., Koskinen, Y., & Zhang, C. (2019). Corporate social responsibility and firm risk: Theory and empirical evidence. *Management Science*, 65(10), 4451–4469. <https://doi.org/10.1287/mnsc.2018.3043>
- Álvarez Jaramillo, J., Zarthá Sossa, J.W., & Orozco Mendoza, G.L. (2019). Barriers to sustainability for small and medium enterprises in the framework of sustainable development—Literature review. *Business Strategy and the Environment*, 28, 512–524. <https://doi.org/10.1002/bse.2261>
- Bielawska, A. (2022). Socially responsible activity of micro-, small-, and medium-sized enterprises – benefits for the enterprise. *Sustainability*, 14(15), 9603. <https://doi.org/10.3390/su14159603>
- Cucari, N., de Falco, E., & Orlando, B. (2018). Diversity of board of directors and environmental social governance: Evidence from Italian listed companies. *Corporate Social Responsibility and Environmental Management*, 25(3), 250–266. <https://doi.org/10.1002/csr.1452>
- Economic and Social Commission for Asia and the Pacific - ESCAP. (2024). Advancing the green transition of SMEs: Insights for SME development agencies to support sustainability practices and reporting. <https://www.unescap.org/kp/2024/advancing-green-transition-smes-insights-sme-development-agencies-support-sustainability>
- European Union. (2020, June 22). Regulation (EU) 2020/852 of the European Parliament and of the Council. Official Journal of the European Union. <https://eur-lex.europa.eu/eli/reg/2020/852/oj/eng>
- European Union. (2022, December 16). Directive (EU) 2022/2464 of the European Parliament and of the Council. Official Journal of the European Union. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464>
- Hammann, E. M., Habisch, A., & Pechlaner, H. (2009). Values that create value: Socially responsible business practices in SMEs – Empirical evidence from German companies. *Business Ethics A European Review*, 18(1), 37-51. <https://doi.org/10.1111/j.1467-8608.2009.01547.x>
- Liu, H., Liu, J., Li, J., & Zhao, S. (2023). A study on the impact of corporate ESG performance on green innovation performance in a dual-carbon context. *Academic Journal of Business and Management*, 5(26), 52-60. <https://doi.org/10.25236/AJBM.2023.052609>
- Moeslinger, M., Fazio, A., & Eulaerts, O. (2022). Data platform support to SMEs for ESG reporting and EU Taxonomy implementation. Publications Office of the European Union. Luxembourg. <https://doi.org/10.2760/69381>
- Pekovic, S., Grolleau, G., & Mzoughi, N. (2018). Environmental investments: Too much of a good thing? *International Journal of Production Economics*, 3(197), 297–302
- Qureshi, M. A., Kirkerud, S., Theresa, K., & Ahsan, T. (2020). The impact of sustainability (environmental, social, and governance) disclosure and board diversity on firm value: The moderating role of industry sensitivity. *Business Strategy and the Environment*, 29(3), 1199–1214. <https://doi.org/10.1002/bse.2427>



- Rudžionienė, K., & Brazdžius, Š. (2023). Cost and Benefits of Sustainability Reporting: Literature Review. In J. Dyczkowska (Ed.), *Sustainable Performance in Business Organisations and Institutions: Measurement, Reporting and Management* (pp. 56-72). Wrocław: Publishing House of Wrocław University of Economics and Business. [https://dbc.wroc.pl/Content/123932/Rudzioniene\\_Brazdzius\\_Cost\\_and\\_Benefits.pdf](https://dbc.wroc.pl/Content/123932/Rudzioniene_Brazdzius_Cost_and_Benefits.pdf)
- Selig, J. (2024, April 10). Small businesses are prioritizing climate action, but they need more support. SME Climate Hub. <https://smeclimatehub.org/small-businesses-are-prioritizing-climate-action-but-they-need-more-support/>
- UK Finance. (2024, May 14). Unlocking the SME net zero transition. <https://www.ukfinance.org.uk/policy-and-guidance/reports-and-publications/unlocking-sme-net-zero-transition>
- Xie, J., Nozawa, W., Yagi, M., Fujii, H., & Managi, S. (2019). Do environmental, social, and governance activities improve corporate financial performance? *Business Strategy and the Environment*, 28(2), 286–300. <https://doi.org/10.1002/bse.2224>
- Zhou, G., Liu, L., & Luo, S. (2022). Sustainable development, ESG performance and company market value: Mediating effect of financial performance. *Business Strategy and the Environment*, 31(7), 3371–3387. <https://doi.org/10.1002/bse.3089>



## DIGITAL READINESS LEVEL (DLR) AND TECHNOLOGY ORGANIZATION ENVIRONMENT (TOE) METHODOLOGY IMPLEMENTATION ON SME-S INDUSTRY 4.0 IMPLEMENTATION

Aleksandra Kovačević, Aleksandar Jankulović \*

*Belgrade Metropolitan University, Faculty of management, Serbia*

**Abstract:** Implementation of Industry 4.0 to Small and Medium Enterprises (SMEs) induces various challenges. The investigation of these issues affecting SMEs is extremely rare, and thus this research has theoretical and especially practical implication on spreading Industry 4.0 implementation. The research is focused on implementation of the Digital Readiness Level (DRL) model and the Technology Organization Environment (TOE) framework for SMEs analyzing Industry 4.0 implementation and readiness. Research demonstrates the suitability of these two models and their shared dimensions. These elements and dimensions are applied to SMEs' digital readiness for Industry 4.0 and serve as suitable instruments for this kind of examination. According to research, there are a number of new influencing factors that are crucial for the implementation of Industry 4.0. These include the volatility of business process parameters, business specificity, user satisfaction, service quality, workforce presence, external knowledge inclusion, funding program research, and the visualization of future improvements. The study suggests aspects that are of main interest to be implemented for the successful implementation of Industry 4.0 based on analysed factors and outcomes.

**Keywords:** Industry 4.0, SMEs, digital readiness assessment, Digital Readiness Level (DLR), Technology-Organization-Environment (TOE)

### 1. INTRODUCTION

The fourth industrial revolution, known as Industry 4.0, includes technologies that present unprecedented challenges to all businesses, including SMEs (Mittal et al., 2018). The implementation of digitalization and industry 4.0 technology presents a number of challenges as well as the important organizational adjustments and work that are required. On the other hand, without their use the company, organizations and the country's economy as a whole, have no chance of survival and development. All of this implies increasing complexity and

---

\* Corresponding author: [aleksandar.jankulovic@metropolitan.ac.rs](mailto:aleksandar.jankulovic@metropolitan.ac.rs)

Aleksandra Kovačević, ORCID: 0009-0001-2972-9968  
Aleksandar Jankulović, ORCID: 0000-0002-0959-1519

uncertainty about the required organizational and technological capabilities (Schumacher et al., 2016). The transition to Industry 4.0 requires appropriate strategies and organizational models, which may result in radical changes in business practices (Gilchrist, 2016).

To understand and facilitate their transition to Industry 4.0, organizations must develop own strategic roadmaps that define their development directions (Ghobakhloo, 2018). While digital transformation (DT) has several potentials, many companies struggle with its implementation (Ghobakhloo and Fathi, 2019). This difficulty is especially true for SMEs that often face limited digitalization level, lack of time, resources and flexibility (Lassnig et al., 2022; Löfving et al., 2014; Schröder, 2016). Despite the fact that they can significantly improve their competitiveness, SMEs face significant challenges when adopting Industry 4.0 technologies (Sommer, 2015; Ganzarain and Errasti, 2016; Horvath and Szabo, 2019, Mittal et al., 2018).

In our research we focus on the exploration of SMEs practices in the field of Industry 4.0 implementation in Easter European economies. The purpose of this paper is to investigate the implementation of two well-established scientific models on Industry 4.0 implementation. Our study is based on the Digital Readiness Level 4.0 (DRL) model developed specifically for SMEs (Pirola et al., 2019) and the Technology-Organization-Environment (TOE) framework (Tornatzky et al., 1990).

We are trying to address the following research questions concerning SMEs of Eastern European country like Serbia.

RQ1: Are DRL and TOE appropriate for Industry 4.0 implementation in SMEs?

RQ2: Is there any additional factors that influence Industry 4.0 implementation that are not stated in DRL and TOE models?

The rest of the work is structured as follows: Section 2 reviews the literature, and Section 3 outlines the research method chosen for the study. Section 4 presents the findings, while section 5 discusses the results and their implications. Section 6 concludes with limitations and suggestions for future research.

## **2. LITERATURE REVIEW**

### **2.1. The theoretical framework**

Industry 4.0 is a basic element of the industrial digital transformation with the primary aim of connecting different devices and systems. As a result, this fourth industrial revolution introduces many new digital technologies as well as new business opportunities (Horvath and Szabo, 2019; Matt and Rauch, 2020). Industry 4.0 significantly improves product efficiency and quality while also providing flexibility and customization.

Big Data, IoT, Cloud Computing, Automation, Additive Manufacturing, Cyber Physical Systems (CPS), Augmented Reality (AR), and Artificial Intelligence (AI) are the most recognized and discussed Industry 4.0 technologies in SMEs and in the literature (Khanzode et al., 2021; Ghobakhloo et al., 2022; Kim, 2022). Organizations must take advantage of all opportunities provided by data availability and integration for knowledge generation and decision support (Pirola et al., 2019). The impact of digital technologies on supply chain performance grows with participant integration and visibility (Patrucco et al., 2022). Additionally, while core processes, such as production, might be increasingly digitized in SMEs, the digitization and integration of supply chain processes with customers and suppliers must not be neglected for all enterprises (Lassnig et al., 2022). A smart factory boosts productivity by automating production management tasks and replacing tasks previously performed by workers with machines, smart sensors, and robots (Wu et al., 2016; Ramakrishna

et al., 2017). Productivity is increased by remodelling and improving the production process (Fragapane et al., 2020). Industry 4.0 can and will affect any company that makes decisions based on data (Saad et al., 2021). Industry 4.0 has also been suggested as a potential solution for the development of socially responsible business practices (Bienhaus and Haddud, 2018; Morrar et al., 2017; Wellener et al., 2019; Asokan et al., 2022). All of these aforementioned provide a need for research in digital readiness evaluation and challenges for digitalization implementation (Chonsawat and Sopadang, 2020). Among other researchers Brozzi et al., 2021 developed a set of Key Readiness Indicators (KRI), deepening the interpretation of the overall digital level of the companies with focus on the digital readiness of companies in terms of strategy, technological requirements, awareness about digital trends, and competences of employees. According to Kumar et al. (2020), the biggest obstacle to the adoption of I4.0 technologies is the lack of enthusiasm from partners and customers, and the primary effect group challenge for ethical and sustainable operations is the fear of I4.0 technology failure. Within literature review research Grufman et al., 2020, found that the main challenges proved being of organizational nature: SMEs need help with company-specific strategies for implementing Industry 4.0; and SMEs need skilled employees and the opportunities are flexibility and openness to innovation, which are pertinent to SMEs. Genest and Gemache, 2020 in their literature review paper find out that in 73% of analysed papers challenges are connected with lack of knowledge, 64% with business strategy and 45% with financial capacity.

Because SMEs account for nearly 99% of all companies in Europe (Matt et al., 2020), it is critical to investigate their role in Industry 4.0 participation. According to some of the researchers, there are numerous barriers to the implementation of Industry 4.0 and digitalization in SMEs (Sommer, 2015; Ganzarain and Erasti, 2016), including a lack of resources (both financial and technical), a methodology and process model, and an action plan for digitalization implementation using software to improve performance by analyzing data (Lee et al., 2015). Furthermore, there is a scarcity of research studies on Industry 4.0 implementation in SMEs, particularly in developing countries (Gross et al., 2022; Ghobakloo et al., 2022).

## **2.2. The research gap**

The majority of the research has primarily focused on large companies in developed countries, with a small portion dealing with research in SMEs and an even smaller portion dealing with research in emerging and developing countries (Gross et al., 2022; Ghobakloo et al., 2022). Small and medium-sized enterprises (SMEs) in emerging and developing economies have much less access to capital and technology and rely more on manual processes (Coad and Tamvada, 2012; Jankulovic and Skoric, 2013).

SMEs may face compelling survival challenges if they are not properly integrated into the broader industrial context that Industry 4.0 is assuming, especially in an uncertain environment. SME leaders urgently need to adapt to the upcoming digital age to avoid losing intellectual property and competitive advantage (Kamble et al., 2018a; Dutta et al., 2020; Raj et al., 2020; Snieska et al., 2020). On the other hand, SMEs play important role in economies of each country especially emerging and developing ones. Given all of these issues, it is critical for SMEs and national economies to conduct research on digitalization as a part of Industry 4.0 implementation and their readiness for implementation in different sectors (Abdallah et al., 2022).

According to literature research paper with a more western perspective of Grufman et al., (2020), future research can be directed to readiness level for Industry 4.0 that can be used in practice for specific SMEs in different industries and different countries. Suggestion is to execute the readiness assessment on the national level by using a case study as a method. Raj

et al., (2020) in their literature research paper reported that the majority of researchers agree that the investigation of barriers related to implementation of Industry 4.0 remains largely unexplored in the literature and merits further investigation (de Sousa Jabbour et al., 2018a, b; Kamble et al., 2018a; Horváth and Szabó, 2019; Oesterreich and Teuteberg, 2016; Xu et al., 2018). Horváth and Szabó (2019) and Kamble et al. (2018b) suggest that the adoption of Industry 4.0 in the context of developing versus developed economies needs further investigation. Horváth and Szabó (2019) propose to analyse Industry 4.0 through a geographical lens, in order to compare similarities and differences across regions. Researchers find out different barriers to the adoption of Industry 4.0 technologies in different countries like Romania, Hungary, Turkey (Turkes et al, 2019; Horváth and Szabó, 2019; Saatçioğlu et al., 2019).

### 2.3. Contribution and aim of the study

In our research we analyse implementation of DRL and TOE models for maturity and readiness assessment for SMEs regarding Industry 4.0 in Serbia as an East European economy. We explore dimensions of these two models, compare them and test their implementation on readiness for Industry 4.0. Analysing these dimensions, we try to find some new previously not mentioned factors that are important for Industry 4.0 implementation. By researching those influential factors, we aim to explore obstacles for implementation and possible solutions for a more successful application of technologies on the path to Industry 4.0. Contribution of these paper is to widen the research of Industry 4.0 implementation factors in SMEs.

## 3. DATA AND METHODOLOGY

The research follows an empirical approach using the exploratory multiple case study according to Stake, 1995. The case study method enables an in-depth, multi-faceted investigation of complex issues in their real-world context, as is the case with the complex issue of digital adoption assessment in order to achieve Industry 4.0 goals. Case studies, according to Yin (2009) and Yin et al. (2018), can be used to explain, describe, or study events or phenomena in their everyday contexts.

In order to discover factors influencing the implementation of Industry 4.0 and the digital readiness of SMEs for Industry 4.0, two models TOE and DRL was chosen for implementation on different companies. These models are chosen because of their prior use in adoption analysis of Industry 4.0 technology implementation in SMEs and comparable dimensions they propose (table 1).

*Table 1.* Dimensions of TOE and DRL models

TOE	DRL
Technology	Technology
Organization	Strategy People Processes
Environment	Integration

Starting with a literature research on the implementation of Industry 4.0 in SMEs, the study model based on DRL and TOE was created, validated, and implemented in different case studies of SMEs from different business sectors in Republic of Serbia, each with a unique set of processes and needs for process realization. The SMEs analysed in this study operate in different business sectors, including metal profile manufacturing, sales and distribution of

construction materials, construction and selling apartments, organic crop production, wine production and higher education as a part of service industry. These companies were available for research, they are typical represent of Serbian SMEs and they showed a certain level of readiness and interest in applying new technologies of Industry 4.0. On the other hand, these case studies belong to important business sectors for the Serbian economy such as manufacturing, agriculture, construction and education. This fact is critical in understanding the sampling method used in the extensive case-study research, which was designed using a judgemental sampling approach (Eisenhardt, 1989; Hameri and Nihtilä, 1998). In contrast to random sampling, judgmental sampling is considered appropriate when resources are limited (Henry, 1990), and this sampling method is more successful in selecting the most appropriate cases for a specific research strategy (Seawright and Gerring, 2008).

### **3.1. The Technology-Organization-Environment (TOE)**

This study employed the Technology-Organization-Environment (TOE) framework developed by Tornatzky et al., (1990), provides a more comprehensive view of technology adoption (Mohtaramzadeh et al., 2018) and incorporates both human and non-human factors. TOE is a well-known framework that is used to systematically examine the technical, organizational, and environmental factors that can influence the behaviour of SMEs when adopting Industry 4.0 technologies (Wong et al., 2019).

### **3.2. The Digital Readiness Level (DRL)**

Pirola et al. (2019) establish DRL model designed specifically for SMEs with modularity that does not force respondents to answer all questions, even those that do not apply to their specific contexts. The model's main component is a set of questions that examine five dimensions: strategy, people, processes, technology, and integration (Table 2).

*Table 2.* Five dimensions of DRL model (Pirola et al., 2019)

Strategy	Analyse the company's digitalization strategy and implementation of Industry 4.0 principles.
People	Analyse people skills and how the know-how is managed inside the company
Processes	Analyse how internal processes are managed from a digitalization point of view and how data are collected, shared and managed inside the company
Technology	Analyse the current adoption of the Industry 4.0 enabling technologies
Integration	Analyse the digitalization level and the integration with other actors of the value chain

## **4. RESULTS AND DISCUSSION**

Table 3 shows the factors that were discussed as influencing the implementation of Industry 4.0 according to previous literature research and TOE model. Factors influencing the implementation of Industry 4.0 in companies were identified through interviews and discussions in focus groups. In addition to answering questions about how they see these factors being applied, they were given the opportunity to identify some additional factors that they believe are important for the implementation of Industry 4.0. As in previous analyses, the scores for these questions were given on a scale of 1-5. Factors identified as important by respondents and not previously mentioned in the literature are denoted with \*\*, indicating contribution of the work in the research of factors influencing application and thus possible solutions and answers for a more successful application of technologies on the path to Industry 4.0.

Table 3. Factors that influence Industry 4.0 implementation

Factors	Average
<b>1. Technology</b>	
1.1 Technical complexity and their cost	5.0
1.2 System integration and information flow	4.3
1.3 Digital data collection and analysis	3.5
1.4 Low cost proof of concept	3.8
1.5 Compatibility of Industry 4.0 technologies	2.7
1.6 Cybersecurity risks of Industry 4.0 technologies	1.8
1.7 Perceived benefits of Industry 4.0 technologies	4.7
1.8 User friendliness of Industry 4.0 technologies	4.7
<b>1.9 KPI measurement using Industry 4.0 technologies **</b>	3.8
<b>2. Organization</b>	
2.1 Technical resources	4.3
2.2 Financial resources	4.8
2.3 Top management support and involvement	4.0
2.4 Organizational culture and structure	3.8
2.5 Human capital	3.7
2.6 Strategic alignment and awareness of Industry 4.0	4.3
2.7 Business properties	4.5
<b>2.8 Business process parameters volatility **</b>	4.3
<b>2.9 Stakeholder satisfaction – user satisfaction **</b>	4.5
<b>2.10 Service quality **</b>	3.7
<b>3. Environment</b>	
3.1 Market dynamics and world economy	2.3
3.2 Competitive environment and pressure	3.2
3.3 Regulatory support and support programs	4.5
3.4 Stakeholder collaboration and knowledge sharing	4.3
3.5 ICT infrastructure and skilled workforce	4.2
3.6 Industry 4.0 accessibility	3.7
<b>3.7 Shortage of workforce **</b>	4.3

This study finds appropriate models of TOE and DRL for analysis of Industry 4.0 implementation in SMEs. It gives the results of dimensions and factors analysis of companies in one East European country like Serbia and based on research find some new factors that are important for analyzed companies. Researched case studies and the application of TOE and DRL methodologies reveal similarities between their dimensions and factors, and we obtain comparable or nearly identical outcomes. This suggests that while the Industry 4.0 process in the case studies examined in Serbian SMEs is still in its infancy, the stakeholders understand how crucial its implementation will be in the future. Analyzed SMEs are aware of the technologies and possibilities of Industry 4.0 implementation, but they are still in the early stages of identifying the best solutions and possibilities to implement, as well as identifying a road map and strategies on the path to Industry 4.0. The overall rating for the SMEs under study is supported by the result of the analysis of the state of the strategy and roadmap preparation for the implementation of Industry 4.0, which are at a low level. The influence of top management on Industry 4.0 implementation and the level of competence of management and employees are both low, which explains why SMEs are at the current level of implementation.

On the one hand, top management support and skilled managers and workers who represent willingness to change and openness to digitalization are recognized as important factors for Industry 4.0 implementation (Amaral and Pecas (2021), Schumacher et al., (2016); Ganzarain and Erasti, (2016), Khin and Kee, (2022); Ghobakhloo (2018), Erol et al., (2016)). As a result, companies must identify and hire those with the skills required to implement the Industry 4.0 strategy and their new business models. Problem-solving, optimization, analytical, big data, and cognitive abilities are becoming increasingly important in this context (Prifti et al., 2017). SMEs in Serbia are increasingly facing labour shortages and rising production costs per unit of product due to rising wages. This issue is one of the factors that will force companies to implement automation and Industry 4.0 on a larger scale and to completely change the structure of the workforce with completely new types of jobs and knowledge.

A study of SMEs in Serbia demonstrates the importance of investment factors as well as the availability of regulatory assistance, support programs, and investment funds for digitalization implementation. In relation to the issue of workers' and managers' lack of knowledge and skills in the area of Industry 4.0 technologies, research Ricci et al., (2021) suggests that collaboration with external partners (universities, research centres, system integrators, suppliers) can aid in the implementation of Industry 4.0. As a result, company shortages of skilled workers and managers can be addressed through collaboration with stakeholders and knowledge sharing with universities and research institutions.

Companies that have been analyzed have the highest level of process maturity and understanding of the importance of good process management. According to our research there exists a clear dependence of digitalization process for Industry 4.0 implementation with type of business within exact industry and with process parameters volatility. The basic performance measures that drive all other Industry 4.0 technology implementation according to our results, are the data science, data processing, data analysis and big data analytics. On the other side although it is clear that SMEs start to implement data analytics and understand importance of data management and big data technology, they do not have investment plan and strategy what to do next in further steps toward digitalization and Industry 4.0.

## 5. CONCLUSION

According to Gilchrist (2016)'s research, our research confirm that companies understand the importance of connecting and communicating on a horizontal and vertical level, exchanging data in real time, and making conclusions and decisions based on that data. On the other hand, the research's integrity demonstrates that companies have a low level of mutual connection and connection with the environment. As a result, companies must continue to develop their data collection and processing systems and automate them more and more with the introduction of new technologies, and this must be one of their first steps toward Industry 4.0, which is fully consistent with Amaral and Pecas's (2021) research. One of the main drivers identified in the analyzed SMEs is expected benefit confirmed also in study of Khin and Kee, 2022, which must be clearly communicated to all company managers and employees.

The need to prepare a digitization system and apply Industry 4.0 technologies in such a way that they are user friendly (element of service quality factor) for users and that their actions ensure a higher level of stakeholder engagement and user satisfaction is one of the important factors determined by this research that was not present in the researched literature. As a result, when developing a strategy, businesses and system implementers should clearly define the need for user-friendly systems that will ensure the satisfaction of all users.

Based on previously stated results it is of great importance to explore technology utilization analysis of exact business and to implement little not expensive visible



improvements that will give the results and raise the level of motivation for Industry 4.0 Implementation. Prepare the organizational culture and structure for Industry 4.0 implementation as well as human resources knowledge for ease of use user friendly new technologies.

The work's limitations are primarily related to the number of case studies processed, and future work will require applying the methodology mentioned to a larger number of companies in the business areas mentioned and testing the results obtained in other companies, industries and countries.

## REFERENCES

- Abdallah Y.O., Shehab, E, Al-Ashaab A (2022) Developing a digital transformation process in the manufacturing sector: Egyptian case study. *Information Systems and e-Business Management* 20: 613-630. <https://doi.org/10.1007/s10257-022-00558-3>
- Amaral A, Pecas P (2021) SMEs and Industry 4.0: Two case studies of digitalization for a smoother integration. *Computers in industry* 125. <https://doi.org/10.1016/j.compind.2020.103333>
- Asokan D, Huq F, Smith C (2022) Socially responsible operations in the Industry 4.0 era: post-Covid-19 technology adoption and perspectives on future research. *International Journal of Operations & Production Management* 42 (13): 185-217. <https://doi.org/10.1108/IJOPM-01-2022-0069>
- Bienhaus F, Haddud A (2018) Procurement 4.0: factors influencing the digitisation of procurement and supply chains. *Business Process Management Journal* 24(4): 965-984. <https://doi.org/10.1108/BPMJ-06-2017-0139>
- Brozzi, R., Riedl, M., Matta, D. (2021). Key readiness indicators to assess the digital level of manufacturing SMEs. *Procedia CIRP*, 96, 201-206.
- Chonsawat, N., Sopadang, A. (2020). Defining SMEs' 4.0 readiness indicators. *Applied sciences*, 10(24), 8998.
- Coad A, Tamvada J.P. (2012) Firm growth and barriers to growth among small firms in India. *Small Business Economics* 9(2): 383–400. <https://doi.org/10.1007/s11187-011-9318-7>
- de Sousa Jabbour, A. B. L., Jabbour, C. J. C., Foropon, C., Godinho Filho, M. (2018b). When titans meet–Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors. *Technological Forecasting and Social Change*, 132, 18-25.
- de Sousa Jabbour, A. B. L., Jabbour, C. J. C., Godinho Filho, M., Roubaud, D. (2018a). Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations. *Annals of Operations Research*, 1-14.
- Dutta G, Kumar R, Sindhvani R, Singh R.K. (2020) Digital transformation priorities of India's discrete manufacturing SMEs – a conceptual study in perspective of Industry 4.0. *Competitiveness. Review* 30(3): 289–314. <https://doi.org/10.1108/CR-03-2019-0031>
- Erol S, Schumacher A, Sihni W. (2016) Strategic guidance towards Industry 4.0 – a three-stage process model. *International Conference on Competitive Manufacturing* 9(1): 495-501.
- Fragapane G, Ivanov D, Peron M, Sgarbossa F, Strandhagen J.O. (2020) Increasing flexibility and productivity in Industry 4.0 production networks with autonomous mobile robots and smart intralogistics. *Annals of Operations Research* 308: 125-143. <https://doi.org/10.1007/s10479-020-03526-7>
- Ganzarain J, Errasti N, (2016) Three stage maturity model in SME's toward industry 4.0. *Journal of Industrial Engineering Management* 9(5): 1119–1128. <https://doi.org/10.3926/jiem.2073>

- Genest, M. C., Gamache, S. (2020). Prerequisites for the implementation of industry 4.0 in manufacturing SMEs. *Procedia Manufacturing*, 51, 1215-1220.
- Ghobakloo M, Iranmanesh M, Vilkas M, Grybauskas A, Amran A. (2022) Drivers and barriers of Industry 4.0 technology adoption among manufacturing SMEs: a systematic review and transformation roadmap. *Journal of Manufacturing Technology Management* 33(6): 1029-1058. <https://doi.org/10.1108/JMTM-12-2021-0505>
- Gilchrist, A (2016) *Industry 4.0: The Industrial Internet of Things*. Apress, Berkeley, CA.
- Gross O, Presser M, Tambo T, (2022) Surround yourself with your betters: Recommendations for adopting Industry 4.0 technologies in SMEs. *Digital Business*, 2(2). <https://doi.org/10.1016/j.digbus.2022.100046>
- Grufman, N., Lyons, S., Sneiders, E. (2020). Exploring readiness of SMEs for industry 4.0. *Complex Systems Informatics and Modeling Quarterly*, (25), 54-86.
- Eisenhardt K.M. (1989) Building theories from case study research. *The Academy of Management Review* 14(4): 532-550. <https://doi.org/10.2307/258557>
- Hameri A.P., Nihtilä, J, (1998) Product data management – exploratory study on state-of-the-art in one-of-a-kind industry. *Computers in Industry* 35(3): 195-206. [https://doi.org/10.1016/S0166-3615\(98\)00064-5](https://doi.org/10.1016/S0166-3615(98)00064-5)
- Henry G.T. (1990) *Practical Sampling*. Sage. Thousand Oaks, CA.
- Horvath D, Szabo R.Z. (2019) Driving forces and barriers of Industry 4.0: do multinational and small and medium-sized companies have equal opportunities? *Technological Forecasting and Social Change* 146: 119–132, <https://doi.org/10.1016/j.techfore.2019.05.021>
- Jankulovic A, Skoric V, (2013), Performance management system implementation in a Southeast European transition economy, *Journal for East European Management Studies*, 18 (2): 173-190.
- Kamble S, Gunasekaran A, Arha H, (2018a) Understanding the Blockchain technology adoption in supply chains-Indian context. *International Journal of Production Research* 57(9): 1–25. <https://doi.org/10.1080/00207543.2018.1518610>
- Kamble S.S., Gunasekaran A., Gawankar S.A. (2018b) Sustainable Industry 4.0 framework: a systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection* 117: 408–425. <https://doi.org/10.1016/j.psep.2018.05.009>
- Khanzode A.G., Sarma P.R.S., Mangla S.K., Yuan, H. (2021) Modeling the industry 4.0 adoption for sustainable production in micro, small and medium enterprises. *Journal of Cleaner Production*, 279. <https://doi.org/10.1016/j.jclepro.2020.123489>
- Khin S, Kee D,M.H. (2022) Factors influencing industry 4.0 adoption. *Journal of Manufacturing Technology Management* 33(3): 448-467. <https://doi.org/10.1108/JMTM-03-2021-0111>
- Kim H. (2022) Performance from building smart factories of small-and-medium sized enterprises: the moderating effects of product complexity and company size. *International Journal of Operations & Production Management* 42(10): 1497-1520. <https://doi.org/10.1108/IJOPM-10-2021-0654>
- Kumar, R., Singh, R. K., Dwivedi, Y. K. (2020). Application of industry 4.0 technologies in SMEs for ethical and sustainable operations: Analysis of challenges. *Journal of cleaner production*, 275, 124063.
- Lassnig, M., Müller, J. M., Klieber, K., Zeisler, A., Schirl, M. (2022). A digital readiness check for the evaluation of supply chain aspects and company size for Industry 4.0. *Journal of Manufacturing Technology Management*, 33(9), 1-18.

- Lee J, Bagheri B, Kao H.A. (2015) A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing Letters* 3: 8-23. <https://doi.org/10.1016/j.mfglet.2014.12.001>
- Löfving M, Säfsen K, Winroth M. (2014) Manufacturing strategy frameworks suitable for SMEs. *Journal of Manufacturing Technology Management* 25(1): 7-26. <https://doi.org/10.1108/JMTM-08-2012-0081>
- Matt D.T., Rauch E. (2020) SME 4.0: The Role of Small- and Medium-Sized Enterprises in the Digital Transformation. In: Matt D, Modrák V, Zsifkovits H. (eds) *Industry 4.0 for SMEs*. Palgrave Macmillan. Cham, 3-36. [https://doi.org/10.1007/978-3-030-25425-4\\_1](https://doi.org/10.1007/978-3-030-25425-4_1)
- Mittal S, Khan M.A., Romero D, Wuest T. (2018) A critical review of smart manufacturing & Industry 4.0 maturity models: implications for small and medium-sized enterprises (SMEs). *Journal of Manufacturing Systems* 49(1): 194–214. <https://doi.org/10.1016/j.jmsy.2018.10.005>
- Morrar R, Arman H, Mousa S. (2017) The Fourth industrial revolution (industry 4.0): a social innovation perspective. *Technology Innovation Management Review* 7(11): 12-20. <https://doi.org/10.22215/timreview/1117>
- NALED, SME sector crucial for the development of the Serbian economy. <https://naled.rs/en/blog-msp-sektor-kljucan-za-razvoj-srpske-ekonomije-246>. Accessed 17 february 2023.
- Oesterreich, T. D., Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Computers in Industry*, 83, 121-139
- Patrucco A, Trabuchhi D, Golini R. (2022) How do Industry 4.0 technologies boost collaborations in buyer-supplier relationships? *Research-Technology Management* 65(1): 48-58. <https://doi.org/10.1080/08956308.2021.1999131>
- Pirola F, Cimini C, Pinto R. (2019) Digital readiness assessment of Italian SMEs: A case study research. *Journal of Manufacturing Technology Management* 31(5): 1045-1083. <https://doi.org/10.1108/JMTM-09-2018-0305>
- Prifti L, Knigge M, Kienegger H, Krcmar, H. (2017) A competency model for ‘Industrie 4.0’ employees. 13th International Conference on Wirtschaftsinformatik, St Gallen, CH.
- Raj A, Dwivedi G, Sharma A, de Sousa Jabbour A.B.L., Rajak S. (2020) Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: an intercountry comparative perspective. *International Journal of Production Economics* 224. <https://doi.org/10.1016/j.ijpe.2019.107546>
- Ramakrishna S, Khong T.C., Leong, T.K. (2017) Smart manufacturing', *Procedia Manufacturing* 12: 128-131. [online] <https://doi.org/10.1016/j.promfg.2017.08.01>
- Ricci R, Battaglia D, Neirotti P. (2021) External knowledge search, opportunity recognition and Industry 4.0 adoption in SMEs. *International Journal of Production Economics* 240. <https://doi.org/10.1016/j.ijpe.2021.108234>
- Saad S, Bahadori R, Jafarnejad H. (2021) The smart SME technology readiness assessment methodology in the context of Industry 4.0. *Journal of Manufacturing Technology Management* 32(5): 1037-1065. <https://doi.org/10.1108/JMTM-07-2020-0267>
- Saatçioğlu, Ö. Y., Özispa, N., Kök, G. T. (2019). Scrutinizing the Barriers That Impede Industry 4.0 Projects: A Country-Wide Analysis for Turkey. In *Agile Approaches for Successfully Managing and Executing Projects in the Fourth Industrial Revolution* (pp. 294-314). IGI Global.
- Seawright J, Gerring J. (2008) Case selection techniques in case study research: a menu of qualitative and quantitative options. *Political Research Quarterly* 61(2): 294-308. <https://doi.org/10.1177/1065912907313077>

- Snieska V, Navickas V, Haviernikova K, Okręglicka M, Gajda W. (2020) Technical, information and innovation risks of industry 4.0 in small and medium-sized enterprises—case of Slovakia and Poland. *Journal of Business Economics & Management* 21(5): 1269–1284. <https://doi.org/10.3846/jbem.2020.12279>
- Sommer L. (2015) Industrial revolution-industry 4.0: are German manufacturing SMEs the first victims of this revolution?. *Journal of Industrial Engineering Management* 8(5): 1512–1532. <https://doi.org/10.3926/jiem.1470>
- Schröder C. (2016) *The Challenges of Industry 4.0 for Small and Medium-Sized Enterprises*. Friedrich- Ebert-Stiftung, Bonn.
- Schumacher A, Erol S, Sihni, W. (2016) A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises. *Procedia CIRP* 52: 161–166. <https://doi.org/10.1016/j.procir.2016.07.040>
- Stake RE. (1995) *The art of case study research*. London: Sage Publications Ltd. ISBN: 9780803957671
- Tornatzky L. G., Fleischer M, Chakrabarti A. K. (1990) *The process of technological innovation*. Lexington, MA: Lexington Books. ISBN: 9780669203486
- Turkeş, M. C., Oncioiu, I., Aslam, H. D., Marin-Pantelescu, A., Topor, D. I., Căpuşneanu, S. (2019). Drivers and Barriers in Using Industry 4.0: A Perspective of SMEs in Romania. *Processes*, 7(3), 153.
- Venkatesh Viswanath, Morris, Michael G, Davis, Gordon B, Davis, Fred D. (2003) User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*. 27(3): 425–478. <https://doi.org/10.2307/30036540>
- Wellener P, Shepley S, Dollar B, Laaper S, Manolian H.A., Beckoff D. (2019) *Deloitte and MAPI smart factory study*. Deloitte Insights.
- Wong L, Leong L, Hew J, Tan G, Ooi K. (2019) Time to seize the digital evolution: Adoption of blockchain in operations and supply chain management among Malaysian SMEs. *International Journal of Information Management* 52. <https://doi.org/10.1016/j.ijinfomgt.2019.08.005>
- Wu L, Yue X, Jin, A., Yen, D.C. (2016) Smart supply chain management: a review and implications for future research. *The International Journal of Logistics Management* 27(2): 395–417. <https://doi.org/10.1108/IJLM-02-2014-0035>
- Xu, L. D., Xu, E. L., Li, L. (2018). Industry 4.0: state of the art and future trends. *International Journal of Production Research*, 56(8), 2941–2962.
- Yin R.K. (2009) *Case study research, design and method*. 4.th edition London: Sage Publications Ltd. ISBN: 1412960991
- Yin, R. K., Campbell D. T. (Donald Thomas 1916-1996 writer of forward), (2018) *Case study research and applications: design and methods*. 6.th edition Thousand Oaks California: SAGE Publications Inc. ISBN: 9781506336169



## **BLENDED, BRIEF, BUT IMPACTFUL? EVALUATING THE EFFECTIVENESS OF ERASMUS+ BLENDED INTENSIVE PROGRAMS**

**Jacob Cornelis Bazen<sup>1</sup>\*, Florin Sebastian Duma<sup>2</sup>**

<sup>1</sup> *Saxion University of Applied Sciences, School of Business, Building & Technology, The Netherlands*

<sup>2</sup> *Babes Bolyai University, Faculty of European Studies, Romania*

### **Abstract:**

This study evaluates the effectiveness of Erasmus+ Blended Intensive Programmes (BIPs) in fostering intercultural competences and international collaboration skills among higher education students. Conducted over three years with participants from five European universities, the study uses pre- and post-program surveys to assess changes in student attitudes and self-perceived skills. Although statistical differences between the pre- and post-tests were not significant, participants reported perceived improvements in intercultural teamwork, international project engagement, and personal development. Qualitative feedback further emphasized the value of practical experiences and cross-cultural collaboration. Suggestions for improvement focused on the organization of the physical mobility component, including better planning and more cultural activities. The average program rating was 7.6 out of 10. While findings highlight a possible participation bias favouring already internationally oriented students, they also indicate the potential of BIPs to serve as impactful, inclusive international learning experiences. Future research with larger samples and control groups is recommended to better understand long-term outcomes and address access equity.

**Keywords:** blended mobility, international education, Erasmus+, intercultural competence, higher education

### **1. INTRODUCTION**

Higher education institutions in Europe are increasingly tasked with preparing students to navigate complex, multicultural environments, one of the consequences of the Bologna process aiming at the integration of European Higher Education (Roy et al., 2019; Terry, 2008). One of the aspects of the Bologna process is the increased attention for bringing students into real life practical learning situations, something not always fitting within traditional academic

---

\* Corresponding author: [j.c.bazen@saxion.nl](mailto:j.c.bazen@saxion.nl)

Jacob Cornelis Bazen, ORCID: <https://orcid.org/0000-0001-7779-7271>  
Florin Sebastian Duma, ORCID: <https://orcid.org/0000-0002-5026-4894>

frameworks (Bazen & Duma, 2019; Reichert, 2010). The Erasmus+ program offers fantastic opportunities for students from the program countries, as well as from partner countries, to study abroad at a partner university for up to one year in any cycle of study: bachelor's, master's, or PhD. Despite the generosity of the Erasmus+ program, both in terms of financing and variety of participating universities, in the past years, the authors observed a relative stagnation in the number of students studying abroad (Bazen & Duma, 2019). To address this issue, the authors came up with the idea to organize some short-term exchange programs, in the form of one-week intensive learning and practical research on a specific topic in mixed groups of students. The main idea was to take the students out of their comfort zone and to help them break the ice in internationalization activities. Short-term programs present some clear advantages for the participating students: relevant for their CV, a good (first) exposure to a different culture, possibility of learning and working in an intercultural team, receiving ECTS for these activities, not interfering too much with the regular study program and so on. Therefore, already since 2010, we started a cooperation between two Universities, one from Romania and the other from the Netherlands, from opposite corners of Europe and very different cultures, so that the students can truly learn and benefit from the intercultural differences. Another reason for this long-time cooperation between our schools is that, despite distance, there are very strong economic relations between these two countries, explained by the fact that the Netherlands is the biggest investor in the Romanian economy. This proved to be very helpful in easily finding several Dutch businesses in Romania interested in being involved in our project, receiving the students for visits and providing practical assignments in connection with the theoretical part of the program. Over the years, short-term exchange projects were organized, for groups of 10 to 15 students from each university, accompanied by one or two academic staff, with courses, company visits and research work on a practical assignment.

The observation of the authors about stagnating Erasmus+ participation at their universities was seen throughout Europe. Recognizing the gap between the intended direction of European Higher Education and the educational practice, the European Union's Erasmus+ programme has introduced Blended Intensive Programmes (BIPs) as an innovative approach to international education. BIPs aim to foster comprehensive skill development and intercultural competence among students (European Commission, 2025; O'Dowd & Werner, 2024) as well as contributing to the policy of digital transformation within the EU (European Commission: Directorate-General for Education & Culture, 2022). BIPs are short, intensive courses that integrate online learning with a brief period of physical mobility, typically ranging from 5 to 30 days. These programmes are developed collaboratively by at least three higher education institutions from different Erasmus+ programme countries, ensuring a diverse and interdisciplinary learning environment (González-Pavón et al., 2024; O'Dowd & Werner, 2024).

## **2. LITERATURE REVIEW**

### **2.1 The nature of the ERASMUS+ Blended Intensive Program**

BIPs are a type of short term exchange programs, with both a virtual and a physical component. There is some debate as to whether short term physical exchange programs do actually bring the desired benefits to participants in terms of knowledge and skills development, or whether a longer term exchange would be required to improve these skills of the participants.

Whereas Alexander et al. (2022) for example, found no significant differences between shorter and longer term exchange programs, and Gaia (2015) argues that short term student exchange programs can be very effective especially when they are faculty-led programs, most literature however, indicates that longer term exchange programs offer better results (Coker et al., 2018; Dwyer, 2004; Roy et al., 2019), with some scholars even going as far as indicating that short term exchange programs may be not much more than “educational” tourism instead of serious international educational study programs (Coker et al., 2018). At the same time, virtual forms of international collaboration became increasingly popular. In particular, the Corona pandemic in the early 2020s, strongly increased the experience with virtual forms of education, including virtual international cooperation (Bedenlier & Marín, 2020). Ruiz-Molina et al. (2020) argue that virtual mobility can be a useful addition to academic programs and are especially valuable for students without opportunities to travel abroad for whatever reason. Similarly, other authors conclude that virtual mobility can be effective, but usually lead to less impact than physical mobility, although a strong support system from the universities involved can help to improve learning results (Bedenlier & Marín, 2020; Enkhtur et al., 2024; Vriens et al., 2010). The introduction of the BIPs within the framework of the Erasmus+ program was an attempt to use the “best of both worlds” of virtual mobility and short term physical mobility (European Commission, 2025), allowing for projects that offer more than a short period of physical mobility abroad for the participants and at the same time mitigate the usually lower impact of virtual mobility projects, by offering a short physical mobility part that is possible for almost all students to participate in. BIPs combine online activities with face-to-face sessions, encouraging participants to engage in a variety of learning activities, an approach that not only enhances language skills but also fosters a deeper appreciation for cultural diversity and mutual understanding (European Commission: Directorate-General for Education & Culture, 2022). Several studies about effectiveness of short term mobility have been published, but the number of studies into the effectiveness of the Erasmus+ Blended Intensive Projects, the combination of virtual and short term physical mobility, are (still) scarce. One of the obvious reasons for this is that the program is still relatively new and not a lot of time has passed to study the results. On the other hand, it is quite complex to study the effects of participation in such a BIP, as it is difficult to distinguish between the effects of virtual and physical mobility on the participants, let alone the combination of the two. Several attempts have been made so far, to study the effects of BIPs.

## **2.2 Organizational aspects of BIPs**

O'Dowd and Werner (2024) have focused on the organizational part of the programs, and have queried academic coordinators for their experiences. Their conclusion is that BIPs are still in their infancy and that these programs are relatively complex and need a strong collaboration and common understanding between academic and support staff in order to be executed successfully. Similarly, Palmquist et al. (2024) describe the challenges of organizing BIPs as such, as well as the challenge to combine existing teaching methods with the organizational requirements of BIPs. Frampton et al. (2025) however, consider the BIP framework to be an “almost ideal” method for organizing education to let students learn by experimenting. This view is shared by others, stating that BIPs are less rigid and easier to implement than other new (international) education models (Moya-Lopez et al., 2025; Piščíkienė & Ginavičienė, 2023; Šajn et al., 2024).

### **2.3 Student experiences and impact on learning**

Another direction of studies is into student experiences and student learning related to BIP participation. Even though student experiences in BIPs are to a certain extent context specific and not easily transferable to other academic fields, some general findings can be observed. Šajn et al. (2024) observed that students with BIP experience tend to attach slightly greater importance to cross-disciplinary soft skills than students without BIP experience. Other studies observe a development in cross-disciplinary skills themselves (Barana et al., 2024; Duś-Ilnicka et al., 2024; Moya-Lopez et al., 2025; Podlaski et al., 2025), an increasing self-efficacy among participating students in terms of the application of theoretical concepts in practice (Palmquist et al., 2024; Piščikienė & Ginavičienė, 2023), increasing competencies in intercultural collaboration (Frampton et al., 2025; Prada et al., 2025) and a better understanding of relevant theoretical concepts (Laine et al., 2024; Piščikienė & Ginavičienė, 2023) as well as relevant international business ecosystems (Laine et al., 2024). An important benefit of BIPs is that they lower existing barriers for international experience for students, therefore contributing to more inclusive education (Cobelli & Amato, 2024).

### **3. PROJECT DESIGN AND METHODOLOGY**

This study deals with the impact of participation in a Blended Intensive Program on the students involved. It deals with a BIP that was running in three consecutive years, 2023, 2024 and 2025 with involvement of universities in Romania, The Netherlands, Hungary, Denmark and Portugal. This BIP was not the first project collaboration between the partners involved, but instead a continuation of more than 10 years of short-term international Dutch-Romanian exchange projects for students. These projects consisted of a one-week exchange program between the students of the home universities of the authors (Bazen & Duma, 2019; Bazen et al., 2015). As these projects were organized yearly (except for the two Covid-19 pandemic years), the partners had a lot of experience in this type of collaborative projects, so that organizationally there were relatively low barriers to commence working together on BIPs. The existing format of the projects before turning them into BIPs, was as a one-week intensive course and research work, with preparation in advance, together with a business and/or a societal organization. These organizations acted as clients and proposed a specific and practical assignment that the students from both countries had to address during that week and came up with a presentation of their solutions and proposal at the end the project. Such clients were usually Dutch companies with activities in Romania, to make sure that students from both countries would need each other and would feel involvement. Clients included companies and organizations such as: Aegon, E. van Wijk logistics, local societal organizations in Cluj, such as Asociatia Cluj 21-Capitala Culturala Europeana, the Dutch business club or the Ethnographic Museum. The assignments proposed throughout the years were very diverse, ranging from improving urban mobility in Cluj with bicycle lines, revitalization of the Ethnographic open-air museum, courtyard developments in the city center and a comparative analysis of the Dutch and the Romanian pension system. The organizers were therefore well prepared to adopt the BIP framework to expand the effectiveness of the projects. The application for the first BIPs was launched in 2022, and already from the first year of implementation, in May 2023 the first BIP was organized, called Financial Management in the international companies. The first BIP brought together more than 30 students and academic staff from the Netherlands, Hungary and



Romania. In 2024, an even larger BIP was organized, this time with four universities involved: Polytechnic Institute of Leiria, Portugal, University College of Northern Denmark, Saxion University, the Netherlands and Babes-Bolyai University, Romania, with almost 60 participating students and academic staff. In April 2025, the third BIP was organized, with about 40 participating students and staff with the same four partner universities. During these three BIPs, the students had onsite courses during the physical week at the Faculty of European Studies, Babes-Bolyai University in Cluj-Napoca and online courses, as well, during the online period and, in the end, they received 3 ECTS. Besides the courses, in order to combine the theoretical part with some practical applications, the students were involved in several small research projects within international companies based in Romania, such as DN Agrar, SFC Energy or E. van Wijk logistics. These research projects or company assignments were on different topics such as electrical long-haul freight transport for E. van Wijk logistics, production efficiency increase for SFC Energy, increasing efficiency of financial administration and on circular economy at DN Agrar. The students participating in the BIP were from different study programs, to achieve as much as possible multi-disciplinary learning.

The main research topic for this paper is to measure the influence these three Blended Intensive Programs had on developing international competences and skills in the participating students. To measure this, the students were given two sets of questionnaires, one before the project started and one after the project ended, a “pre-test” and a “post-test.” The pre-test consisted of 24 questions, while the post-test had 28, in both cases, a combination of open-ended and closed-ended questions. The questions in both tests were almost similar, just that in the post-test, some questions were changed from the future to the past tense. Some extra open-ended questions for specific feedback and improvement suggestions were added. In the pretest, the focus was mostly on students' expectations related to the program, while in the post-test, more on what the students learned and achieved. By comparing the results of both tests, the perceived personal development of the students after participating in one of the blended intensive programs could be identified. The first questions were about some basic identification information and if they have already participated in an Erasmus+ student exchange semester, and/or in an internship abroad or if they have any international work experience. Then a few questions about how familiar they are with Romania and the city of Cluj-Napoca, where the host university is located. We continued with the main questions, asking the students about their perceived skills, like the ability to work in international projects, desire to have an international career, confidence in working together with people from different cultures, creativity, desire to open their own business, openness for new experiences, desire for working together with students from different disciplines etc. We asked them to grade their answers on a scale from 1 to 5. The last questions were about their expectations and learning outcomes from the program in the case of the pretest, while for the post-test were related to results, feedback and improvement suggestions.

#### **4. FINDINGS**

The questionnaire with pretest and post-test was sent out to all participants over the three years of the BIP projects, in total to 130 participants. The total response for the pre- and post-tests was 93, meaning a response percentage of 72%. Individual questions could have lower response percentages, as some questions were left blank by the respondents. In cases where this happened, it is mentioned specifically.

In terms of participation in all the BIPs together, there were more male than female participants, 34 females and 59 males. This gender disbalance is caused by the fact that most students were from technical studies, such as Industrial Engineering & Management or Mechanical Engineering. The participation rate among males/females within the BIP is not significantly different compared to the general population of students from the originating study programs. In terms of the participating nationalities, Table 1 shows the nationalities/citizenships of the participants.

*Table 1: Citizenship of the BIP Participants*

Country	Frequency	Percentage
Danish	17	18.3
Dutch	28	30.1
Hungarian	8	8.6
Portuguese	18	19.4
Romanian	22	23.7
Total	93	100.0

The BIPs were open for both undergraduate/bachelor and graduate/master students. Of all 93 respondents, 78 (83%) studied at bachelor level and 15 (17%) on master level. Table 2 shows the previous international experience of the respondents, of which none is statistically significantly different for study level or citizenship. In other words, the group of participants appears to be homogeneous in terms of previous international experience when controlling for citizenship or study level. The percentage of respondents with previous Erasmus+ mobility participation is almost three times as high as the average percentage of 9% Erasmus+ mobility participation for all students in the EU (European Commission, 2024).

*Table 2: Previous international experience of the participants*

Type of international experience	Yes	No	Percentage Yes
Has worked abroad or done an internship abroad before	27	66	29.0
Has participated in an Erasmus+ mobility semester for study/internship before	24	69	25.8

Table 3 shows an overview of the reported proficiency level in English of the participants. The self-assessment of the students indicates, just like with the previous Erasmus+ participation, that the group of participants might have a participation bias, as the reported levels of proficiency in English are higher than those of the average student population.

*Table 3: Self-assessment of level of proficiency in English*

Level of proficiency	Frequency	Percentage
Beginner	3	3.2
Intermediate	24	25.8
Advanced	36	38.7
Proficient	24	25.8
(Near) native speaker	6	6.5
Total	93	100.0

Given these personal characteristics of the participants, taking into account that they already have on average more professional international experience and language proficiency than the average student population, there may be a participation bias among the participants of these three BIP programmes, in the sense that they have attracted more students who are quite internationally oriented in the first place.

To measure the effectiveness of the educational intervention, in terms of development of skills and attitude towards intercultural and ambiguous situations, a pre- and post-test was filled in by the participants. First of all, both before and after the BIP, participants were asked to fill in a self-evaluation of their level of English proficiency. An independent samples t-test was conducted to compare differences between the reported level of proficiency in English before and after the test. As the pre and post-tests were separate questionnaires and both were anonymous, it was not possible to integrate them into paired samples. There was no significant difference in reported level of English proficiency before and after BIP participation,  $t = -.664$ ,  $p$  (two-tailed) = .507 (indicating a statistical non-significant difference), Cohen's  $d = -.112$  (indicating a very weak effect). This t-test indicates that the post-test participants reported on average a slightly higher level of English proficiency, but that these differences are statistically not significant.

The goal of a BIP is to develop intercultural competences among the participants. To test this, questions on personality, future career and intercultural skills were asked in both the pre and post-tests. Participants ranked their answers on a scale from 1 to 5 with 1 being strongly disagree and 5 being strongly agree. An independent sample t-test was conducted for all the different questions in the survey. Although some differences in the results can be observed, none of the differences between pre- and post-tests are statistically significant. Table 4 shows the details of the t-test for each variable.

*Table 4: Results independent t-test on scores of pre-test and post-test (n=93)*

Statement	Mean Pre-test	Mean Post-test	t-score	Significance $p$ (two-sided)
I have enough skills to work on international projects	3.84	4.04	-1.443	.151
I would like to have an international career	3.88	3.89	-.091	.928
I feel confident in working with people from other cultures	4.02	4.15	-.922	.358
I like to work on projects with open, unknown outcomes	3.49	3.67	-1.084	.280
I consider myself to be creative	3.53	3.51	.122	.903
I would like to have my own business	3.51	3.28	1.051	.295
I consider myself to be open-minded (n=92)	4.32	4.29	.182	.856
I am always looking for new and exciting experiences (n=92)	4.23	4.13	.738	.461
Stability is important for me	3.68	3.84	-.962	.338

To illustrate the differences between pre-test and post-test, the scores are visualized in Figure 1 to 3, with Figure 1 being both scores on personality statements, Figure 2 being the scores on intercultural skills and Figure 3 being the scores on future career ideas. Even though none of the changes is statistically significant in this study, it nonetheless shows some interesting potential directions that are worth exploring further in future studies. Since the

number of respondents of these three BIPs is limited, a larger number of respondents would potentially show more easily whether these changes would be significant or not.



Figure 1: Personality scores and development during BIP participation

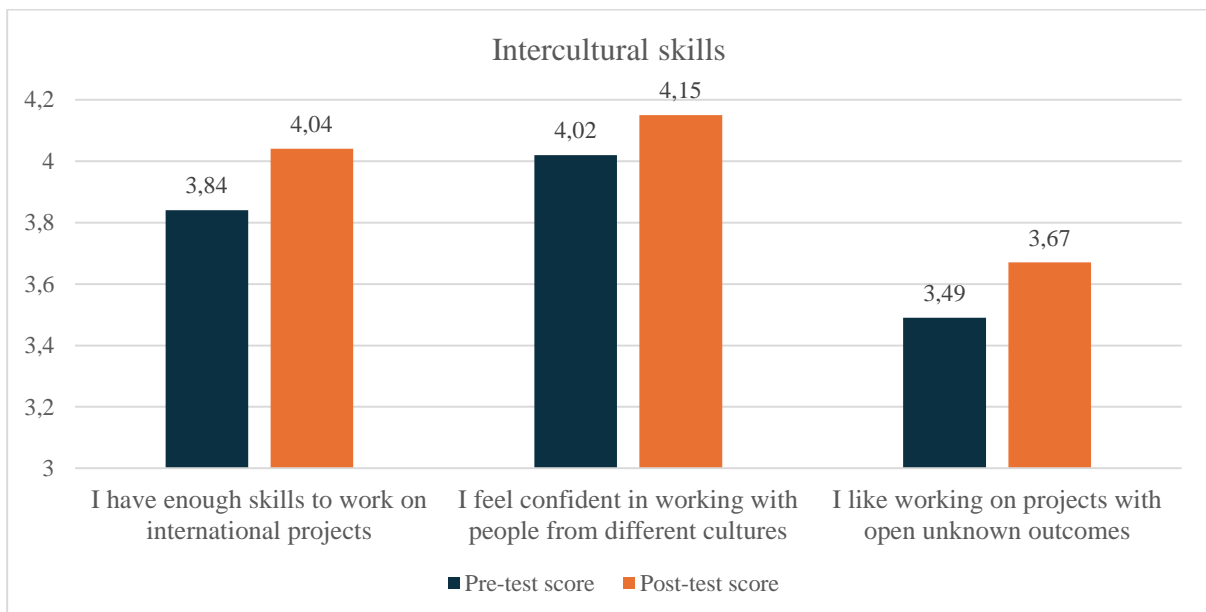


Figure 2: Intercultural skills scores and development during BIP participation

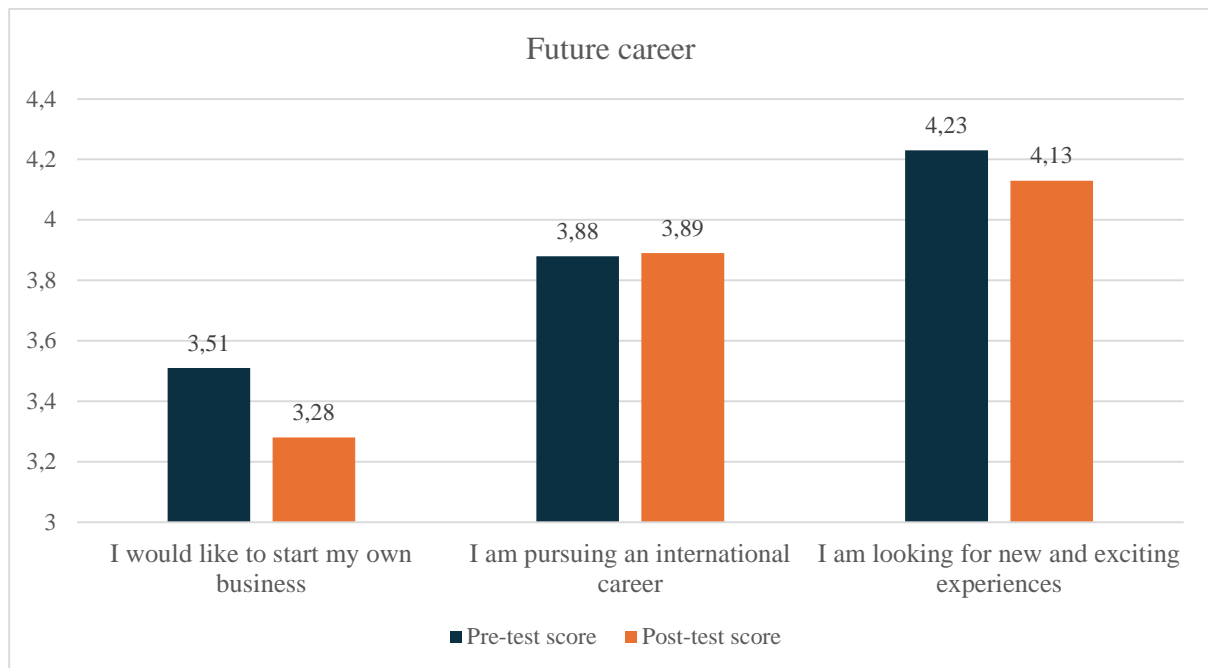


Figure 3: Future career scores and development during BIP participation

Interesting differences on the pre-test and post-test scores can be seen on the intercultural communication skills, which all show an upward direction, and for personality scores it appears as if students perceive stability more on the expense of creativity and open-mindedness after participation. Still, more research is needed to establish whether these relationships are statistically significant or not. In terms of future career, the students appear to be less interested in starting their own business and looking for new and exciting experiences, even though this score remains very high, with an average of more than 4 on a scale of 5.

Given the relatively small number of respondents/BIP participants, it is useful to have some more qualitative data next to the more quantitative data, as discussed before. Participants were asked about what they consider to be the most valuable learning experience in the BIP and what they think could be improved to make participation in such a BIP (even) more worthwhile. Table 5 shows a clustering of subjects mentioned by the participants as their most important learning results from participation in the BIP. By far most respondents mention that they have learned to work better with people from abroad, understood better the different ways that people from different countries work and become more effective in bridging these differences (41 mentions). The second most mentioned aspect was about learning new content, in terms of theoretical knowledge, for example on financial analysis, new previously unknown brainstorming techniques or conditions for investment (15 mentions), the third most mentioned learning was about getting to know more practical knowledge of international businesses work (12 mentions), and the fourth most mentioned learning was about becoming better in teamwork (9 mentions). Indeed, as expected from previous literature on the subject of BIPs and short term mobility, also in these BIPs, the reported learning from the participants focuses on practicing intercultural communication and having apparently the feeling of becoming more skillful and knowledgeable in handling cultural differences and still being able to deliver a meaningful team product.

*Table 5: Most important learning results from participation in the BIP (n=78)*

Learning results	Mentioned by # of respondents*
Learning to work better with people from abroad	41
Learned previously unknown methods/content	15
Practical knowledge of international business	12
Becoming better in teamwork	9
Becoming more open-minded personally	8
Project management general	7
Becoming more organized	4
Language improvement	4
Knowing more about Romania	2
Motivating others	1
Overcoming fear of public speaking	1
Not much	1

\*some respondents mentioned more than 1 “most important” thing that they learned

There were also several issues that participants would like to see improved in future versions of BIPs, some of the improvement suggestions were specifically aimed at the individual BIP in which they participated, some have a more general overarching meaning for different BIPs and could even be useful for policy makers. The suggestions for improvement are listed in Table 6.

*Table 6: Most important points for improvement of the BIP (n=73)*

Improvement categories	Mentioned by # of respondents*
Better structure/schedule/planning of the physical mobility	37
More (time for) socio-cultural (i.e. not assignment related) activities	10
Communication problems in general	8
Time issues, too little time for group work, physical mobility too short	7
Communication problems during groupwork within and between groups	6
Motivation improvement of group members	4
Bureaucratic hassle to apply for the BIP grant	3
Feeling sort of lost at the host university/lack of support local host	3
No relevant points for improvement	2
Quality of participating lecturers in general	2
Insufficient intercultural competences of some of the lecturers involved	1
Better preparation of the practical tasks during the virtual mobility	1

\*some respondents mentioned more than 1 important thing that they would like to see improved

Around half of the respondents (37 mentions) indicated that they considered that more structure or better planning was needed to let them experience the physical mobility period better. This is an interesting finding, especially since it strongly connects with intercultural skills in planning and doing international/intercultural projects. When people from different cultures communicate, ambiguity in communication (e.g. high context communication) may be easily interpreted as an unclear message in general or a lack of planning & control. Other frequently mentioned points were about too few socio-cultural activities (e.g. museum visits & sightseeing activities), either organized or with time-slots for own initiatives (10 mentions). Communication problems in terms of language differences or miscommunication (8 mentions) came in third and that the physical mobility was too short in general (7 mentions) was fourth.

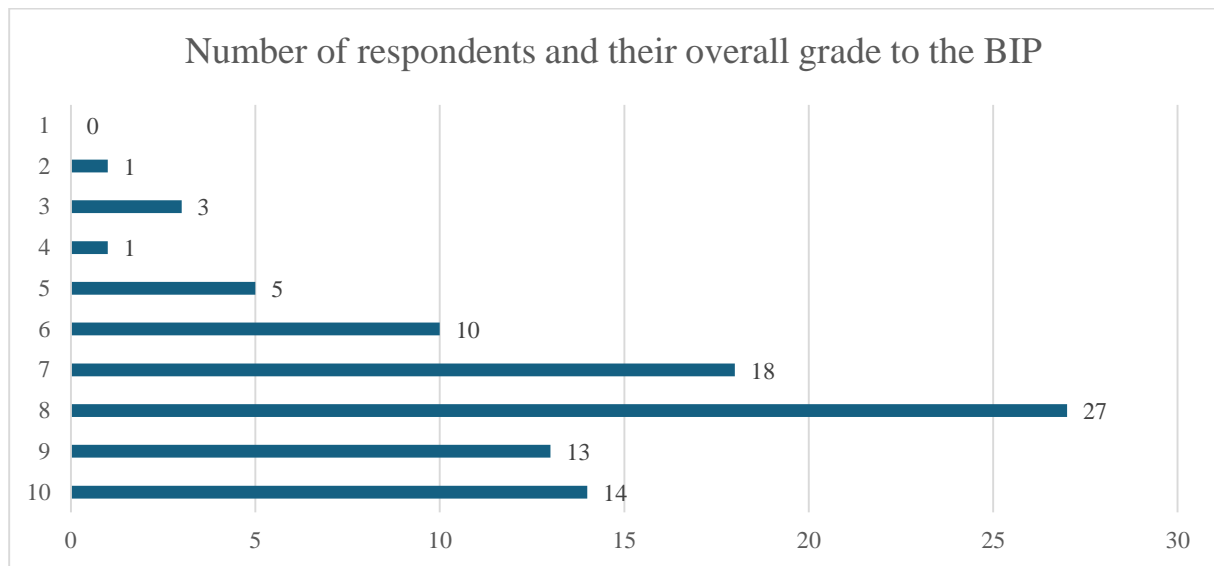


Figure 4: BIP Satisfaction, overall grade of the BIP (1 to 10)

Finally, the question was asked that overlooking everything (i.e. what they learned, what they enjoyed and what could be improved), which grade the participants would give to the BIP, ranging from 1 to 10, where 1 would be extremely bad and 10 would be an outstanding life-changing experience. Figure 4 shows a visual overview of all respondents that gave a certain grade for participation in the program. The range of grades is large: 14 respondents gave the program an outstanding grade, and one respondent graded the program with a very poor grade. The average grade for the BIP is 7.6, with no statistically significant difference between the different BIP editions.

## 5. DISCUSSION

The effects of participation in the BIP, as measured in between the pre-test and post-test, have not been shown to be significant. This however could change when a larger number of respondents is interviewed, so that sample-size related uncertainty will be lower. The direction of the development of the perceived attitudes and skills of the participants is interesting. Their scores on intercultural skills are apparently all improving, whereas their attitude towards an international career and especially towards entrepreneurship, seems to be decreasing. It is unclear what causes these decreases and that would be a good subject for further, qualitative research.

One of the other directions for further research would be to focus also on the longer term impact of participation in a BIP, and compare the results with a control group which did not participate in such a BIP. From the available BIP literature, the picture arises that long term impact studies are very scarce. Furthermore, even though BIPs have the aim to lower the barriers for mobility participation, it is still questionable whether this aim has been reached. The results of this study show that there is still a likely participation bias. Erasmus+ mobility experience and international work/internship experience are clearly higher than among the general student population. One of the areas of study could be why students, given the generous funding opportunities, still experience barriers to participate in such a program.

## 6. CONCLUSION

Blended Intensive Programmes (BIPs) under Erasmus+ represent a promising innovation in international higher education, combining the flexibility of online learning with the immersive benefits of short-term physical mobility. This study investigated three BIPs conducted between 2023 and 2025, focusing on their impact on students' intercultural skills, international competence, and personal development.

Quantitative analysis using pre- and post-program surveys revealed no statistically significant changes across most measured variables. However, there were modest trends suggesting improved self-perception in intercultural communication and teamwork abilities. The lack of statistically significant outcomes may be due to the small sample size, the brief physical mobility period, or the fact that many participants already had above-average international experience and language proficiency—a possible indication of participation bias. Despite the limited statistical findings, qualitative feedback strongly supports the educational value of BIPs. Students highlighted key learning outcomes such as improved collaboration across cultures, exposure to practical business contexts, and the application of theory in real-world settings. Challenges included logistical planning issues, limited socio-cultural engagement, and time constraints during the physical mobility phase.

Overall, while more robust, large-scale, and longitudinal research is needed to determine long-term impacts, this study affirms that BIPs offer valuable experiential learning opportunities. They may not dramatically shift student competencies in the short term but do contribute meaningfully to international exposure and soft skill development. Addressing logistical issues and broadening access to students less likely to seek international experiences could enhance their impact further. BIPs should continue to evolve as inclusive, interdisciplinary tools within the broader landscape of European higher education.

## 7. REFERENCES

- Alexander, K. C., Ingersoll, L. T., Shields, C. G., Miller, M. L., Gipson, J. A., Calahan, C. A., DeMaria, A. L., & Alexander, S. C. (2022). Cultural Intelligence and Short-Term Study Abroad Length: The Effect of an Undergraduate Cultural Development Course and Short-Term Study Abroad Program on Student CQ. *Frontiers: The Interdisciplinary Journal of Study Abroad*, 34(2), 280-301. DOI: 10.36366/frontiers.v34i2.567
- Barana, A., Cambria, A., Conte, M. M., & Spinello, E. (2024). Unpacking the Three Spheres of Interest in a Blended Intensive Programme: Collaborative Learning, Blended Learning and Internationalisation. *International Association for Development of the Information Society*.
- Bazen, J. C., & Duma, F. S. (2019). Role of international educational projects in supporting european integration in the context of romania. *Online Journal Modelling the New Europe*(30), 65-77, DOI: 10.24193/OJMNE.2019.30.04
- Bazen, J. C., Duma, F. S., & Stamate, D. (2015). *International project education of the future? Measuring effectiveness of short-term international exchange projects* Mokslo taikomieji tyrimai Kauno kolegijoje, Kaunas. Lithuania.
- Bedenlier, S., & Marin, V. I. (2020). Engaging students through virtual mobility, in *Digital experiences of international students: Challenging assumptions and rethinking engagement*, p.85
- Cobelli, M., & Amato, R. (2024). Fostering global learning through Erasmus+ Blended Intensive Programmes. In *ISYDE 2024*, <https://hdl.handle.net/11571/1509435>



- Coker, J. S., Heiser, E., & Taylor, L. (2018). Student Outcomes Associated with Short-term and Semester Study Abroad Programs. *Frontiers: The Interdisciplinary Journal of Study Abroad*, 30(2), 92-105. <https://doi.org/10.36366/frontiers.v30i2.414>
- Duś-Ilnicka, I., Paradowska-Stolarz, A., Mazur, M., Radwan-Oczko, M., Perra, A., Paula, V. S. d., Ward, L. S., Valente, N. A., Firkova, E., & Karteva, T. (2024). Blended intensive programme's implementation in dental education: post-pandemic evolution of learning. *BMC Medical Education*, 24(1), 352, <https://doi.org/10.1186/s12909-024-05301-9>
- Dwyer, M. M. (2004). More is better: The impact of study abroad program duration. *Frontiers: The Interdisciplinary Journal of Study Abroad*, 10, 151-163, <https://doi.org/10.36366/frontiers.v10i1.139>
- Enkhtur, A., Zhang, X., Li, M., & Chen, L. (2024). Exploring an Effective International Higher Education Partnership Model Through Virtual Student Mobility Programs: A Case Study. *ECNU Review of Education*, 7(4), 971-990. <https://doi.org/10.1177/20965311241232691>
- European Commission. (2024). *Education and Training Monitor 2024*. <https://op.europa.eu/webpub/eac/education-and-training-monitor/en/monitor-toolbox/themes/higher-education.html>
- European Commission. (2025). *Erasmus+ Programme Guide*. <https://erasmus-plus.ec.europa.eu/erasmus-programme-guide>
- European Commission: Directorate-General for Education, Y. S., & Culture. (2022). *Blended mobility implementation guide for Erasmus+ higher education mobility KA131*. Publications Office of the European Union. <https://doi.org/doi/10.2766/467485>
- Frampton, M., Schiller, U., Parker, J., Hartogh, T., Arlinghaus, G. A., Fry, A. D., Autio, K., & Ndhlovu, G. N. (2025). Using the arts in social work education for short-term European mobility: evaluating student experiences on an Erasmus+ blended intensive program. *Social Work Education*, 1-17, <https://doi.org/10.1080/02615479.2025.2466707>
- Gaia, A. C. (2015). Short-term faculty-led study abroad programs enhance cultural exchange and self-awareness. *International Education Journal: Comparative Perspectives*, 14(1), 21-31.
- González-Pavón, C., Tarrazó-Serrano, D., Rubio, C., Seres, I., Víg, P., & Gasque, M. (2024). Bridging Learning and International Practice for Enhancing Physics Education. *European Journal of Education and Pedagogy*, 5(4), 79-83. <https://doi.org/10.24018/ejedu.2024.5.4.865>
- Laine, I., Pirrone, G., Phan, K. H. Q., Milotta, M., Väättänen, J., & Hagen, B. (2024). Integrating real-world entrepreneurship with international learning: insights from a blended intensive programme. *Journal of International Education in Business*(ahead-of-print). doi:10.1108/JIEB-08-2024-0112
- Moya-Lopez, C., Alonso-Moreno, C., Posadas, I., Carrión, M. P., Bravo, I., de Andrés Segura, F., Santos, R. F., Martínez, J. G., & Tomás, J. S. (2025). Drug discovery and development (D3): A blended intensive program to engage students in the drug discovery process while promoting international collaboration, INTED2025 Proceedings, doi: [10.21125/inted.2025.1174](https://doi.org/10.21125/inted.2025.1174)
- O'Dowd, R., & Werner, S. (2024). The first steps of blended mobility in European higher education: a survey of blended intensive programmes. *Journal of Studies in International Education*, 28(5), 798-817, <https://doi.org/10.1177/10283153241235704>
- Palmquist, A., Alves, J., Baranyi, R., Munkvold, R., Carvalho, V., & Oliveira, E. (2024). Blended Realities-Higher Education Student Reflections on Acquiring Skills for Game Creation in a Project-Based-and Blended Learning Environment. *ACM Games: Research and Practice*, 3(1), 2-26. <https://doi.org/10.1145/3704414>

- Piščikienė, I., & Ginavičienė, J. (2023). Blended intensive programme - a new way to implement students' skills, *ICERI2023 Proceedings* (pp. 5801-5805). IATED, doi: [10.21125/iceri.2023.1441](https://doi.org/10.21125/iceri.2023.1441)
- Podlaski, K., Beczkowski, M., Simbeck, K., Dziergwa, K., O'Reilly, D., Dowdall, S., Monteiro, J., Lucas, C. O., Hautamaki, J., & Ahonen, H. (2025). Software development projects as a way for multidisciplinary soft and future skills education. *arXiv*, <https://doi.org/10.48550/arXiv.2502.21114>
- Prada, E., Mareque, M., Dias de Carvalho, A., & Pino-Juste, M. (2025). A Blended intensive programme behind the scenes: Organisational and methodological effectiveness. *International Journal of Instruction*, 18(3), 659-682.
- Reichert, S. (2010). The intended and unintended effects of the Bologna reforms. *Higher Education Management and Policy*, 22(1), 99-118. <https://doi.org/10.6017/ihe.2009.57.8459>
- Roy, A., Alexander, N., Tori, E., & Pyman, A. (2019). Outcomes of international student mobility programs: a systematic review and agenda for future research. *Studies in Higher Education*, 44(9), 1630-1644. <https://doi.org/10.1080/03075079.2018.1458222>
- Ruiz-Molina, M. E., Moise, M. S., Marín-García, A., & Gil-Saura, I. (2020). Virtual mobility: sharing higher education knowledge internationally, *INTED2020 Proceedings* (pp. 4144-4151). IATED, doi: [10.21125/inted.2020.1148](https://doi.org/10.21125/inted.2020.1148)
- Šajn, M., Kutnjak, A., & Hrustek, L. (2024). Enhancing student skills - the role of project-based learning in blended intensive programs and higher education courses, . *EDULEARN24 Proceedings*, doi: [10.21125/edulearn.2024.0867](https://doi.org/10.21125/edulearn.2024.0867)
- Terry, L. S. (2008). The Bologna process and its impact in Europe: it's so much more than degree changes, *Vanderbilt Journal of Transnational Law* 41, 107.
- Vriens, M., Van Petegem, W., de Beeck, I. O., & Achten, M. (2010). Virtual mobility as an alternative or complement to physical mobility. In *EDULEARN10 Proceedings* (pp. 6695-6702). IATED.



## IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN PROJECT-ORIENTED ORGANIZATIONS: A COMPARATIVE ANALYSIS OF SERBIA AND THE REGION

Jelena Ružić<sup>1\*</sup>, Sanela Golubović Corcione<sup>2</sup>, Ivan Jovanović<sup>3</sup>

<sup>1</sup>University Educons, Faculty of Project and innovation management Prof. dr Petar Jovanović, Belgrade, <sup>2</sup>University Business Academy in Novi Sad, Faculty of Contemporary Arts, Belgrade, <sup>3</sup>University of Belgrade, Technical Faculty in Bor, Serbia

**Abstract:** The paper analyzes the implementation of artificial intelligence (AI) in project-oriented organizations through a comparative study of Serbia and the region. It focuses on the impact of AI on improving efficiency, innovation, and decision-making quality, as well as the role of knowledge management and continuous learning in the digital transformation process. Using theoretical frameworks, empirical data, and case studies, the paper identifies key advantages and challenges of AI adoption in Serbia, which lags behind more developed regional countries like Slovenia and Croatia in terms of digitalization and integration of advanced technologies. Concrete examples of successful AI applications in various sectors (energy, construction, creative industries, finance) are presented, along with obstacles such as a lack of skilled personnel, limited resources, and organizational inertia. Based on the comparative analysis, the paper provides recommendations for enhancing the digital transformation of project-oriented organizations in Serbia, confirming the hypothesis that the integration of AI and knowledge management significantly contributes to increased efficiency, innovation, and competitiveness.

**Keywords:** artificial intelligence, project-oriented organizations, knowledge management, digitalization, efficiency

### 1. INTRODUCTION

In today's business environment, project-oriented organizations face increasingly complex challenges resulting from rapid technological advancement, intensified competition, and constant shifts in market demands. Globalization and digitalization have significantly

---

\* Corresponding author: [jruzic45@gmail.com](mailto:jruzic45@gmail.com)

Jelena Ružić, ORCID: 0009-0000-4715-2288

Sanela Golubović Corcione, ORCID: 0009-0003-1765-1002

Ivan Jovanović, ORCID: 0000-0002-3713-5203

impacted how organizations plan, implement, and monitor projects, rendering traditional management models insufficient for achieving optimal outcomes. In this context, artificial intelligence (AI) emerges as a key instrument for transforming business processes, enabling organizations to enhance efficiency, accuracy, and innovation in project execution (Davenport & Prusak, 1998; Smith & Johnson, 2021).

AI, through the automation of routine tasks, advanced analytics, and the ability to recognize patterns in large datasets, enables managers and teams to make more informed decisions, optimize resources, and proactively identify potential risks. These benefits are particularly evident in project-oriented organizations, where the ability to quickly adapt and learn from past experiences is essential for successful project realization (Nonaka & Takeuchi, 1995). The integration of AI into daily business processes not only boosts productivity but also facilitates the development of new business models based on continuous learning and innovation (Brown & Duguid, 2000).

Furthermore, the concept of knowledge management (KM) is becoming increasingly important for organizations striving to build sustainable competitive advantages. Knowledge management involves the systematic collection, organization, and sharing of information within an organization, which promotes organizational learning and innovation. AI significantly enhances these processes by enabling automatic knowledge analysis and distribution, identifying best practices, and supporting personalized employee learning (Davenport & Prusak, 1998). In a rapidly changing environment, the ability of an organization to efficiently manage knowledge and leverage AI to improve its processes becomes crucial for long-term success.

Despite global trends, the degree of AI implementation in project-oriented organizations varies significantly across countries and sectors. In Serbia, although there are individual cases of successful AI application, the overall level of digitalization and advanced technology integration lags behind more developed regional markets. This disparity highlights the need for a detailed analysis of factors influencing AI adoption, as well as the identification of obstacles and opportunities for improvement. A comparative observation of Serbia and neighboring countries, such as Slovenia and Croatia, can provide valuable insights into best practices and strategies that lead to successful digital transformation of project-oriented organizations.

Therefore, this paper aims to provide a comprehensive analysis of the implementation of artificial intelligence in project-oriented organizations, with a particular focus on the role of knowledge management and continuous learning. Through a comparative analysis of Serbia and neighboring countries, the paper will identify key advantages, challenges, and recommendations for improving digital transformation in this sector. Starting from the hypothesis that the integration of AI and knowledge management significantly contributes to increased efficiency, innovation, and competitiveness, the paper will use theoretical frameworks, empirical data, and case studies to provide relevant conclusions and practical guidelines.

## **2. LITERATURE REVIEW**

### **2.1. Artificial Intelligence in Contemporary Project Management**

Artificial intelligence (AI), as a set of technologies enabling machines to imitate human intelligence through processes of learning, reasoning, and self-improvement, has recently become one of the most important drivers of business transformation (Russell & Norvig, 2021). In the field of project management, AI is used to enhance project planning, monitoring, and execution, as well as to optimize resources and manage risks (Smith & Johnson, 2021). The

automation of routine and repetitive tasks—such as report generation, data analysis, and progress tracking—frees project managers to focus on strategic activities and decision-making based on relevant information (Kerzner, 2017).

One of the key contributions of AI in project management is its capacity for predictive analytics. By using machine learning algorithms, organizations can more accurately anticipate potential problems, identify risk patterns, and optimize workflows. For instance, tools like Microsoft Copilot enable automatic processing of vast amounts of project data, generate optimization suggestions, and provide timely alerts about possible delays or budget overruns (Microsoft, 2023). Such solutions significantly enhance transparency and agility in project execution, which is especially important in dynamic and uncertain environments (Turner, 2009).

## **2.2. Knowledge Management as a Foundation for Innovation and Continuous Learning**

Knowledge management (KM) involves the systematic collection, organization, sharing, and application of knowledge within an organization, with the aim of improving organizational efficiency and innovation (Davenport & Prusak, 1998). In project-oriented organizations, where knowledge is often created and lost through completed projects, KM is essential for preserving and transferring valuable experiences and best practices (Nonaka & Takeuchi, 1995).

AI further enhances KM through automated information analysis and classification, pattern recognition, and personalized learning processes. AI-based systems can automatically identify relevant knowledge from previous projects, propose optimal solutions, and create personalized development plans for employees (Brown & Duguid, 2000). In this way, AI enables continuous learning at both the individual and organizational level, fostering innovation and adaptability (Alavi & Leidner, 2001).

Of particular importance is the concept of organizational learning, which refers to an organization's ability to transform experiences and information into new competencies and competitive advantages. AI supports this process through the development of adaptive learning systems that adjust to user needs and enable faster acquisition of new knowledge (Argote, 2013). In the context of project-oriented organizations, this means faster responses to environmental changes, more effective problem-solving, and reduced risk of repeating past mistakes (Senge, 2006).

## **2.3. Digital Transformation and the Specificities of Project-Oriented Organizations**

Digital transformation refers to the integration of digital technologies into all aspects of business, fundamentally changing how organizations operate and deliver value to customers (Westerman et al., 2014). Project-oriented organizations are particularly suited for digital transformation, as their operations are based on the execution of clearly defined goals through time-limited projects, which facilitates the implementation of new technologies and processes (Kerzner, 2017).

The implementation of AI in such organizations brings numerous benefits:

- Increased productivity through automation and process optimization (Smith & Johnson, 2021).
- More precise resource management thanks to advanced analytics and predictive models (Microsoft, 2023).

- Faster and higher-quality decision-making through real-time access to relevant information (Turner, 2009).
- Encouragement of innovation through effective knowledge management and continuous learning (Alavi & Leidner, 2001).

However, successful digital transformation also requires changes in organizational culture, development of employees' digital competencies, and strong management support (Westerman et al., 2014). In Serbia and the region, the challenges include a lack of qualified personnel, limited financial resources, and uneven digital literacy, which slow down digitalization processes and the integration of AI into project-oriented organizations (ICT Hub, 2025).

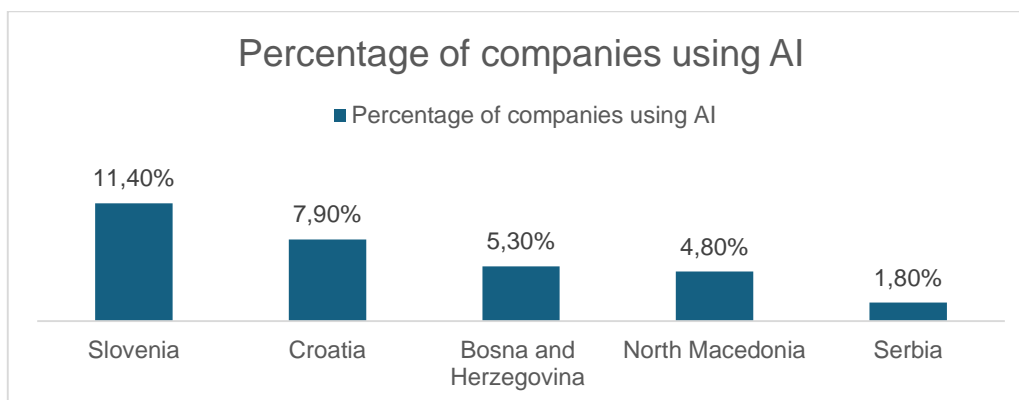
### 3. DATA AND METHODOLOGY

The level of AI implementation and digital transformation varies across countries, sectors, and organization sizes. In more developed countries of the region, such as Slovenia and Croatia, digital transformation is driven by national strategies, investments in education, and stronger cooperation between academia and industry (Bloomberg Adria, 2024). In Serbia, although there are isolated examples of successful AI adoption, the overall level of digitalization lags behind the regional average, indicating a need for a strategic approach and increased investment (ICT Hub, 2025).

Comparative analysis enables the identification of best practices, barriers, and success factors, which can contribute to faster and more efficient digital transformation of project-oriented organizations in Serbia. Understanding the regional context and experiences of other countries is essential for the development of sustainable strategies and policies that will fully realize the potential of artificial intelligence and knowledge management.

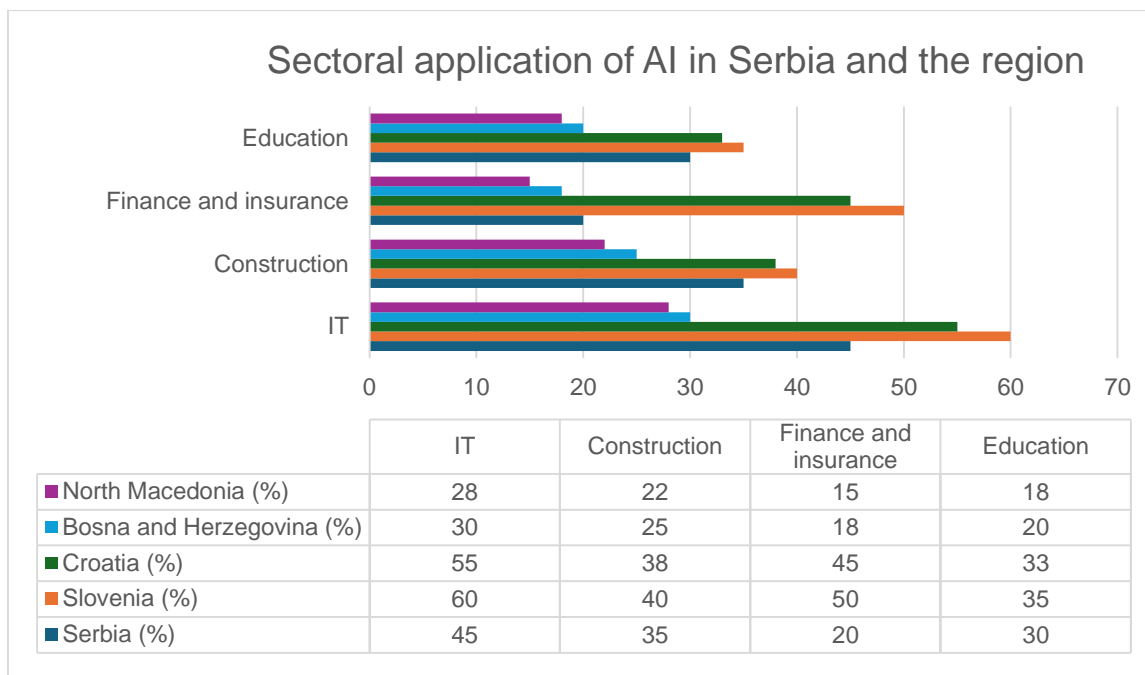
#### 3.1. Comparative Analysis of AI Implementation in Serbia and the Region

In recent years, Serbia has significantly improved its position in the field of artificial intelligence by adopting national AI development strategies for the periods 2020–2025 and 2025–2030 (Ministry of Science, 2025; Nitra.gov.rs, 2025). These strategies define goals related to economic growth, the development of scientific personnel, and the ethical use of AI, aligned with European initiatives. However, despite institutional efforts, Serbia ranks at the bottom of the region in terms of the percentage of companies using AI in their operations—only 1.8%, compared to Slovenia with 11.4%, Croatia with 7.9%, Bosnia and Herzegovina with 5.3%, and North Macedonia with 4.8% (Bloomberg Adria, 2025).



Graph 1. Degree of adoption of AI in companies by country (Bloomberg Adria, 2025)

Sectoral analysis shows that IT and construction are the leading sectors in Serbia in terms of AI adoption, with 45% and 35% of companies using these technologies, respectively. In comparison with the region, Slovenia and Croatia demonstrate broader and deeper AI penetration in the financial and insurance sectors, where AI adoption has reached 50% and 45% of companies, while in Serbia that percentage is only around 20% (Chambers and Partners, 2024; Badža, 2024; Bloomberg Adria, 2025). The education sector, although still developing, shows a growing trend of AI implementation across all countries in the region, which is particularly important for the future development of human capacities.



*Chart 2. Sectoral implementation of AI in Serbia and the region (Blomberg Adria 2025)*

### 3.2. Examples of Artificial Intelligence Integration in Serbia and the Region

#### 3.2.1. Examples from Serbia

##### 1. Microsoft Development Center Belgrade – Project for EPS

In collaboration with Elektroprivreda Srbije (EPS), Microsoft developed an AI-based system for electricity consumption prediction, leading to savings of approximately €600,000 annually (Government of Serbia, 2022). The system uses advanced algorithms to analyze historical data and forecast consumption, enabling better planning and reduced losses.

##### 2. Construction Company "ABC Gradnja"

The company implemented an AI tool to monitor project progress and optimize scheduling, resulting in a 20% reduction in project duration and improved cost control (Jovanović et al., 2023). The system automatically generates reports and alerts for potential delays.

##### 3. AI4SME Project

Focused on the application of artificial intelligence in small and medium-sized enterprises (SMEs) in Serbia, this project enables SMEs to access AI technologies that enhance operations, improve efficiency, and increase competitiveness. The



project fosters innovation and digital transformation in the domestic economy (ICT Hub, 2024; AI Ecosystem Serbia).

4. **Institute for Artificial Intelligence Research and Development of Serbia (IVI)**  
This institute develops AI technologies for various industries, including process automation in manufacturing, data analysis, and the development of collaborative robots. One notable project is AI-WELD, aimed at automating welding processes (IVI, 2025).
5. **National AI Platform** A platform providing resources and tools for developing AI projects in Serbia, enabling researchers and companies to test and apply AI solutions in areas such as healthcare, agriculture, and energy (ICT Hub, 2024).

### 3.2.2. Examples from the Region

1. **Nordeus (Serbia, with regional presence)**  
Although a Serbian company, Nordeus applies AI in the development and optimization of its video games. It uses AI to analyze the behavior of millions of players and optimize game mechanics, enabling personalized experiences and increased user engagement. This approach has significantly contributed to the company's market success both regionally and globally, highlighting AI's role in creative industries (ICT Hub, 2024).
2. **Spar (Slovenia) – AI-Generated Advertising Campaign**  
Spar Slovenia launched an advertising campaign in which the video content was entirely created using AI tools. This innovation represents the first such project in the retail sector in the region and demonstrates how AI can enhance creative processes and reduce production costs (InStore.hr, 2024).
3. **Visa Global Product Drop – AI in Commerce in Croatia and Slovenia**  
At the "Visa Global Product Drop" event, projects were showcased that use AI to enhance commerce and customer experience in Croatia and Slovenia. By applying AI tools for data analysis and offer personalization, these companies have increased efficiency and customer engagement (Bloomberg Adria, 2024).
4. **Bloomteq (Bosnia and Herzegovina) – AI for Banking and Insurance**  
Bloomteq develops AI solutions for the banking and insurance sectors in Bosnia and Herzegovina, focusing on automating customer support, risk analysis, and fraud detection. These solutions help companies increase efficiency and reduce operational costs (Bloomberg Adria, 2025).
5. **North Macedonia – Development of AI Tools for EU Regulatory Compliance**  
North Macedonia is actively developing AI solutions to support compliance with European Union regulations, particularly in the fields of data protection and digital security. These tools are intended for both public and private sectors, representing a significant step toward the country's digital transformation (Bloomberg Adria, 2025).
6. **Zavarovalnica Triglav (Slovenia) – AI for Fraud Detection and Customer Support**  
Zavarovalnica Triglav uses AI chatbots to automate customer support and advanced AI tools to detect insurance fraud attempts. This has led to significantly reduced response times and improved efficiency in client interactions (Bloomberg Adria, 2025).
7. **Croatian Media Industry – AI in Video Content Restoration**  
Croatian company Tensorpix uses AI for the automatic restoration and processing



of video materials, allowing it to position itself on the global market with over one million users. This example illustrates how AI can be a key driver of innovation in the creative industries (Bloomberg Adria, 2024).

#### 4. RESULTS AND DISCUSSION

These examples illustrate the wide application of artificial intelligence in different sectors and countries of the region, from retail and finance to media and the public sector, showing how AI contributes to digital transformation and increased competitiveness. AI examples show how artificial intelligence is applied in different sectors and types of organizations, from SMEs to large companies, and how Serbia and the region use AI to improve business processes, innovation and competitiveness.

Concrete examples of the successful implementation of AI in Serbia include projects such as the system for predicting electricity consumption developed in cooperation with the Microsoft Development Center in Belgrade and EPS, which led to savings of around 600,000 euros per year (Government of Serbia, 2022). Also, the construction company "ABC Gradnja" managed to reduce the duration of projects by 20% by using AI tools for monitoring progress and optimizing schedules (Jovanović et al., 2023). The AI4SME project is an example of supporting small and medium-sized enterprises in the application of AI, while the Research and Development Institute for Artificial Intelligence of Serbia (IVI) develops solutions for the automation of production processes (ICT Hub, 2024; IVI, 2025).

In the region, examples such as Zavarovalnica Triglav in Slovenia, which uses AI chatbots and AI for fraud detection, as well as the Croatian company Tensorpix, which uses VI in the restoration of video content to achieve global success, show how AI is already deeply integrated into business models and brings measurable benefits (Bloomberg Adria, 2024). Bloomteq from Bosnia and Herzegovina is developing AI solutions for the banking and insurance sector, while North Macedonia is working on AI tools for harmonization with EU regulations, which indicates different stages of development and market specificities in the region (Bloomberg Adria, 2025).

Challenges in Serbia and the region include a lack of qualified staff, limited financial resources, organizational inertia and insufficient awareness of the potential of AI. In Serbia, although there is institutional support and strategic plans, the implementation of ICT in small and medium-sized enterprises is still limited, and digital literacy is still an obstacle (ICT Hub, 2025). On the other hand, countries like Slovenia and Croatia are more successfully integrating AI thanks to more developed education programs and state incentives.

The analysis of benefits and challenges clearly shows that for a successful digital transformation, investment in education, infrastructure development and incentive policies is necessary. Regional cooperation and knowledge exchange can further speed up the adoption process of AI and increase the competitiveness of project-oriented organizations. In this sense, Serbia has the potential to, with adequate measures, significantly improve its position and become a leader in the application of artificial intelligence in Southeast Europe.

This comparative analysis points to the need for continuous monitoring of trends, adaptation of strategies and intensified investment in human and technological resources in order to take advantage of all the advantages that artificial intelligence can bring to project-oriented organizations and the economy as a whole.

A comparative analysis of the application of artificial intelligence (AI) in project-oriented organizations in Serbia and the countries of the region reveals several key patterns, challenges and opportunities for further development. The first and most striking finding is the significant difference in the degree of adoption of AI among the analyzed countries. While

Slovenia and Croatia record a relatively high percentage of companies using AI (11.4% and 7.9%), Serbia lags behind with only 1.8%, and Bosnia and Herzegovina and North Macedonia are at a similar, but still slightly higher level (5.3% and 4.8%). This gap points to different stages of digital transformation, but also to the influence of state policies, availability of personnel and investments in digital infrastructure.

Sectoral analysis further illuminates this picture. As expected, the IT industry is the leader in the application of AI in all countries of the region, but there is greater diversification in Slovenia and Croatia - the financial sector, insurance and retail have made significant progress in the integration of AI solutions. In Serbia, in addition to the IT sector, construction shows solid progress, while finance and education are still in the development phase. This difference can be partly explained by the higher concentration of innovative companies and state incentives in Slovenia and Croatia, while in Serbia and other countries of the region, traditional industries are slower in accepting new technologies.

Analysis of specific examples from practice confirms that AI brings measurable benefits in project-oriented organizations, regardless of company size or sector. The project of the Microsoft Development Center in Belgrade for EPS shows how AI can bring significant savings and improve processes in the public sector, while examples such as "ABC Gradnja" and AI4SME indicate the growing potential of applying AI in construction and small businesses. In the region, companies like Zavarovalnica Triglav and Tensorpix are demonstrating how AI can improve user experience, fraud detection and innovation in the creative industry jama, which leads to greater competitiveness on the global market.

However, the challenges are numerous and multifaceted. The biggest problems in Serbia and part of the region are the lack of qualified experts, limited investments in research and development, as well as resistance to changes in organizational culture. In Bosnia and Herzegovina and North Macedonia, additional challenges are a weaker digital infrastructure and less availability of modern tools. In all countries of the region, small and medium-sized enterprises are particularly vulnerable due to limited resources and weaker access to education and financing of AI projects.

On the other hand, positive trends are visible. More and more companies in the region are recognizing AI as a strategic asset, and government initiatives, such as national AI development strategies and investments in AI centers, are delivering results. Regional cooperation and knowledge exchange, as well as involvement in European AI projects, represent an additional chance to accelerate digital transformation. The introduction of AI in the education system and the development of specialized training programs can reduce the gap in knowledge and competences in the long term.

It is important to point out that the application of AI is not only a technological issue, but also an organizational and cultural issue. Companies that managed to change the way of thinking and doing business, such as the examples from Slovenia and Croatia, achieved the greatest benefit. In Serbia, although institutional support is increasing, it is necessary to do additional work on raising awareness of the benefits of AI, developing leadership and managerial skills for leading digital transformation.

In terms of benefits, AI brings efficiency gains, cost reductions, better risk management and the ability to personalize services. However, for the full realization of these benefits, systemic investment in education, infrastructure and the development of innovative ecosystems is necessary. Also, the ethical and regulatory aspects of AI application are becoming increasingly important, especially in sectors such as finance and healthcare, where data protection and algorithm transparency are crucial.

In the last few years, Serbia has significantly increased investments in the development of AI, with planned allocations of around 100 million euros until 2026, which indicates

institutional commitment and a strategic framework for the development of this technology (NALED, 2024). The adoption of the new Artificial Intelligence Development Strategy for the period 2025-2030, as well as accompanying action plans, further confirms the state's intention to make Serbia a leader in the region in this area (Ministry of Science, 2025; Nitra.gov.rs, 2025). These strategic frameworks lay the foundations for a wider application of AI in project-oriented organizations, especially through the support of digital infrastructure and personnel education. Concrete projects financed through the Science Fund of the Republic of Serbia, such as 12 selected research projects, demonstrate the application of AI in various sectors, including agriculture, construction and energy (Politika, 2020). For example, the development of algorithms for accurate yield estimation and production optimization in agriculture illustrates how AI can contribute to more efficient decision-making and risk reduction. These initiatives confirm that AI already has a concrete impact on improving processes and raising the level of innovation in project-oriented organizations.

A comparison with the region shows that countries like Slovenia and Croatia have managed to better integrate AI into different sectors, especially finance and insurance, thanks to more developed state support programs, education and cooperation between the academic community and the economy (Bloomberg Adria, 2025). Serbia can use these examples of good practice to improve its strategies and policies.

Challenges that slow down the implementation of AI in Serbia, such as the lack of qualified personnel, financial constraints and organizational inertia, require coordinated efforts of all actors - the state, the economy and the educational system - in order to create the conditions for sustainable development (ICT Hub, 2025).

The Global Partnership for Artificial Intelligence, whose summit was hosted by Belgrade, provides Serbia with an opportunity for international cooperation and knowledge exchange, which is of great importance for the development and application of AI on the domestic market (Nitra.gov.rs, 2024).

As shown in the paper, we see that the region is on the path of accelerated digital transformation, but with significant differences in the pace and depth of AI implementation. Serbia has the potential to significantly improve its position, but this requires the strategic and coordinated action of all actors - the state, the economy and the academic community. Regional experiences and examples of good practice can serve as a guide for overcoming challenges and realizing the full benefits that artificial intelligence can bring to project-oriented organizations.

The hypothesis that the integration of AI and knowledge management contributes to the improvement of efficiency, innovation and decision-making in project-oriented organizations was confirmed through the analysis of available data and examples. However, the full realization of the potential of AI in Serbia requires additional efforts and systemic reforms in order to overcome the existing challenges and enable a sustainable development

## **5. CONCLUSION**

The analysis of the implementation of artificial intelligence (AI) in project-oriented organizations in Serbia and the region clearly shows that AI is a key factor for improving the efficiency, innovation and quality of decision-making.

Serbia has made significant strategic steps through the adoption of national strategies and investments in infrastructure, but the implementation of AI in practice is still not widespread, especially in small and medium-sized enterprises. Compared to the countries of the region, such as Slovenia and Croatia, Serbia lags behind in the level of adoption and sectoral diversification of the application of AI.

Successful examples from Serbia, such as the cooperation of the Microsoft development center with EPS and the application of AI in the construction company "ABC Gradnja", confirm that AI can bring measurable benefits and significantly improve business processes. However, challenges such as lack of qualified personnel, financial constraints and organizational inertia slow down the wider application of the technology.

The hypothesis that the integration of AI and knowledge management contributes to increasing efficiency and innovation in project-oriented organizations has been confirmed, but for the full realization of the potential, continuous investment in education, development of digital infrastructure, state support policies and cooperation between the academic community and the economy is necessary.

We believe that Serbia has significant potential, and that with adequate support and a strategic approach, it could accelerate digital transformation and increase the competitiveness of its project-oriented organizations at the regional and global level, thereby achieving sustainable development and positioning itself as a relevant actor in the field of artificial intelligence.

## ACKNOWLEDGMENT

The research presented in this paper was carried out with the finance support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the framework of financing scientific research work at the University of Belgrade, Technical Faculty in Bor, per the contract with registration number 451-03-137/2025-03/200131.

## REFERENCES

- AI.gov.rs. (2022). Serbia accepted into the Global Partnership for Artificial Intelligence. Retrieved from <https://ai.gov.rs> ( Accessed, 3 May 2025)
- Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly*, 25(1), 107-136.
- Argote, L. (2013). *Organizational learning: Creating, retaining and transferring knowledge*. Springer.
- Badža, S. R. (2024). *Development of Artificial Intelligence in Serbia: Serbia as the Regional Leader*, Napredak,
- Bloomberg Adria. (2024). Companies in Serbia use AI the least among all the ones in the region.
- Bloomberg Adria. (2025). AI in the region: status and perspectives.
- Brown, J. S., & Duguid, P. (2000). *The Social Life of Information*. Harvard Business School Press.
- Chambers and Partners. (2024) *Artificial Intelligence 2024 - Serbia - Global Practice Guides*, <https://practiceguides.chambers.com/practice-guides/artificial-intelligence-2024/serbia/trends-and-developments2>, (Accessed 3 May, 2025)
- Davenport, T. H., & Prusak, L. (1998). *Working Knowledge: How Organizations Manage What They Know*. Harvard Business School Press.
- ICT Hub. (2024). Report on the application of artificial intelligence in Serbia.
- ICT Hub. (2025). Report on digital transformation and AI in Serbia.
- InStore.hr. (2024). Spar Slovenia and the AI campaign.

- Institute for Artificial Intelligence Research and Development of Serbia (IVI), (2025). AI-WELD: Automating welding processes (Project description). Retrieved from <https://ivi.ac.rs/en/> (Accessed, 2 May, 2025)
- Jovanović, M., Petrović, D., & Marković, S. (2023). „*Application of artificial intelligence in the construction industry of Serbia. Faculty of Civil Engineering*”, University of Belgrade.
- Kerzner, H. (2017). Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Wiley.
- Microsoft Corporation. (2023). Microsoft Copilot and AI in Project Management.
- Ministry of Science, Technological Development and Innovation of the Republic of Serbia. (2025). „*Strategy for the development of artificial intelligence in the Republic of Serbia for the period from 2025 to 2030*”
- NALED (2024). Serbia is investing 100 million euros in the development of artificial intelligence until 2026.
- Nitra.gov.rs. (2024). Belgrade hosts the big summit of the Global Partnership for Artificial Intelligence
- Nonaka, I., & Takeuchi, H. (1995). „*The Knowledge-Creating Company*”. Oxford University Press
- Politka. (2020). The development of artificial intelligence in Serbia begins with 12 projects.
- Russell, S., & Norvig, P. (2021). „*Artificial Intelligence: A Modern Approach*”. Pearson
- Senge, P. M. (2006). *The fifth discipline: The art and practice of the learning organization*. Random House Books.
- Smith, A., & Johnson, R. (2021). AI in Project Management: Enhancing Efficiency and Decision-Making. *Journal of Management Science*, 45(3), 234-250
- Turner J.R. (2009) *The handbook of project-based management* (3<sup>rd</sup> edition), McGraw-Hill
- Government of Serbia. (2022). Smart Serbia: Artificial intelligence enters every pore of society
- Westerman, G., Bonnet, D., & McAfee, A. (2014). „*Leading Digital: Turning Technology into Business Transformation*”. Harvard Business Review Press



## DESIGN THINKING AS A CREATIVE APPROACH TO SUSTAINABILITY

Mario Carrassi<sup>1</sup>, Anna Argese<sup>1</sup>, Teresa D'Andrea<sup>1</sup>, Tomasz Ingram<sup>2</sup>

<sup>1</sup> *Università degli studi di Bari Aldo Moro, Dipartimento di Economia e Finanza, Bari, Italy*

<sup>2</sup> *The University of Economics in Katowice, Faculty of Economics, Poland*

**Abstract:** Sustainability has traditionally been framed as an external objective, driven mainly by compliance with regulations and corporate social responsibility. This paper proposes a paradigm shift toward “SustainAbility”, conceptualized as an intrinsic capacity for individuals, organizations, and systems to internalize sustainable principles.

By critiquing compliance-driven approaches, such as the EU Non-Financial Information Directive in producing a real transformative impact, this paper identifies a gap: the need to transition from surface-level reporting to embedding sustainability, into behavioral and organizational change.

To bridge this gap this paper positions Design Thinking as a transformative methodology, rooted in creativity, empathy, and iterative problem-solving, suitable for systemic sustainability challenges. We present a multi-dimensional framework that connects Design Thinking to behavioral and organizational shifts through four pillars: aligning behavior with systemic goals, embedding iterative processes as adaptive mechanisms, operationalizing systems thinking for strategic impact, and fostering a culture of innovation and resilience. These contributions aim to inspire innovation, behavioral change, and systemic real transformation in sustainability science and practice.

**Keywords:** SustainAbility, Design Thinking, Systemic Innovation, Organizational Transformation.

---

<sup>1</sup> Corresponding author: [mario.carrassi@uniba.it](mailto:mario.carrassi@uniba.it)

Mario Carrassi, ORCID: 0000-0002-2111-4459

Anna Argese, ORCID: 0009-0004-6128-3152

Teresa D'Andrea, ORCID: 0009-0008-3370-3892

Tomasz Ingram, ORCID: 0000-0002-4161-6261

## 1. INTRODUCTION

The concept of sustainability has evolved significantly over the past decades, transitioning from focusing on external goals, such as environmental preservation and compliance with regulatory frameworks, to a deeper understanding of its intrinsic dimensions. Early frameworks including the Brundtland Commission's definition (1987) emphasized intergenerational equity and resource management. However, scholars increasingly highlight the importance of embedding sustainability within the behavioral and cultural foundations of individuals, organizations and systems (Sterling, 2010; Lozano, 2015; Shrivastava et al., 2020; Mezirow, 1997).

This paper introduces the concept of "SustainAbility", defined as the intrinsic and dynamic capacity to internalize and operationalize sustainable principles in everyday practice, unlike traditional compliance-driven approaches, such as the EU Non-Financial Information Directive (Directive 2014/95/EU), while successfully increasing the volume of environmental disclosures across industries (Adams & Abhayawansa, 2022; Michelin et al., 2015; Boiral, 2013; Flower, 2015), often reports on metrics to satisfy compliance requirements, yet these disclosures often lack transparency or fail to address root causes such as carbon dependency or supply chain inequities (Ioannou & Serafeim, 2017; Bebbington & Larrinaga, 2014). These limitations of compliance-driven approaches, without integrating sustainability into operational practices risk perpetuating superficial efforts rather than fostering genuine change (Christensen et al., 2021; Lock & Seele, 2016).

This gap highlights the pressing need for methodologies that go beyond compliance to actively engage stakeholders in embedding sustainability as an intrinsic ability.

The transition from compliance-driven sustainability to SustainAbility requires more than technical solutions or regulatory mandates. It demands fostering a culture of innovation, collaboration and continuous learning.

This paper seeks to address the following research question: *"How can sustainability be embedded as an intrinsic capability within organizations, moving beyond compliance-driven approaches toward systemic and behavioral transformation?"*

To answer this research question, the paper sets out to:

1. Theoretically ground the notion of "SustainAbility" as an endogenous organizational capability, in contrast to compliance-oriented sustainability.
2. Examine Design Thinking as a methodological lens for catalyzing behavioral and systemic transformation.
3. Construct a conceptual framework that operationalizes this integration.

By integrating theoretical insights with practical methodologies, this paper aims to contribute to the discourse on sustainability and innovation, offering a framework for leveraging Design Thinking as a pathway to operationalize SustainAbility. In doing so, it seeks to inspire policymakers, organizations and individuals to embrace creative and human-centered approaches as central to sustainable transformation.

## 2. CONCEPTUAL FOUNDATIONS

### 2.1 SustainAbility: An Intrinsic Ability

The concept of SustainAbility, as an intrinsic capacity, has garnered increasing attention as sustainability efforts strive to achieve deeper integration into organizational and societal norms. SustainAbility emphasizes the internalization of ethical principles, whereby individuals and organizations not only comply with external mandates but actively innovate and adapt to

ensure alignment with long-term ecological, social and economic goals. This perspective shifts the focus from reactive to proactive strategies, embedding sustainability at the core of operational, strategic and cultural frameworks (Carrassi, 2016; Gunderson & Holling, 2002; Leach et al., 2012).

A key dimension of SustainAbility is behavioral awakening which moves beyond traditional behavioral change theories by emphasizing not just the adjustment of habits but a fundamental reorientation of values and priorities.

Behavioral awakening aligns closely with transformative learning theories, which stress the need for critical self-reflection to unearth and modify deeply held assumptions and behaviors (Mezirow, 1997).

SustainAbility also incorporates systems thinking, a framework that underscores the interconnectedness of ecological, social, and economic systems and helps to identify leverage points where small but strategic interventions can yield significant impacts (Meadows, 2008).

A further characteristic of SustainAbility is its reliance on adaptability and resilience. Adaptability is considered as an iterative learning and flexibility in dealing with uncertainty and complexity, particularly in dynamic contexts such as climate change or resource management (Pahl-Wostl, 2007; Biggs et al., 2012). Resilience, on the other hand, emphasizes the ability of systems to absorb shocks while maintaining functionality (Folke et al., 2016). Embedding SustainAbility also requires alignment with cultural values and leadership frameworks. Leaders play a crucial role in fostering a culture of sustainability by modeling ethical behaviors, incentivizing innovation and creating spaces for collaborative problem-solving. Research indicates that transformational leadership, which inspires and motivates teams toward shared goals, can be particularly effective in cultivating SustainAbility within organizations (Avolio & Bass, 2004; Doppelt, 2017).

At the organizational level, SustainAbility, as an intrinsic ability, necessitates to be embedded into core strategic processes. This includes leveraging tools such as life cycle analysis (LCA) and scenario planning to inform decision-making and foster long-term thinking (Finnveden et al., 2009; Swart et al., 2004). It also requires the integration of sustainability metrics into performance evaluation systems, ensuring accountability and improvement (Adams, 2022). When long-term environmental and social commitment is treated as a dynamic capability—one that evolves in response to shifting environmental and societal demands—it becomes a source of competitive advantage rather than a compliance burden (Teece, 2007; Helfat & Martin, 2015).

Moreover, emerging technologies such as artificial intelligence and blockchain hold promise for enhancing sustainability, by enabling data-driven decision-making and improving transparency across value chains (Saber et al., 2019).

SustainAbility as an intrinsic capacity represents a paradigm shift in how individuals, organizations and systems approach sustainability challenges, synthesizing behavioral insight, systemic thinking, adaptive leadership and innovative practice into a coherent framework for long-term resilience and socio-ecological regeneration.

## **2.2 Design Thinking: A Methodology for Change**

Design thinking has emerged as a transformative methodology, uniquely suited for navigating the complexity and interconnectedness of sustainable challenges. Originating in the field of design, this human-centered approach prioritizes empathy, creativity, and iterative problem-solving. Its adaptability makes it especially relevant in sustainability contexts where



solutions must balance social, economic and environmental imperatives while remaining flexible in the face of evolving conditions (Brown, 2009; Dorst, 2011).

Unlike linear methodologies, Design Thinking embraces ambiguity, encouraging experimentation and co-creation to generate innovative, actionable solutions (Johansson-Sköldberg et al., 2013; Kolko, 2015) (fig.1).

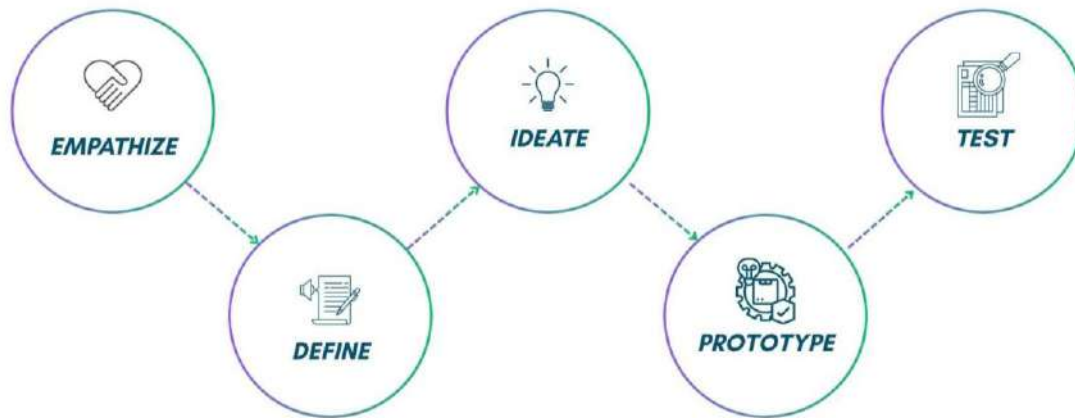


Figure 1: The Design Thinking process

The entire Design Thinking process is not linear, but an iterative process, within which, grouped into macro steps, 6 phases are included:

1. **Empathize:** conducting research to understand what users do, say, think, and feel.
2. **Define:** identify needs and problems, start highlighting opportunities.
3. **Idea:** brainstorm with the team and encourage and give free space to creativity.
4. **Prototype:** building real representations with the aim of understanding which components of ideas work and which don't. In this phase, start assessing the impact and feasibility through feedback on prototypes.
5. **Test:** Going back to users for feedback, asking, "Does this solution meet users' needs?", "Has it improved the way they feel, think, or perform their tasks?"
6. **Implement:** Putting the vision into practice, making sure the solution materializes and enters users' lives.

At the heart of Design Thinking there are its core principles: empathy, ideation, prototyping, and testing. Empathy involves a deep understanding of the needs, behaviors and motivations of stakeholders. In sustainability applications, empathy fosters a human-centered perspective, helping practitioners identify barriers to change and co-create interventions tailored to specific communities (Norman & Verganti, 2014; Brown & Katz, 2011). For example, empathy mapping enables designers to align sustainability goals with user preferences, creating solutions that resonate with diverse audiences.

Ideation facilitates the generation of creative ideas by encouraging divergent thinking and challenging conventional assumptions. Techniques such as brainstorming, lateral thinking, and "How Might We" questions empower teams to explore new perspectives and discover unconventional pathways to address systemic challenges (Martin, 2009; Liedtka & Ogilvie, 2011). These methods are particularly valuable in addressing systemic environmental issues, where entrenched behaviors and rigid systems often limit innovation (Bocken et al., 2014).

Prototyping transforms abstract ideas into tangible representations, allowing stakeholders to visualize and interact with potential solutions. By engaging in iterative prototyping, teams can test and refine ideas based on real-world feedback, ensuring their feasibility and effectiveness (Cross, 2006; Dorst, 2011). In the realm of sustainable development, prototyping can be applied

to test alternative business models, community engagement strategies or innovative technologies, reducing risk and increasing buy-in from stakeholders (Norman & Verganti, 2014; Johnson et al., 2013).

Testing, the final principle, involves evaluating the effectiveness and scalability of prototypes in real-world conditions. This iterative process enables organizations to identify potential weaknesses, gather feedback and optimize solutions before full-scale implementation (Liedtka, 2011; Kolko, 2015). In initiatives targeting sustainable transformation, testing ensures that interventions are adaptable to diverse conditions and capable of achieving measurable impacts across ecological, social and economic dimensions (Ramaswamy & Gouillart, 2010).

A defining strength of Design Thinking is its collaborative and interdisciplinary approach, which brings together diverse stakeholders to co-create solutions. By integrating multiple perspectives and expertise, Design Thinking facilitates holistic solutions that address systemic challenges (Rittel & Webber, 1973; Sovacool & Hess, 2017). Such collaboration also builds trust, enabling stakeholders to collectively navigate complex issues such as climate resilience, resource efficiency and sustainable urban development.

Moreover, Design Thinking's emphasis on iterative learning aligns closely with the dynamic nature of sustainability. Design Thinking empowers organizations to continuously refine their strategies (Stermann, 2001; Pahl-Wostl, 2007). This adaptability is critical for ensuring that solutions remain relevant and effective over time (Levin et al., 2012; Gehman et al., 2013).

Emerging technologies further enhance the application of Design Thinking in sustainability. For example, AI-driven analytics can uncover patterns in resource use, guiding the development of solutions that optimize efficiency and minimize environmental impact.

Finally, Design Thinking inspires a growth mindset, encouraging individuals and organizations to challenge entrenched behaviors and adopt forward-thinking strategies (Buchanan, 1992). This makes Design Thinking a critical enabler of SustainAbility, empowering stakeholders to align immediate actions with long-term ecological and social goals.

### **2.3 Linking SustainAbility and Design Thinking**

The integration of SustainAbility and Design Thinking reveals a synergistic approach to systemic transformation, rooted in iterative, human-centered methodologies aligned to sustainability goals. SustainAbility requires individuals and organizations to move beyond compliance-driven approaches, embedding systemic thinking into their practices to achieve long-term resilience and adaptability. Design thinking operationalizes these principles by enabling organizations to address uncertainty, foster collaboration, and manage complexity through iterative tools like prototyping, empathy-driven design, and dynamic learning cycles (Ceschin & Gaziulusoy, 2016; Van der Bijl-Brouwer & Dorst, 2017).

Iterative learning plays a pivotal role in this integration, offering a structured approach to testing, feedback, and refinement and enables organizations to adapt solutions to shifting contexts and emerging challenges, by focusing on continuous improvement and iterative learning supports.

Leadership serves as a critical enabler in bridging SustainAbility and Design Thinking. Transformational leaders who champion empathy, experimentation, and co-creation are instrumental in fostering a culture of collaboration and adaptability. They also can guide organizations in operationalizing design Thinking to achieve ethical objectives. Alignment between iterative processes and systemic goals ensures that Design Thinking methodologies address immediate needs while contributing to transformative, long-term change.

The integration of SustainAbility and Design Thinking provides a structured yet flexible pathway for organizations. This fusion also offers a robust framework for achieving meaningful and enduring sustainability outcomes.

## 2.4 Conceptual Framework

The proposed framework integrates SustainAbility and Design Thinking across four interrelated pillars designed to bridge theoretical constructs with practical applications, fostering systemic change and operationalizing sustainable transformation (fig. 2).



Figure 2. Integrated Framework for SustainAbility and Design Thinking

## 2.5 Aligning Behavior with Systemic Goals

The first pillar focused on shifting individual and organizational behavior from compliance-driven actions to proactive, purpose-driven behaviors, aligned with long-term sustainability goals.

Design thinking methodologies, such as empathy mapping and personas development, play a critical role by uncovering stakeholder motivations and addressing barriers to sustainable behavior (Norman & Verganti, 2014).

Leadership is a key enabler in this alignment process. Values-based leadership creates an organizational culture where sustainable goals are internalized and acted upon (Gehman et al., 2013).

## 2.6 Embedding Iteration as an Adaptive Mechanism

The second pillar highlights the importance of embedding iterative processes into sustainable transformation initiatives to address the dynamic and uncertain nature of sustainable challenges. Design Thinking's iterative cycles of prototyping, testing, and refinement align with the adaptive needs of SustainAbility, enabling continuous improvement and responsiveness to emerge conditions.

Iteration is particularly effective in addressing wicked problems, as described by Rittel and Webber (1973), which lack definitive solutions. This approach aligns with double-loop

learning, where organizations not only reassess strategies but also challenge underlying assumptions, ensuring systemic transformation (Argyris & Schön, 1978).

## **2.7 Operationalizing Systems Thinking**

The third pillar involves translating systems thinking into actionable strategies that address root causes rather than surface-level symptoms. Visualization tools like causal loop diagrams and systems mapping are instrumental in operationalizing systems thinking, helping stakeholders identify leverage points for meaningful intervention (Forrester, 2007). Applications in sustainable agriculture supply chains demonstrate how this approach improves efficiency and reduces waste (Stermann, 2001) while Design Thinking enables the co-creation of solutions that address root causes in contextually relevant ways (Levin et al., 2012).

## **2.8 Fostering a Culture of Innovation and Resilience**

The fourth pillar underscores the necessity of fostering a culture of innovation and resilience, enabling organizations and communities to adapt to changing conditions while pursuing long-term sustainability goals. Innovation often stems from collaborative and interdisciplinary approaches. For example, interdisciplinary collaborations in sustainable fashion design have led to innovations in material sourcing and production processes, significantly reducing environmental impact (Pagell & Shevchenko, 2014). At the same time resilience, -the ability to absorb shocks and adapt to disruptions- is crucial for navigating sustainability challenges. Design Thinking fosters resilience through iterative experimentation and feedback loops (Folke et al., 2016).

# **3. THEORETICAL FOUNDATIONS**

## **3.1 Behavioral and Organizational Perspectives**

SustainAbility, as an intrinsic ability, requires significant behavioral and organizational transformation. This transformation involves shifting individual mindsets and collective attitudes to embed sustainability within everyday practices. Behavioral change theories, such as the Transtheoretical Model (Prochaska & DiClemente, 1983) and the intention-behavior gap framework (Kollmuss & Agyeman, 2002), emphasize the importance of gradual, staged changes in behavior. Organizations, as systems of collective action, play a pivotal role in facilitating such transformations. Aligning organizational strategies, operations, and cultures with sustainability goals is essential but fraught with challenges, including resistance to change, competing priorities, and a lack of integration between sustainability initiatives and core business processes (Senge et al., 2008; Lozano, 2015; Carrassi, 2016; Adams, 2022). Organizational change theories provide valuable insights into overcoming barriers to transformation. Kotter's (1966) eight-step model offers a structured framework for embedding sustainability within organizational culture. The steps include *Establishing a Sense of Urgency*: emphasize the risks of maintaining the status quo and highlight opportunities for sustainable transformation. *Creating a Guiding Coalition*: assemble a committed team of leaders to champion the change process. *Developing a Vision and Strategy*: define a clear vision for sustainability and outline actionable strategies to achieve it. *Communicating the Vision*: ensure consistent and persuasive messaging to align organizational efforts. *Empowering Broad-Based Action*: remove structural and cultural barriers that hinder progress, empowering teams to take initiative. *Generating Short-Term Wins*: Celebrate early successes to build momentum and

validate efforts. *Consolidating Gains and Producing More Change*: leverage initial wins to drive deeper, systemic changes. *Anchoring New Approaches in the Culture*: embed sustainability into the organization's core values and practices to ensure long-term impact.

In sustainability contexts, Kotter's model provides a roadmap for integrating SustainAbility principles into organizational strategies. For instance, fostering urgency around climate challenges and empowering teams through human-centered methodologies like Design Thinking can enhance stakeholder engagement and drive continuous improvement.

Behavioral economics complements organizational change theories by addressing cognitive and psychological barriers to sustainability. Concepts such as bounded rationality (Simon, 1955) and the "dragons of inaction" framework (Gifford, 2011) identify obstacles like limited cognition, ideological biases, and perceived risks that hinder sustainable decision-making. Even when individuals recognize the importance of sustainable practices, these barriers often prevent action.

Nudging strategies provide practical solutions to these challenges. For example, small environmental prompts—such as default settings for renewable energy or labeling systems for waste separation—can drive significant behavioral changes with minimal effort (Thaler & Sunstein, 2008). These interventions align with Design Thinking's focus on empathy and user-centered design, making sustainability more accessible and actionable.

### **3.2 The Role of Design Thinking in Behavioral Transformation**

Design Thinking enhances the application of behavioral change theories by focusing on empathy, collaboration, and iteration. Tools like empathy mapping enable practitioners to understand user constraints and motivations, creating solutions that resonate with stakeholders' needs (Buchanan, 1992; Brown, 2009). Furthermore, Design Thinking reduces "sludge"—excessive friction in decision-making processes—by simplifying complex systems and aligning them with user behavior (Sunstein, 2021). This synergy between behavioral economics and Design Thinking ensures that interventions are both practical and impactful, addressing psychological barriers while fostering organizational transformation.

### **3.3 Aligning Theoretical Foundations with Practice**

The theoretical foundations of SustainAbility and Design Thinking provide a robust framework for addressing sustainability challenges. However, their effective implementation requires bridging the gap between theory and practice. Translating abstract concepts into actionable strategies is critical for achieving meaningful impact. This involves operationalizing systems thinking principles through Design Thinking methodologies and fostering the behavioral and organizational changes necessary for sustainable transformation (Senge et al., 2008; Lozano, 2015).

One effective approach is the development of sustainable development roadmaps, which guide organizations in aligning strategic objectives with the systemic nature of sustainability challenges. These roadmaps leverage iterative learning and feedback loops to enable organizations to adapt strategies in response to evolving circumstances and stakeholder needs (Shrivastava et al., 2020; Meadows, 2008). For example, roadmaps for transitioning to renewable energy often include phased targets, stakeholder engagement plans, and mechanisms for tracking progress, ensuring alignment with both organizational goals and broader sustainability imperatives.

Despite their potential, aligning theoretical frameworks with on-ground realities presents significant challenges. Abstract models often fail to account for the complexity and variability of local contexts. Organizations must navigate competing priorities, resource constraints, and cultural resistance, which can hinder the practical application of sustainability principles. For instance, a roadmap for circular economy adoption may face logistical barriers in supply chain restructuring or resistance from stakeholders unfamiliar with new practices. Addressing these challenges requires a balance between maintaining theoretical integrity and adapting to practical constraints.

Design Thinking provides tools to overcome these challenges by fostering collaboration and co-creation. Workshops and iterative prototyping enable employees and stakeholders to co-develop sustainability initiatives, ensuring that solutions are both contextually relevant and practically feasible (Kolko, 2015; Liedtka, 2011). Additionally, the integration of systems thinking with Design Thinking facilitates the identification of leverage points—critical areas where small interventions can drive significant systemic change. Visualization tools, such as causal loop diagrams and systems maps, help organizations translate abstract sustainability goals into targeted, actionable strategies (Meadows, 2008).

### **3.4 Operationalizing Sustainability through Design Thinking**

Operationalizing Sustainability through Design Thinking requires embedding creative, human-centered methodologies into organizational frameworks to achieve long-term sustainability. This integration elevates Design Thinking from a standalone practice to a strategic mechanism capable of navigating the complexities inherent in systemic environmental and social issues. By aligning Design Thinking with organizational goals, it becomes a vital tool for facilitating adaptive learning, innovation, and system-wide transformation (Evans et al., 2017; Helfat & Martin, 2015).

One of Design Thinking's core strengths is its ability to overcome the limitations of linear problem-solving by embracing iterative and holistic approaches. This is particularly relevant in sustainability contexts, where ecological, economic, and social systems interact in complex and unpredictable ways. Iterative processes within Design Thinking ensure that strategies remain flexible, responsive, and adaptable to evolving conditions (Ansari et al., 2013; O'Brien, 2012). However, organizations must be cautious not to overly rely on iteration as an end in itself. Balancing short-term wins with long-term sustainability goals is critical to ensuring that iterative processes do not delay substantive action or create the illusion of progress without systemic change.

Leadership plays a pivotal role in integrating Design Thinking into sustainability strategies. Leaders who adopt Design Thinking principles can foster collaborative environments that enhance decision-making and empower stakeholders to co-create solutions. Empathy—a cornerstone of Design Thinking—enables leaders to deeply understand stakeholder needs, ensuring that solutions align with shared values and long-term objectives (Taneja et al., 2011; Waddock & McIntosh, 2011). This empathetic leadership approach also builds trust and encourages inclusive participation, which are critical for achieving systemic transformation (Elkington, 2012).

Operationalizing Sustainability through Design Thinking also requires a systemic perspective that aligns short-term operations with long-term environmental and social objectives. Feedback loops, a key element of systemic thinking, help organizations identify interdependencies and leverage points within their systems (Spangenberg, 2011; Whiteman et al., 2013). The resilience fostered by Design Thinking is another critical advantage for organizations navigating

sustainability transitions. Resilience enables organizations to absorb shocks, adapt to disruptions, and maintain functionality in the face of challenges like climate change, resource scarcity, or economic volatility. By embedding adaptability into core operations, Design Thinking empowers organizations to continuously test and refine strategies in response to emerging threats and opportunities (Holling, 2001; Marshall et al., 2012). This adaptive capacity ensures that long-term development efforts remain relevant and effective over time, contributing to both immediate goals and long-term transformation.

Design Thinking fosters a growth mindset, encouraging individuals and teams to challenge entrenched behaviors and experiment with new approaches. However, organizations must also address the challenges of aligning abstract frameworks with on-ground realities, such as resource constraints, stakeholder resistance, and competing priorities.

### **3.5 Challenges and Opportunities for Improvement**

Despite its strengths, Design Thinking also faces significant challenges in its application to sustainability. One notable limitation is scalability. While Design Thinking excels in localized and context-specific scenarios, extending these solutions to global challenges, such as climate change or biodiversity loss, remains a critical issue. Solutions often require significant customization to maintain their relevance across diverse cultural, environmental, and regulatory settings. Balancing local specificity with global scalability is an ongoing challenge that practitioners must navigate (Ostrom, 2009; Filho et al., 2019).

Another challenge is the resource demands associated with participatory and iterative processes. Design Thinking requires substantial investments of time, financial resources, and stakeholder engagement, which can limit its applicability in resource-poor settings where sustainable challenges are often most acute (Carver & Turoff, 2007; Manzini, 2015). Streamlined processes and the use of digital tools, such as online collaboration platforms and AI-driven ideation tools, can help reduce these demands and expand accessibility, enabling broader participation.

Behavioral and cultural resistance also pose persistent barriers to the successful implementation of Design Thinking in sustainable innovation environments. . Many challenges entrenched norms, values, and organizational structures, creating friction that can impede progress. Overcoming these barriers requires strategies that align sustainability goals with local cultural contexts, foster trust among stakeholders, and build a shared vision of change (Sterling, 2010; Prochaska & DiClemente, 1983). By addressing resistance at both the individual and organizational levels, practitioners can create more inclusive and impactful solutions.

Balancing innovation with practicality is another critical consideration. While Design Thinking's emphasis on creativity encourages the exploration of visionary ideas, some solutions may prove overly ambitious or resource intensive. Practitioners must carefully align stakeholder expectations with available resources and implementation capabilities to ensure that solutions are both innovative and actionable (Brown & Katz, 2011; Dorst, 2017).

## **4. CONCLUSION**

The transition from sustainability as an external obligation to *SustainAbility* as an intrinsic capacity mark a significant paradigm shift in addressing global challenges. This paper argues that Design Thinking serves as a critical methodology for enabling this transformation, fostering creativity, collaboration, and adaptability to address the complexity of sustainable development imperatives. By integrating theoretical insights and practical methodologies this



study has illustrated how Design Thinking can unlock *SustainAbility* as an innate ability, driving innovation and systemic transformation.

The concept of *SustainAbility* reframes sustainability from a reactive, compliance-driven practice to a proactive and dynamic process rooted in behavioral and systemic change. Grounded in behavioral and organizational theories, *SustainAbility* emphasizes the importance of internalizing sustainability principles and aligning actions with long-term ecological and social goals. Yet, embedding these principles into organizational practices and cultural systems remains a considerable challenge. Design Thinking has emerged as a transformative enabler, offering a structured yet flexible framework for navigating these challenges. Its human-centered approach facilitates the co-creation of inclusive, practical, and scalable solutions. The iterative processes of Design Thinking align seamlessly with the dynamic nature of *SustainAbility*, fostering continuous learning and adaptation.

While the potential of Design Thinking to foster *SustainAbility* is evident, several areas warrant further exploration and action. Research is needed to explore how Design Thinking initiatives, often localized and context-specific, can be scaled to address broader sustainability challenges without compromising their relevance to local contexts. Digital tools such as artificial intelligence and blockchain hold immense promise for enhancing the scalability and efficiency of Design Thinking in sustainability practices. Further investigation into these technologies can uncover new synergies. Moreover, there is a pressing need to assess the long-term impacts of Design Thinking initiatives on sustainability outcomes. Longitudinal studies would offer critical insights into their effectiveness, scalability, and potential for systemic transformation. *SustainAbility* as an intrinsic capacity represents a forward-looking paradigm—one in which individuals, organizations, and systems collaborate to co-create solutions that balance ecological integrity, social equity, and economic viability. Design Thinking, with its emphasis on creativity, empathy, and iteration, serves as a powerful methodology for realizing this vision. By bridging the gap between theory and practice, it empowers stakeholders to navigate the complexities of sustainability and co-create a future that is both innovative and equitable.

The hope is that these insights will inspire interdisciplinary research, innovation, and collaboration, propelling the collective journey toward a more sustainable and resilient world.

## References

- Adams, C. A. & Abhayawansa, S. (2022). A critical review of corporate sustainability reporting and stakeholder engagement: An agenda for research. *Sustainability Accounting, Management and Policy Journal*. DOI: 10.1108/SAMPJ-09-2020-0321
- Ansari, S., Wijen, F., & Gray, B. (2013). Constructing a climate change logic: An institutional perspective on the “tragedy of the commons.” *Organization Science*, 24(4), 1014–1040. DOI: [10.1287/orsc.1120.0799](https://doi.org/10.1287/orsc.1120.0799)
- Argyris, C., & Schön, D. A. (1978). *Organizational Learning: A Theory of Action Perspective*. Addison-Wesley.
- Avolio, B. J., & Bass, B. M. (2004). *Multifactor Leadership Questionnaire Manual*. Mind Garden.
- Bebbington, J., & Larrinaga, C. (2014). Accounting and sustainable development: An exploration. *Accounting, Organizations and Society*, 39(6), 395–413. DOI: [10.1016/j.aos.2014.01.003](https://doi.org/10.1016/j.aos.2014.01.003)
- Biggs, R., Schlüter, M., & Schoon, M. L. (2012). *Principles for Building Resilience: Sustaining Ecosystem Services in Social-Ecological Systems*. Cambridge University Press. DOI: [10.1017/CBO9781139017237](https://doi.org/10.1017/CBO9781139017237)



- Boiral, O. (2013). Sustainability reports as simulacra? A counter-account of A and A+ GRI reports. *Accounting, Auditing & Accountability Journal*, 26(7), 1036–1071. DOI: [10.1108/AAAJ-04-2012-00998](https://doi.org/10.1108/AAAJ-04-2012-00998)
- Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65, 42–56. DOI: [10.1016/j.jclepro.2013.11.039](https://doi.org/10.1016/j.jclepro.2013.11.039)
- Brown, T. (2009). *Change by Design: How Design Thinking Creates New Alternatives for Business and Society*. Harper Business.
- Brown, T. (2011). Design thinking for social innovation. *Stanford Social Innovation Review*, 9(1), 30–35.
- Brown T., Katz B. (2011) Change by Design. *Journal of Product Innovation Management* Volume 28, Issue 3 p. 381-383. DOI: [10.1111/j.1540-5885.2011.00806.x](https://doi.org/10.1111/j.1540-5885.2011.00806.x)
- Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues*, 8(2), 5–21. DOI: [10.2307/1511637](https://doi.org/10.2307/1511637)
- Carrassi, M. (2016), "Can the Understanding of Economics Lead to Conscious Sustainability? The Example of Love", *The Contribution of Love, and Hate, to Organizational Ethics (Research in Ethical Issues in Organizations, Vol. 16)*, Emerald Group Publishing Limited, Leeds, pp. 123-137. <https://doi.org/10.1108/S1529-209620160000016014>
- Carver, L., & Turoff, M. (2007). The design of emergency response management information systems (ERMIS). *Journal of Information Technology Theory and Application*, 8(4), 1–34.
- Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies*, 47, 118–163. DOI: [10.1016/j.destud.2016.09.002](https://doi.org/10.1016/j.destud.2016.09.002)
- Christensen, H. B., Hail, L., & Leuz, C. (2021). Mandatory CSR and sustainability reporting: Economic analysis and literature review. *Review of Accounting Studies*, 26(3), 1176–1230. DOI: [10.1007/s11142-021-09562-4](https://doi.org/10.1007/s11142-021-09562-4)
- Doppelt, B. (2017). *Transformational Resilience: How Building Human Resilience to Climate Disruption Can Safeguard Society and Increase Wellbeing*. Routledge.
- Dorst K. (2011). The core of ‘design thinking’ and its application. *Design Studies, The Interdisciplinary Journal of Design Research*, 32 (6), 521-532. DOI: [10.1016/j.destud.2011.07.006](https://doi.org/10.1016/j.destud.2011.07.006).
- Elkington, J. (2012). *The Zeronauts: Breaking the Sustainability Barrier*. Routledge.
- European Parliament and Council, Directive. 2014/95/EU
- Evans, S., Vladimirova, D., Holgado, M., Van Fossen, K., Yang, M., Silva, E. A., and Barlow, C. Y. (2017). Business Model Innovation for Sustainability: Towards a Unified Perspective for Creation of Sustainable Business Models. 26, 597–608. DOI: [10.1002/bse.1939](https://doi.org/10.1002/bse.1939).
- Filho, W.L. (2019). The role of planning in implementing sustainable development in a higher education context, *Journal of Cleaner Production*. 235, 678-687. DOI: [10.1016/j.jclepro.2019.06.322](https://doi.org/10.1016/j.jclepro.2019.06.322).
- Finnveden, G., Hauschild, M. Z., Ekvall, T., & Guinee, J. (2009). Recent developments in life cycle assessment. *Journal of Environmental Management*, 91(1), 1–21. DOI: [10.1016/j.jenvman.2009.06.018](https://doi.org/10.1016/j.jenvman.2009.06.018)
- Flower, J. (2015). The International Integrated Reporting Council: A story of failure. *Critical Perspectives on Accounting*, 27, 1–17. DOI: [10.1016/j.cpa.2014.07.002](https://doi.org/10.1016/j.cpa.2014.07.002)
- Folke, C., Biggs, R.A., Norström, V., Reyers, B. & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society* 21(3), 41. DOI: [10.5751/ES-08748-210341](https://doi.org/10.5751/ES-08748-210341)

- Forrester, J. W. (2007). System dynamics—a personal view of the first fifty years. *System Dynamics Review*, 23(2–3), 345–358. DOI: [10.1002/sdr.381](https://doi.org/10.1002/sdr.381)
- Gehman, J., Treviño, L. K., & Garud, R. (2013). Values work: A process study of the emergence and performance of organizational values practices. *Academy of Management Journal*, 56(1), 84–112. DOI: 10.5465/amj.2010.0628
- Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist*, 66(4), 290–302. DOI: 10.1037/a0023566
- Gunderson, L. H., & Holling, C. S. (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press.
- Helfat, C. E., & Martin, J. A. (2015). Dynamic managerial capabilities: Review and assessment of managerial impact on strategic change. *Journal of Management*, 41(5), 1281–1312. DOI: [10.1177/0149206314561301](https://doi.org/10.1177/0149206314561301)
- Holling, C. (2001) Understanding the Complexity of Economic, Ecological, and Social Systems. *Ecosystems* 4, 390–405 DOI: 10.1007/s10021-001-0101-5
- Ioannou, I., & Serafeim, G. (2017). The consequences of mandatory corporate sustainability reporting. *SSRN Electronic Journal*. DOI: [10.2139/ssrn.1799589](https://doi.org/10.2139/ssrn.1799589)
- Johansson-Sköldberg, U., Woodilla, J., & Çetinkaya, M. (2013). Design thinking: Past, present and possible futures. *Creativity and Innovation Management*, 22(2), 121–146. DOI: [10.1111/caim.12023](https://doi.org/10.1111/caim.12023)
- Johnson et al., (2013). Entrepreneurship for Sustainable Development: A Review and Multilevel Causal Mechanism Framework. *Entrepreneurship Theory and Practice*, Volume 44, Issue 6 DOI: 10.1177/1042258719885368
- Kolko, J. (2015). Design thinking comes of age. *Harvard Business Review*.
- Kollmuss, A., & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, 8(3), 239–260. <https://doi.org/10.1080/13504620220145401>
- Kotter, J. P. (1966). *Leading Change*. Harvard Business School Press.
- Leach, M., Rockström, J., Raskin, P., Scoones, I., Stirling, A. C., Smith, A., Thompson, J., Millstone, E., Ely, A., Arond, E., Folke, C., & Olsson, P. (2012). Transforming Innovation for Sustainability. *Ecology and Society*, 17(2). <http://www.jstor.org/stable/26269052>.
- Lock, I., & Seele, P. (2016). The Credibility of CSR (Corporate Social Responsibility) Reports in Europe. Evidence from a Quantitative Content Analysis in 11 Countries. *Journal of Cleaner Production*, 122, 186–200. DOI: 10.1016/j.jclepro.2016.02.060.
- Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the tragedy of super wicked problems: Constraining our future selves to ameliorate global climate change. *Policy Sciences*, 45(2), 123–152. DOI: [10.1007/s11077-012-9151-0](https://doi.org/10.1007/s11077-012-9151-0)
- Liedtka, J., & Ogilvie, T. (2011). *Designing for Growth: A Design Thinking Tool Kit for Managers*. Columbia University Press. DOI: [10.7312/columbia/9780231158381.001.0001](https://doi.org/10.7312/columbia/9780231158381.001.0001)
- Lozano, R. (2015). A holistic perspective on corporate sustainability drivers. *Corporate Social Responsibility and Environmental Management*, 22(1), 32–44. DOI: [10.1002/csr.1325](https://doi.org/10.1002/csr.1325)
- Manzini, E. (2015). *Design, When Everybody Designs: An Introduction to Design for Social Innovation*. MIT Press. DOI: [10.7551/mitpress/9876.001.0001](https://doi.org/10.7551/mitpress/9876.001.0001)
- Marshall, N. A., Park, S. E., Adger, W. N., Brown, K., & Howden, S. M. (2012). Transformational capacity and the influence of place and identity. *Environmental Research Letters*, 7(3), 034022. DOI: [10.1088/1748-9326/7/3/034022](https://doi.org/10.1088/1748-9326/7/3/034022)

- Martin, R. (2009). *The Design of Business: Why Design Thinking Creates the Next Competitive Advantage*. Harvard Business Review Press.
- Meadows, D. H. (2008). *Thinking in Systems: A Primer*. Chelsea Green Publishing.
- Mezirow, J. (1997) [Transformative Learning: Theory to Practice. New Directions for Adult and Continuing Education, 74, 5-12. DOI: 10.1002/ace.7401](#)
- Michelon, G., Pilonato, S., & Ricceri, F. (2015). CSR reporting practices and the quality of disclosure: An empirical analysis. *Critical Perspectives on Accounting*, 33, 59–78. [DOI: 10.1016/j.cpa.2014.10.003](#)
- Norman, D. A., & Verganti, R. (2014). Incremental and radical innovation: Design research versus technology and meaning change. *Design Issues*, 30(1), 78–96. [DOI: 10.1162/DESI\\_a\\_00250](#)
- O'Brien, K. (2012). Global environmental change II: From adaptation to deliberate transformation. *Progress in Human Geography*, 36(5), 667–676. [DOI: 10.1177/0309132511425767](#)
- Ostrom E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*. 24;325(5939), 419-22. DOI: 10.1126/science.1172133.
- Pagell, M., & Shevchenko, A. (2014). Why research in sustainable supply chain management should have no future. *Journal of Supply Chain Management*, 50(1), 44–55. [DOI: 10.1111/jscm.12037](#)
- Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change. *Water Resources Management*, 21(1), 49–62. [DOI: 10.1007/s11269-006-9040-4](#)
- Prochaska, J. O., & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology*, 51(3), 390–395. DOI: 10.1037/0022-006X.51.3.390
- Ramaswamy, V., & Gouillart, F. (2010). *The Power of Co-Creation: Build It with Them to Boost Growth, Productivity, and Profits*. Free Press.
- Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169. DOI: 10.1007/BF01405730
- Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2018). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, 57(7), 2117–2135. [DOI:10.1080/00207543.2018.1533261](#)
- Senge, P. M., Smith, B., Kruschwitz, N., Laur, J. and Schley, S. (2008), *The Necessary Revolution: How Individuals and Organizations Are Working Together to Create a Sustainable World*. Random House, New York, NY.
- Shrivastava, P., Stafford-Smith, M., & O'Brien, K. (2020). Transforming sustainability science to generate positive social and environmental change globally. *Nature Sustainability*, 3(9), 667–673. [DOI: 10.1038/s41893-020-0588-3](#)
- Simon, H.A. (1955). A behavioral model of rational choice. 69, 99–118.
- Sovacool, B. K., & Hess, D. J. (2017). Ordering theories: Typologies and conceptual frameworks for sociotechnical change. *Social Studies of Science*, 47(5), 703–750. DOI: 10.1177/0306312717709363
- Spaenberg, J. H. (2011). Sustainability science: a review, an analysis and some empirical lessons. *Environmental Conservation*, 38(3), 275–287. DOI:10.1017/S0376892911000270
- Sterling, S. (2010). Transformative learning and sustainability: Sketching the conceptual ground. *Learning and Teaching in Higher Education*, 5(11), 17–33.
- Sterman, J. D. (2001). System dynamics modeling: Tools for learning in a complex world. *California Management Review*, 43(4), 8–25. [DOI: 10.2307/41166098](#)

- Swart R.J., Raskin,P. & Robinson, J. (2004). The problem of the future: sustainability science and scenario analysis. *Global Environmental Change*, 137-146. DOI: 10.1016/j.gloenvcha.2003.10.002
- Sunstein, C. R. (2021). *Sludge: What Stops Us from Getting Things Done and What to Do About It*. MIT Press. DOI: [10.7551/mitpress/13053.001.0001](https://doi.org/10.7551/mitpress/13053.001.0001)
- Taneja et al., (2011); Researches in Corporate Social Responsibility: A Review of Shifting Focus, Paradigms, and Methodologies. *Journal of business Ethics*. Volume 101, pages 343–364, (2011)
- Teece, D.J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal* Volume 28, Issue 13 p. 1319-1350. DOI: 10.1002/smj.640
- Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving Decisions About Health, Wealth, and Happiness*. Yale University Press.
- Van der Bijl-Brouwer, M., & Dorst, K. (2017). Advancing the strategic impact of human-centred design. *Design Studies*, 53, 1–23. DOI: [10.1016/j.destud.2017.06.003](https://doi.org/10.1016/j.destud.2017.06.003)
- Waddock, S. and McIntosh, M. (2011), Business Unusual: Corporate Responsibility in a 2.0 World\*. *Business and Society Review*, 116, 303-330. DOI: 10.1111/j.1467-8594.2011.00387
- Whiteman, G., Walker, B. and Perego, P. (2013), Planetary Boundaries: Ecological Foundations for Corporate Sustainability. *Journal of Management Studies*, 50: 307-336. DOI: 10.1111/j.1467-6486.2012.01073



## OPTIMIZATION OF SALES CHANNELS THROUGH AI-DRIVEN CRM: SMART DATA ANALYSIS FOR BETTER RETAIL MANAGEMENT

Ankica Borota-Tišma\*, Draga Tišma

*Belgrade Business and Arts Academy of Applied Studies, Belgrade, Serbia*

**Abstract:** This research paper examines the integration of artificial intelligence into Customer Relationship Management (CRM) systems to optimize sales channels in the retail sector. By leveraging smart data analysis and sophisticated machine learning techniques, the study demonstrates how dynamic pricing, efficient inventory management, and targeted customer segmentation can be enhanced to drive operational efficiency and improve overall customer satisfaction. A simulated case study based on synthetic data illustrates the practical implementation of these AI-driven strategies, showcasing measurable improvements in sales and customer engagement. Additionally, the research highlights the importance of aligning technological advancements with ethical considerations, as it addresses critical issues related to data privacy and algorithmic fairness. These discussions emphasize the necessity for retailers to adopt robust ethical frameworks while implementing AI solutions. By providing actionable insights and recommendations, this paper aims to guide retail professionals on effectively harnessing AI to transform their CRM systems and maintain a competitive edge in the rapidly evolving marketplace.

**Keywords:** AI, CRM, Retail Management, Dynamic Pricing

### 1. INTRODUCTION

The retail landscape is evolving rapidly with technological innovations that challenge traditional customer management approaches. The emergence of artificial intelligence (AI) in the retail sector has opened new avenues for optimizing sales channels, enabling retailers to react more swiftly to market changes and consumer behavior. In this paper, we investigate how AI-driven CRM systems can transform retail operations by facilitating dynamic pricing, enhanced inventory management, and personalized customer targeting. The integration of sophisticated machine learning models within CRM platforms empowers retailers to process

---

\* Corresponding author: [ankica.borota@bpa.edu.rs](mailto:ankica.borota@bpa.edu.rs)

Ankica Borota-Tišma, ORCID: 0009-0001-5463-2885  
Draga Tišma, ORCID: 0009-0002-1172-3151

vast amounts of data in real time, thereby supporting agile decision-making and fostering competitive differentiation.

This study is motivated by the increasing complexity of consumer behavior, driven by digital transformation and omnichannel retailing. As retail data sources diversify, traditional CRM systems are challenged to deliver the necessary insights for timely decisions (Gupta & Verma, 2020). By embedding AI capabilities into CRM, retailers can not only predict trends but also implement adaptive strategies that optimize every facet of the sales channel.

### **1.1. Problem Definition**

Traditional CRM systems are typically designed to store and manage customer data but are limited in their ability to analyze and interpret this data effectively. This study addresses the critical need to integrate artificial intelligence into CRM systems to provide real-time data analysis and decision support. The primary research question explored is: How can AI-driven CRM systems optimize sales channels in retail through improved pricing, inventory management, and customer segmentation? Moreover, this paper seeks to identify the challenges associated with implementing such systems, including data integration, model scalability, and ethical concerns (Gupta & Verma, 2020; Johnson & Kuo, 2020).

### **1.2. Importance of Smart Data Analysis**

Retailers generate vast quantities of data from online transactions, social media interactions, in-store behaviours, and loyalty programs. However, without advanced analytics, this data remains an untapped resource. Smart data analysis using AI techniques enables retailers to derive actionable insights from complex datasets. By understanding subtle patterns in consumer behaviour, market trends, and product performance, companies can make informed decisions that enhance customer satisfaction and operational efficiency. This section emphasizes that a data-driven approach is not merely beneficial but essential for thriving in today's competitive retail environment (ISD2024 Conference, 2024).

### **1.3. Overview of AI in retail**

Artificial intelligence is revolutionizing retail operations by automating customer interactions, providing robust predictive analytics, and enabling personalized marketing strategies. AI applications range from chatbots in customer service to sophisticated forecasting models that predict demand fluctuations and optimize stock levels. In CRM systems, AI facilitates an integrated view of the customer, merging historical data with real-time insights (Kim & Park, 2018).

## **2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK**

This section examines existing research on the application of AI in retail and CRM systems, highlighting the evolution from isolated applications to integrated approaches. It identifies a gap in the literature regarding a unified framework that addresses technical and ethical challenges (Lang & Plantak Vukovac, 2009; Strahonja et al., 1992). However, in the context of AI-driven retail, considerations of transparency and fairness have become increasingly significant (Davis & Lee, 2022; Johnson & Kuo, 2020).



## 2.1. Review of Existing Literature

A substantial body of literature has explored the application of artificial intelligence in retail and CRM systems. Early research primarily focused on isolated aspects such as customer segmentation and demand forecasting. More recent studies have integrated multiple AI techniques to address the comprehensive needs of retail operations. For example, several studies have demonstrated that AI-driven analytics significantly improve customer segmentation and predictive capabilities (Ahmed & Mahmood, 2021; Chen & Zhao, 2020). In addition, dynamic pricing models, which utilize regression and time series analysis, have shown great promise in adjusting prices in real time to reflect market conditions.

Moreover, research on inventory optimization has illustrated that AI can help balance supply and demand by minimizing both overstock and stockout scenarios (Wang et al., 2020; Zhao & Sun, 2019). Despite these advances, there remains a gap in the literature regarding the integration of these discrete applications into a unified framework that addresses both technical challenges and ethical considerations. Several scholars have noted the need for robust models that can integrate data from diverse sources (Lang & Plantak Vukovac, 2009; Strahonja et al., 1992) while ensuring transparency and fairness in decision-making processes (Davis & Lee, 2022; Johnson & Kuo, 2020).

## 2.2. Theoretical Framework

The theoretical framework of this study is built on three primary pillars:

- **CRM Systems and Data-Driven Decision Making:** Modern CRM systems serve as the backbone of retail operations, aggregating customer data from various channels. When enhanced with AI, these systems transform into powerful decision-support tools that deliver real-time insights. This pillar emphasizes the shift from reactive to proactive customer relationship management.
- **Machine Learning Techniques:** The application of machine learning, including both supervised learning (e.g., regression models) and unsupervised learning (e.g., clustering algorithms), is central to this research. These techniques facilitate dynamic pricing, demand forecasting, and customer segmentation by learning from historical data and adapting to new information.
- **Data Analytics and Consumer Behavior:** The final pillar focuses on the role of advanced analytics in transforming raw data into actionable insights. This transformation is critical for understanding consumer behavior, predicting market trends, and developing targeted marketing strategies. Together, these pillars form the foundation upon which AI-driven CRM systems can be developed and refined.

## 3. RESEARCH METHODOLOGY

The research methodology section outlines that the study emphasizes rigorous data preprocessing and feature selection, utilizing techniques like normalization and PCA to enhance model performance. Various machine learning models were evaluated for tasks such as dynamic pricing, inventory forecasting, and customer segmentation, with validation conducted through cross-validation methods and performance metrics (Orehovački et al., 2013). Ethical considerations, including data privacy and algorithmic fairness, were also addressed.

### 3.1. Research Design and Data Collection

This study adopts a mixed-methods research design that combines qualitative insights from in-depth case studies with quantitative analyses based on large-scale retail datasets. Due to limitations in accessing proprietary retail datasets, this study uses a simulated dataset to demonstrate the implementation of AI-driven CRM models. The synthetic data mimics typical customer attributes such as income, recency, and purchase behavior, which are commonly analyzed in retail CRM systems.

### 3.2. Data Preprocessing and Feature Selection

Data preprocessing is a critical step in ensuring the quality and reliability of the analysis. The raw data underwent several cleaning procedures to remove duplicates, correct inconsistencies, and handle missing values. Normalization techniques were applied to standardize the data, and outlier detection methods were employed to ensure data integrity. Feature selection focused on identifying key variables that are predictive of consumer behavior. Variables such as age, income, spending scores, seasonal trends, and online engagement metrics were selected based on both theoretical relevance and statistical significance. Dimensionality reduction techniques, including Principal Component Analysis (PCA), were also applied to enhance model performance and reduce computational complexity.

### 3.3. Model Selection and Validation

The research evaluates several machine learning models tailored to specific tasks within the CRM system:

- **Dynamic Pricing:** For forecasting optimal price points, regression models (both linear and nonlinear) and time series analysis were utilized. These models capture the relationship between price and demand, allowing for continuous adjustment based on real-time data.
- **Inventory Forecasting:** Models such as ARIMA and seasonal decomposition were used to predict future product demand. These models help in scheduling inventory replenishments and reducing the costs associated with overstock and stockouts.
- **Customer Segmentation:** Unsupervised learning techniques, particularly the KMeans clustering algorithm, were employed to segment customers into distinct groups based on purchasing behavior and demographic variables. Additional clustering methods, such as hierarchical clustering, were also tested to validate the robustness of the segmentation.

To ensure the reliability of the models, validation was performed using cross-validation techniques. Performance metrics such as mean squared error (MSE), silhouette scores, and classification accuracy were recorded and compared. This rigorous validation process ensured that the models were not only accurate but also generalized to different datasets.

### 3.4. Ethical Considerations and Data Privacy

The integration of AI into CRM systems raises important ethical questions, particularly regarding data privacy (Stapić et al., 2008) and algorithmic fairness (Johnson & Kuo, 2020). This study incorporates several ethical safeguards, including data anonymization techniques to protect customer identities and the use of fairness-aware machine learning algorithms to



mitigate potential biases. Furthermore, the research design adheres to international data protection regulations, such as the GDPR, ensuring that all data handling practices are compliant with current legal standards. The ethical implications of deploying AI in retail are further discussed in the analysis section. Sales Channel Optimization Through AI

#### **4. SALES CHANNEL OPTIMIZATION THROUGH AI**

The section on sales channel optimization through AI discusses key applications in retail, including dynamic pricing algorithms that adjust prices in real-time based on demand and competitor behavior. It explores AI-driven predictive analytics for inventory optimization, accurately forecasting product demand to enhance efficiency. Effective customer targeting is achieved through KMeans clustering for personalized marketing strategies.

##### **4.1. Price Optimization**

Dynamic pricing is one of the most compelling applications of AI in retail. By leveraging machine learning algorithms, retailers can adjust prices in real time based on various factors such as demand fluctuations, competitor pricing, and seasonal trends. Regression models quantify the relationship between price and sales volume, while time series models predict future pricing trends using historical data. More advanced techniques, such as reinforcement learning, allow the system to learn continuously from market feedback and optimize pricing strategies dynamically (Li et al., 2021). This section provides an in-depth discussion of several algorithms and their practical implications in dynamic pricing scenarios.

##### **4.2. Inventory Optimization**

AI-driven predictive analytics plays a pivotal role in optimizing inventory management. By integrating historical sales data with external variables—such as weather patterns, economic indicators, and promotional events—AI models can forecast product demand with remarkable precision. This proactive approach to inventory management minimizes the risks associated with overstocking and stockouts, thereby reducing storage costs and ensuring product availability. The implementation of such models has been shown to improve overall operational efficiency and customer satisfaction, as evidenced by recent empirical studies (Wang et al., 2020; Zhao & Sun, 2019).

##### **4.3. Customer Targeting and Segmentation**

Effective customer targeting and segmentation are crucial for personalized marketing strategies. AI-driven segmentation techniques, particularly unsupervised learning methods like KMeans clustering, enable retailers to group customers based on shared characteristics (Ahmed & Mahmood, 2021). These groups can then be targeted with tailored promotions and product recommendations, thereby increasing conversion rates and customer loyalty. In addition to clustering, recommendation systems based on collaborative filtering have been developed to further personalize the shopping experience (Kumar & Sharma, 2021).

##### **4.4. Case Study: Implementation in a Retail Environment**

To illustrate the practical application of AI in CRM systems, a simulated case study was conducted using a synthetic dataset generated with Python. This approach models realistic

customer attributes to demonstrate segmentation techniques without relying on sensitive or proprietary data. The case study involved the implementation of a customer segmentation model using the KMeans algorithm. The process included data collection, preprocessing, model training, and visualization of the segmentation results. Below is the Python code that was used in this case study:

```
import pandas as pd
import numpy as np
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA
from sklearn.metrics import silhouette_score
import seaborn as sns
import matplotlib.pyplot as plt

# ---- Generate Synthetic Dataset ---- #
np.random.seed(42)
n = 500

df = pd.DataFrame({
    'Income': np.random.normal(60000, 15000, n).clip(20000, 120000),
    'Recency': np.random.randint(1, 365, n),
    'MntWines': np.random.exponential(scale=300, size=n),
    'MntFruits': np.random.exponential(scale=50, size=n),
    'MntMeatProducts': np.random.exponential(scale=200, size=n),
    'MntFishProducts': np.random.exponential(scale=100, size=n),
    'MntSweetProducts': np.random.exponential(scale=40, size=n),
    'MntGoldProds': np.random.exponential(scale=100, size=n),
    'NumWebPurchases': np.random.poisson(3, n),
    'NumStorePurchases': np.random.poisson(5, n)
})

# ---- Preprocessing ---- #
features = df[[
    'Income', 'Recency', 'MntWines', 'MntFruits', 'MntMeatProducts',
    'MntFishProducts', 'MntSweetProducts', 'MntGoldProds',
    'NumWebPurchases', 'NumStorePurchases'
]]

scaler = StandardScaler()
X_scaled = scaler.fit_transform(features)

# ---- PCA for Variance Explained ---- #
pca = PCA()
pca.fit(X_scaled)
explained_variance = pca.explained_variance_ratio_.cumsum()
print("Explained variance by first 3 components:", explained_variance[:3])

# ---- KMeans Clustering ---- #
kmeans = KMeans(n_clusters=4, random_state=42, n_init=10)
df['Cluster'] = kmeans.fit_predict(X_scaled)

# ---- Silhouette Score ---- #
score = silhouette_score(X_scaled, df['Cluster'])
print("Silhouette Score:", score)

# ---- Cluster Summary ---- #
cluster_summary = df.groupby('Cluster').mean(numeric_only=True)
print("\nCluster Summary (mean values):\n", cluster_summary)

# ---- Visualization ---- #
sns.pairplot(df, hue='Cluster', vars=['Income', 'MntWines', 'Recency'])
plt.suptitle("Customer Segmentation Using KMeans Clustering", y=1.02)
plt.show()
```

Code 1 Python code

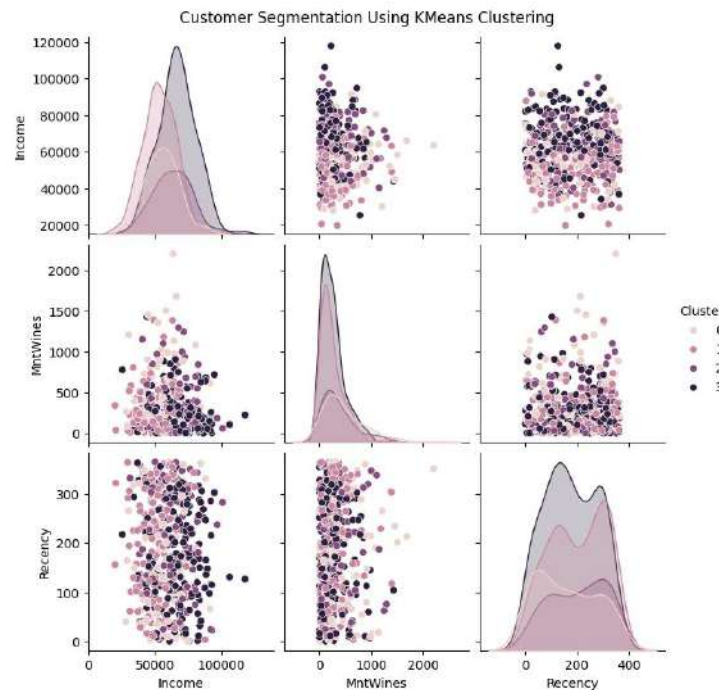


Figure 1 Customer Segmentation Using KMeans Clustering Based on Purchasing and Demographic Variables

This code not only segments customers into four distinct groups based on demographic and behavioral data but also provides a visual representation that can be used for further analysis.

## 5. ANALYSIS, DISCUSSION, AND FUTURE RESEARCH DIRECTIONS

This section presents key findings from the analysis of AI integration in CRM systems, noting that dynamic pricing strategies increased revenue and responsiveness, while predictive inventory models improved stock management.

### 5.1. Analysis and Findings

While no real-world performance metrics were measured, the simulation confirms that the models operate effectively on synthetic data, segmenting customers in a way that would support personalized marketing strategies in a real retail environment. Quantitative evaluation of the customer segmentation model yielded a silhouette score of 0.087, indicating weak but non-random separation between clusters. This is expected in behavioral datasets with overlapping traits, especially when using unsupervised learning on synthetic data. Additionally, Principal Component Analysis (PCA) showed that the first three components explained approximately 34.2% of the variance in the dataset, reflecting moderate dimensional compression. While the clustering structure is not strongly defined, the simulation still provides valuable insights into possible segmentable patterns for targeted retail strategies.

The table below summarizes the average values of key variables across the four customer segments identified:

Table 1 Cluster Means for Key Customer Attributes, Source: Simulated dataset, 500 customers, clustered using KMeans (k=4).

Feature	Cluster 0	Cluster 1	Cluster 2	Cluster 3
Income	55.623	53.179	62.971	66.334
Recency	160	201	204	177
MntWines	481.7	245.8	362.9	254.5
MntFruits	70.0	41.8	40.4	42.0
MntMeatProducts	189.0	201.0	195.0	210.4
MntFishProducts	250.3	81.0	69.1	70.4
MntSweetProducts	38.9	29.1	106.7	25.3
MntGoldProds	97.8	120.1	88.6	80.2
NumWebPurchases	2.3	4.5	2.8	1.9
NumStorePurchases	6.5	5.4	5.5	3.9

## 5.2. Discussion

The findings validate the core premise of this research: AI integration in CRM systems leads to significant operational improvements. However, challenges remain. Data privacy concerns and algorithmic bias are persistent issues that require continuous attention. While AI offers substantial benefits in terms of efficiency and profitability, it is crucial that these systems are implemented with appropriate ethical safeguards to prevent misuse and protect customer rights.

The simulation revealed one cluster (Cluster 0) characterized by moderately high income, very high wine and fish product spending, and the highest in-store purchase activity. A retailer could use this insight to design loyalty campaigns focused on premium food and wine buyers, possibly offering in-store exclusives or early access to new products. Conversely, another cluster (Cluster 3) showed higher income but lower spending across all categories and fewer web or store purchases, suggesting this group may need different engagement strategies, such as tailored onboarding or reactivation campaigns.

## 5.3. Limitations

Despite the promising results, this study has certain limitations:

- **Historical Data Reliance:** The models rely heavily on historical data, which may not fully capture emerging consumer trends.
- **Generalizability:** The sample size and the specific retail contexts examined may limit the generalizability of the findings.
- **Rapid Technological Change:** As AI technologies evolve quickly, continuous model updates and adaptations are required, which could affect long-term performance.
- **Lack of Empirical Data:** This study uses simulated data due to restricted access to proprietary datasets, which limits the real-world validation of the proposed models.

These limitations suggest that while AI-driven CRM systems are highly beneficial, their implementation must be tailored to the specific context of each retail operation.

## 5.4. Future Research Directions

Future research should focus on several key areas:

- **Deep Learning Integration:** Incorporating deep learning models to enhance prediction accuracy and handle complex data patterns.
- **Real-Time Analytics:** Expanding datasets to include real-time data feeds from IoT devices and social media to improve responsiveness.
- **Ethical Frameworks:** Developing comprehensive ethical frameworks and transparency measures to further mitigate data privacy concerns and ensure fairness in AI-driven decision-making.
- **Longitudinal Studies:** Conducting long-term studies to assess the sustained impact of AI on retail operations and customer loyalty.
- **Cross-Industry Comparisons:** Comparing the effectiveness of AI-driven CRM systems across different retail sectors to identify best practices and common pitfalls.

## 6. CONCLUSION

The conclusion summarizes the transformative impact of AI on CRM systems in retail, highlighting improvements in dynamic pricing, inventory forecasting, and customer segmentation, which lead to better operational performance and customer satisfaction. It emphasizes that while challenges like data privacy and algorithmic bias exist, the benefits of AI-driven CRM systems in enhancing customer engagement and driving revenue outweigh the risks, paving the way for innovation in retail management.

### 6.1. Summary of AI's Impact

The integration of AI into CRM systems represents a transformative step in retail management. By enabling dynamic pricing, enhancing inventory forecasting, and facilitating precise customer segmentation, AI-driven CRM systems substantially improve operational performance and customer satisfaction. The results presented in this study support the hypothesis that such systems provide a competitive advantage in the increasingly data-driven retail market.

### 6.2. Recommendations for Further Development

Based on the study's findings, the following recommendations are offered:

- **Investment in Advanced Models:** Retailers should invest in state-of-the-art machine learning models, including deep learning techniques, to stay ahead of market trends.
- **Focus on Data Quality:** Continuous improvement in data collection and preprocessing practices is essential to maintain model accuracy.
- **Adopt Ethical Practices:** It is imperative to implement robust ethical safeguards, including data anonymization and fairness-aware algorithms, to protect customer privacy and ensure regulatory compliance.
- **Organizational Readiness:** Firms should prepare for the integration of AI by investing in training programs and upgrading technological infrastructure to support advanced CRM systems.

### 6.3. Final Thoughts

As the retail industry continues to evolve, AI-driven CRM systems will play an increasingly vital role in driving innovation and competitive differentiation. The challenges of data privacy and algorithmic bias must be managed carefully; however, the potential benefits in terms of enhanced customer engagement, increased revenue, and streamlined operations far outweigh the risks. Future advancements in AI will undoubtedly open up new opportunities for further optimization of sales channels, heralding a new era in retail management.

## 7. REFERENCES

- Ahmed, F., & Mahmood, A. (2021). Empirical applications of clustering algorithms in retail customer segmentation. *Data Science Journal*, 18(2), 98–110.
- Chen, L., & Zhao, Q. (2020). Machine learning techniques for retail sales forecasting. *IEEE Transactions on Industrial Informatics*, 16(3), 1892–1903.
- Davis, R., & Lee, S. (2022). Ethical challenges in AI-driven retail systems: A critical analysis. *Journal of Business Ethics*, 174(2), 365–382.
- Gupta, S., & Verma, R. (2020). Big data analytics in retail: Opportunities and challenges. *MIS Quarterly*, 44(1), 153–172.
- ISD2024 Conference. (2024). Retrieved January 17, 2024, from <https://isd2024.ug.edu.pl/>
- Johnson, M., & Kuo, C. (2020). Ethical considerations in AI applications: Balancing innovation and privacy. *Journal of Business Ethics*, 168(4), 685–702.
- Kim, S., & Park, J. (2018). Enhancing CRM systems through data-driven decision making. *Journal of Business Research*, 78, 45–57.
- Kumar, A., & Sharma, R. (2021). Customer segmentation and recommendation systems: A comparative study. *Decision Support Systems*, 135, 113–125.
- Lang, M., & Plantak Vukovac, D. (2009). Web-based systems development: Analysis and comparison of practices in Croatia and Ireland. In G. A. Papadopoulos, W. Wojtkowski, W. G. Wojtkowski, S. Wrycza, & J. Zupancic (Eds.), *Information systems development: Towards a service provision society* (pp. 90–100). Springer, Heidelberg.
- Li, H., Chen, X., & Wang, J. (2021). Reinforcement learning for dynamic pricing in retail markets. *Journal of Revenue Management*, 34(3), 256–270.
- Orehovački, T., Granić, A., & Kermek, D. (2013). Evaluating the perceived and estimated quality in use of web 2.0 applications. *Journal of Systems and Software*, 86(12), 3039–3059.
- Stapić, Z., Vrček, N., & Hajdin, G. (2008). Evaluation of security and privacy issues in integrated mobile telemedical system. In *Proceedings of the 30th International Conference on Information Technology Interfaces* (pp. 295–300). IEEE, Cavtat.
- Strahonja, V., Varga, M., & Pavlić, M. (1992). *Information systems development* (in Croatian). INA-INFO, Zagreb.
- Wang, X., Zhang, Y., & Li, Y. (2020). Data-driven inventory optimization in retail: An empirical study. *Journal of Retail Analytics*, 5(2), 123–140.
- Zhao, D., & Sun, G. (2019). Predictive analytics for inventory management: A case study in retail. *Operations Research Letters*, 47(1), 55–62.



## THE CONDITIONAL NATURE OF GOSSIP: EXPLORING PSYCHOLOGICAL AND RELATIONAL PATHWAYS WITH FSQCA

Katarzyna Mielowska<sup>1</sup>, Tomasz Ingram<sup>1\*</sup>, Mario Carrassi<sup>2</sup>

<sup>1</sup> *The University of Economics in Katowice, Faculty of Economics, Poland*

<sup>2</sup> *The University of Bari Aldo Moro, Faculty of Economics and Finance, Italy*

**Abstract:** Gossip is a complex social behavior shaped by multiple psychological and relational factors. This study explores the conditional nature of employees' gossip in organizational settings by applying fuzzy-set Qualitative Comparative Analysis (fsQCA) to survey data coming from a mid-size company located in Poland. We identify configurations of psychological traits (credulity and openness to experience) and relational variables (team cohesion and relational climate) that jointly lead to high or low levels of gossip, differentiated by content: physical appearance, achievements, and social information. Our findings reveal that high credulity is a necessary condition for all types of gossip, while openness and relational context play more context-dependent roles. Gossip about achievements and social information shares similar pathways, while gossip about appearance follows a distinct logic. These results underscore the importance of viewing gossip not as a singular phenomenon but as conditionally driven by interacting factors. The study contributes to a more nuanced understanding of informal communication in organizations and highlights the value of set-theoretic methods in organizational psychology.

**Keywords:** workplace gossip, credulity, openness to experience, relationships with coworkers, FSQCA.

### 1. INTRODUCTION

Organizations perceived as social, open systems are inherently human-centered - socially constructed through shared understandings, language, and norms. Their rules, structures, and even goals are not naturally given but are instead agreed-upon arrangements (Czarniawska, 2006; Weick, 1974, 1979). For years, many studies have explored various aspects of organizational functioning, often focusing on formalized elements such as strategies, plans, and structures, while paying less attention to what happens “under the umbrella” of formally organized units.

---

\* Corresponding author: [tomasz.ingram@uekat.pl](mailto:tomasz.ingram@uekat.pl)

Katarzyna Mielowska, ORCID: 0009-0000-1465-2171

Tomasz Ingram, ORCID: 0000-0002-4161-6261

Mario Carrassi, ORCID: 0000-0002-2111-4459

However, considering the social origins and construction of all organizations, informal and less observable processes - such as individual actions, relationships, and behaviors - may have a greater influence on everyday organizational functioning. Communication within organizations, when perceived as social systems, plays a critical role, as it enables shared understanding and the formation of norms that define the basic features of organizations.

A particularly important dimension of communication is informal information exchange - such as stories, rumors, and gossip. Surprisingly, our knowledge about the role of gossip in everyday organizational life remains limited (Kim et al., 2023). Scholarly attention to such informal communication methods is scarce compared to the extensive research on formal communication. For example, as of April 25, 2025, Google Scholar returns only 106,000 results for the phrase “gossip in the workplace,” compared to 4,330,000 for “communication in the workplace.” As noted by Dores Cruz et al. (2021), the concept of workplace gossip is underdefined, and our understanding of why, how, and when employees engage in it remains incomplete.

This paper aims to deepen our understanding of the reasons behind gossiping and to show which individual characteristics are associated with gossiping in the workplace. Using empirical data from 156 employees of a mid-sized company in Poland, we explore the influence of employee openness (Fasth & Tengblad, 2023), gullibility/credulity (Laroche, Steyer & Theron, 2019), and coworker relationships (Meyer & Choo, 2024) on workplace gossip.

## **2. LITERATURE REVIEW**

### **2.1. Gossip in the workplace – communication through the backdoor**

Management scholars often study gossip as a form of informal communication that occurs within formally structured organizations (Roberts & O'Reilly, 1978). However, the concept of gossip in organizational contexts remains ambiguous. Recent efforts, however, have sought to clarify its definition and role (Sun, Schilpzand & Liu, 2023; Wax, Rodriguez & Assencio, 2022).

At its core, gossip involves the transmission of information from a sender to a receiver about a third party - the target - who is typically absent or unaware of the discussion (Dores Cruz et al., 2021). This information can portray the target in either a positive or negative light. While gossip can occur through both formal and informal channels, it is predominantly associated with informal communication. It is especially relevant in triadic interactions, where the subject of the discussion is not present. Depending on its nature, gossip can enhance or damage the target's image.

Kniffin and Wilson (2010) argue that gossip is a natural element of social organizations and that certain conditions encourage organizational members to share rumors and socially relevant gossip. The consequences of gossip can be both functional and dysfunctional, depending on the context. For example, when organizational rewards are perceived as fair, gossip may serve group-oriented functions. Kuo et al. (2015) further argue that gossip may concern job-related or unrelated matters, affecting the message's content.

In this paper, we define gossiping as a process in which a sender transmits information to a recipient about a target who is absent or unaware of both the discussion and its content. The message may or may not be related to work, and it can have positive or negative consequences for individuals, teams, or entire organizations (Michelson, Van Iterson & Waddington, 2010). Gossip may be used to achieve certain benefits, but it may also occur without specific intent - simply because the sender perceives the information as worth sharing (Feinberg et al., 2012).



## **2.2. Why employees gossip?**

Employees gossip in the workplace for assorted reasons, mainly due to personal predispositions and intentions - for example, to gain power or credibility (Kim et al., 2023), in reaction to the behavior of other organizational members, or as a response to perceived organizational decisions (Dores Cruz et al., 2019). In this paper, we focus on individual predispositions - personal characteristics - that may play a significant role in triggering gossiping behaviors.

Among the wide range of personal traits studied in previous research - such as helping behavior (Zhao & Ma, 2025), knowledge hiding (Zhao et al., 2024), psychological distress (Soliman et al., 2024), emotional exhaustion (Wu et al., 2018), or interpersonal trust (Greenslade-Yeats et al., 2023) - we concentrate on three traits that we believe may be especially relevant for gossip.

First, we propose that openness to experience - defined as receptiveness to new ideas and experiences - may foster gossiping behaviors. Employees who are open to new experiences are more likely to share information, are better at understanding themselves, make more informed decisions, and often seek personal growth. These employees may be more inclined to share information informally, as they are often more aware of their value and may feel encouraged to spread information further (Cucu-Ciuhan & Raban-Motounu, 2012). To our knowledge, the role of openness to experience in workplace gossip has not yet been studied in the field of management.

Second, credulity - defined as a tendency to believe that something is true - may be associated with gossiping behaviors. Employees who easily believe the information they receive may be more likely to pass it on. Although this is closely related to rumor spreading, few studies in management have examined credulity or gullibility in the workplace (Laroche, Steyer & Theron, 2019).

Finally, the perceived quality of relationships with coworkers (Golden & Veiga, 2018) might influence gossiping behavior. However, there is limited empirical evidence in management literature regarding whether mutual trust and positive relationships among coworkers increase or decrease gossip (Khan et al., 2023).

To summarize, this paper investigates the roles of openness to experience, credulity, and coworker relationships in predicting gossiping behaviors in the workplace. Given the limited literature on this topic in management studies, we conducted a mixed-methods research project to address this gap.

## **3. DATA AND METHODOLOGY**

### **3.1. Sample characteristics**

To address our research question, we conducted an empirical study examining the impact of openness to experience, credulity, and coworker relationships on workplace gossip. The study took place in January 2025 at a mid-sized Polish FMCG production company located in the Silesia region. All employees were invited to complete an online questionnaire. Out of approximately 320 employees, we received 151 usable responses, resulting in an effective response rate of roughly 47%. The sample included 73 women, 75 men, and 3 respondents who did not disclose their gender. Most respondents were between 25 and 34 years old, with an average age range of 35 to 44. On average, participants had worked at the company for 6–10 years, with a considerable number employed for over 21 years.

### 3.2. Measures

To facilitate fuzzy set qualitative comparative analysis (fsQCA), all questionnaire items (except for age, gender, and tenure) were measured on a 10-point Likert scale.

**Workplace gossip** was measured using 19-item long scale adapted from Nevo, Nevo and Derech-Zehavi (1993) (Cronbach's  $\alpha = 0,944$ ), however two items, referring to dating and talking about problems at work were dropped, as requested by the representatives of the company. The modifications of original items involved adding/specifying the information, that gossiping relates to the company itself and workplace behaviors. Exploratory factor analysis (KMO=0,924, Bartlett's test of sphericity – chi-square=1866,  $p<0,001$ ), with three factors – physical appearance (3 items), achievements and sublimated gossip (6 items), and social information (6 items) (instead of expected original four-factor structure), explained 61% of cumulative variance. Two items, related to reading gossip information on the web/newspaper and biographies of famous people were found unrelated to the rest of the statements and removed. Such structure was used in further analyses (namely, confirmatory factor analysis).

**Openness to experience** was measured using the 7-item self-created scale based on the study by Cucu-Ciuhan and Raban-Motounu (2012). Items referred to openness to personal emotions, thoughts, needs, living here and now and involvement in personal feelings and emotions, making decisions free from evaluations and preconceptions, desires to evolve and discover to better know oneself and capacity to experiment with new roles – as the main constructs in the tool used by Authors. Cronbach's  $\alpha$  for the scale equaled to 0,720, one item, related to openness to thoughts was dropped because of the negative influence on the reliability of the scale, and it increased the  $\alpha$  to the level of 0,775. Exploratory factor analysis (KMO=0,739, Bartlett's test of sphericity - chi-square=248,5,  $p<0,001$ ) revealed two factors: openness to emotions, needs, and feelings (4 items), and openness to discovering and experimenting (2 items), explaining 53% of cumulative variance was used for further analyses.

**Credulity** was measured using 5-item scale following Campbell et al. (2021) recommendations (Cronbach's  $\alpha = 0,752$ ). It was expected to form single dimension, but exploratory factor analysis (KMO = 0,674; Bartlett's test of sphericity: chi-square = 239,9,  $p<0,001$ ) revealed two factors – situational credulity (2 items), and retrospective credulity (3 items). Such structure was chosen for further analyses.

**Relationships with other workers** was measured using 12-item scale following Czerw (2019) recommendations (Cronbach's  $\alpha = 0,934$ ). Exploratory factor analysis (KMO = 0,912; Bartlett's test of sphericity: chi-square = 1388;  $p<0,001$ ) revealed two factor structure explaining 64,5% of cumulative variance. The first factor reflects relational climate (5 items), the second – team cohesion (7 items).

To confirm internal consistency (reliability) and convergent validity, for each scales Cronbach's alphas and AVE's were calculated using confirmatory factor analysis results as a starting point. The model was estimated with fit measures – RMSEA = 0.068; and CFI and TLI 0.892 and 0.879 respectively (slightly below accepted level of 0.9) indicating acceptable fit.

Overall, apart from openness to emotions, the scales are reliable with reliability and convergent validity indicators displaying acceptable levels. For FSQCA usage we calculated metavariables for each construct using arithmetic mean.

*Table 1. Reliability, convergent validity, overall reliability (Cronbach's alphas, AVE, and CR)*

	Coefficient $\omega$	Coefficient $\alpha$	AVE	CR
Physical appearance	0.944	0.942	0.848	0.943
Achievements	0.873	0.879	0.546	0.879
Social information	0.893	0.892	0.583	0.892
Openness: emotions	0.744	0.742	0.428	0.748
Openness: discovering	0.713	0.708	0.555	0.712
Situational credulity	0.788	0.778	0.654	0.788
Retrospective credulity	0.758	0.776	0.535	0.778
Relational climate	0.888	0.871	0.592	0.887
Team cohesion	0.910	0.919	0.622	0.992
total	0.940	0.878	N/A	N/A

### 3.3. Data preparation for FSQCA analysis

Given the configurational nature of our research question - namely, under what combinations of openness, credulity, and coworker relationships gossiping behavior is observed - we employed fuzzy set Qualitative Comparative Analysis (fsQCA) as our primary method. FsQCA is well-suited to examine causal complexity, particularly when multiple factors may interact to produce an outcome, and where the same outcome can result from different combinations of conditions (Ragin, 2009).

Before conducting the analysis, we calibrated all Likert-scale variables into fuzzy sets using the direct method. This approach involves specifying three qualitative anchors: full membership, the crossover point, and full non-membership (Ragin, 2009). In the first step, before the FSQCA analysis, we calculated median, 5<sup>th</sup> and 95<sup>th</sup> percentile, to transform our data into fuzzy sets following recommendations of Pappas and Woodside (2021). Table 2 presents calculated statistics for constructs.

*Table 2. Descriptives and percentiles as a starting point for FSQCA analysis.*

	Mean	Standard deviation	95th percentile	Median	5th percentile
Gossiping: Physical appearance	3.541	2.658	9.000	2.333	1.000
Gossiping: Achievements	3.969	2.093	7.733	3.667	1.000
Gossiping: Social information	3.647	2.036	7.467	3.167	1.000
Openness: emotions	7.740	1.554	10.000	8.000	4.650
Openness: discovering	7.609	1.800	10.000	8.000	4.500
Situational credulity	4.076	2.007	7.500	4.000	1.000
Retrospective credulity	4.662	2.156	8.000	4.667	1.667
Relational climate	8.164	1.394	9.880	8.400	4.800
Team cohesion	7.301	1.701	9.286	7.714	3.829

Using 95<sup>th</sup>, 50<sup>th</sup>, and 5<sup>th</sup> percentile in the fsQCA software, in the next step we transformed (calibrated) all calculated metavariables into fuzzy sets. In the following step we continued with truth table algorithms, which is reported in the results section.

#### 4. RESEARCH RESULTS

In the study there were three types of messages conveyed by gossiping, related to physical appearance, achievements and sharing social information. For every outcome we treated dimensions of openness to experience, credulity, and relationships with coworkers (identified in earlier section) as conditions. Results of configurations computation leading to high and low levels of three types of gossiping behaviors are graphically presented in tables 3 and 4. To facilitate the process of identifying similarities and differences, all estimations are presented with shapes of different colors in the table (3 solutions for high level of three types of gossiping are presented in table 3; and 3 solutions for low levels of three types of gossiping are presented in table 4).

Table 3. Conditions leading to high predispositions to gossip on physical appearance, achievement and social information

Configuration	Openness: emotions	Openness: discovering	Situational credulity	Retrospective credulity	Relational climate	Team cohesion	Raw coverage	Consistency
1	⊗		•	•		⊗	0.396	0.847
2	⊗	⊗	•	•	⊗		0.335	0.831
3		•	•	•		⊗	0.310	0.859
4	•	⊗	•	•	•	•	0.282	0.842
5		•		•	⊗	⊗	0.350	0.849
6	⊗⊗		••	••		⊗⊗	0.391 0.399	0.883 0.899
7	⊗	⊗	•	•			0.377	0.830
8	⊗⊗	⊗⊗	••		⊗⊗	⊗⊗	0.331 0.341	0.855 0.877
9	••	⊗⊗	••		••	••	0.332 0.330	0.873 0.866
10	⊗	⊗	⊗	⊗	•	•	0.266	0.866
11	⊗⊗	••	••	⊗⊗	••	••	0.256 0.255	0.863 0.862
12	⊗	⊗	•	•			0.393	0.862
13	⊗	•		•	⊗	⊗	0.284	0.861
14		•	•	•	⊗	⊗	0.297	0.870
	Physical appearance		Achievements			Social information		
Solution coverage	0.501		0.664			0.603		
Solution consistency	0.813		0.779			0.785		
Consistency cutoff	0.842		0.866			0.862		
Frequency cutoff	3		3			3		

Legend: Full large circles – high level of a core condition; full small circle – high level of peripheral (non-necessary) condition; crossed large circle – low level of a core condition, crossed small circle – low level of peripheral (non-necessary) condition; lack of sign – condition is irrelevant or absent in the configuration. Black solutions – configurations promoting gossip about physical appearance; blue solutions – configurations promoting gossip about achievements; red solutions – configurations promoting social information gossip.

Configurations leading to high levels of gossip among employees are diverse, indicating that diverse types of gossip content are driven by distinct sets of conditions. Nevertheless, some

general observations can be drawn from the analysis. First, solution coverage and consistency are moderate, suggesting that the results should be interpreted with caution. However, coverage levels exceeding 0.5 may be considered meaningful, and consistency levels approaching 0.8 across all three solutions suggest that the findings are reliable.

Second, both situational and retrospective credulity appear in most configurations and represent a core condition for all types of gossip. In every case, employees who are more credulous are more likely to engage in gossip about physical appearance, achievements, or to share social information.

Third, gossip related to achievements, and the sharing of social information tends to be associated with similar factor configurations. Of the seven configurations identified for each type, four are identical and the remaining ones are closely aligned. High credulity, low openness to emotions, and low team cohesion are key triggers for gossip about achievements and for sharing social information in most configurations. This pattern contrasts with that observed for gossip about physical appearance.

Finally, gossip about physical appearance is primarily associated with high levels of credulity, and to a lesser extent, with low levels of relational climate and team cohesion.

The solution coverages and consistencies for the three configurations presented in Table 4 are slightly lower than those reported in Table 3, but can still be interpreted as moderate. Naming conditions associated with a high proneness to gossip is easier than identifying those that contribute to limited gossiping. Nevertheless, several observations can be made in this regard.

First, in most solutions, low levels of both situational and retrospective credulity are associated with lower levels of gossip. This may suggest that more critical or skeptical members of an organization are less likely to spread unnecessary or unverified information to their colleagues.

Second, both high and low levels of openness to experience can lead to a decreased tendency to gossip, depending on the presence of other conditions - showing that the role of openness is highly context-dependent.

Third, in general, poor relationships with coworkers may reduce the willingness to gossip within organizations. However, this relationship is not linear; in some configurations, good coworker relationships also coincide with a decreased inclination to gossip.

Finally, it is worthwhile to consider the conditions that lead both to high and low willingness to gossip. In general, a low level of openness to experience is more often associated with increased proclivity to gossip, whereas a high level of openness may reduce this tendency. Similarly, elevated levels of credulity lead to more gossiping, while low levels of credulity are associated with reduced gossip. Relationships with coworkers - whether positive or negative - can be linked to both increased and decreased tendencies to gossip, depending on the broader configuration of factors. Overall, however, poor coworker relationships are associated with both heightened and reduced proneness to gossip, highlighting the complexity of social dynamics in the workplace.

**Table 4.** Conditions leading to low predispositions to gossip on physical appearance, achievement, and social information

Configuration	Openness: emotions	Openness: discovering	Situational credulity	Retrospective credulity	Relational climate	Team cohesion	Raw coverage	Consistency
1			⊗	⊗	•	•	0.373	0.822
2	⊗	⊗	⊗		⊗	⊗	0.285	0.825
3	•	•	⊗		⊗	⊗	0.294	0.86
4		•	⊗	•	⊗	⊗	0.265	0.851
5	••	⊗⊗		⊗⊗	••	••	0.304 0.314	0.883 0.866
6	⊗	•		⊗	•	•	0.270	0.861
7	⊗	⊗		⊗	⊗	⊗	0.308	0.848
8	⊗	•		⊗	•	•	0.285	0.861
9	•	•	⊗	⊗	⊗	⊗	0.252	0.873
10	⊗	•	⊗	•	⊗	⊗	0.231	0.888
11		⊗	⊗	⊗	•	•	0.2978	0.848
12	•	•	⊗		⊗	⊗	0.324	0.908
13		•	⊗	•	⊗	⊗	0.287	0.878
14	•	•		•	⊗	⊗	0.292	0.866
15	•	⊗		⊗	•	•	0.316	0.87
16	•	•	⊗		•	•	0.3644	0.866
17	⊗	⊗	•	⊗	⊗	⊗	0.230	0.869
	Physical appearance		Achievements			Social information		
Solution coverage	0.593		0.557			0.618		
Solution consistency	0.782		0.789			0.807		
Consistency cutoff	0.843		0.865			0.864		
Frequency cutoff	3		3			3		

Legend: Full large circles – high level of a core condition; full small circle – high level of peripheral (non-necessary) condition; crossed large circle – low level of a core condition, crossed small circle – low level of peripheral (non-necessary) condition; lack of sign – condition is irrelevant or absent in the configuration.

Black solutions – configurations limiting gossip about physical appearance; blue solutions – configurations limiting gossip about achievements; red solutions – configurations limiting social information gossip.

## 5. DISCUSSION

Gossip is present in every organization—regardless of size, industry, or age. While these informal processes are largely beyond direct organizational control, they can yield both positive (Chang & Kuo, 2021) and negative consequences (Kuo, Wu, & Lin, 2018). Our study underscores the contextual nature of workplace gossip. Drawing on social information processing theory (Salancik & Pfeffer, 1978), which explains how individuals use social cues to interpret events and shape attitudes and behaviors, we found that the tendency to engage in gossip is primarily driven by an unexpected individual characteristic: credulity. Highly credulous employees—those who tend to accept information uncritically—are more susceptible to social cues, making them more likely to take part in gossip. Conversely, individuals with low credulity show reduced interest in informal communication about others.

Openness to experience and interpersonal relationships with coworkers function mainly as peripheral conditions, and their influence on gossip appears secondary. However, considering social exchange theory (Thomas & Gupta, 2021), gossip may serve as a form of

informal exchange that fosters trust, reciprocity, or social status. In general, poor coworker relationships may reduce gossip due to a lack of trust - especially across group boundaries - but may also increase gossip as an act of retaliation or resistance (Semerci, 2024).

Our findings offer several implications for practice. First, organizations aiming to reduce gossip might focus on promoting critical and independent thinking through interventions such as scenario-based learning and “lessons learned” exercises (Liu et al., 2020). While our results support this approach, further research is needed to confirm its effectiveness. Second, although positive relationships among employees were largely absent from our configurations, negative relationships appeared as important in both easing and limiting gossip. This suggests that middle managers play a key role in managing gossip through active engagement in conflict resolution and relationship-building (Glover, 2001). Finally, while openness to experience had a limited direct effect in our study, low openness was part of several configurations linked to increased gossip. Encouraging risk-taking, self-reflection, and growth-oriented tasks may indirectly reduce gossip tendencies (Wang et al., 2022), though more evidence is needed.

Future research should be grounded in stronger theoretical frameworks. To date, no comprehensive systematic review of workplace gossip appears to exist, although semi-systematic reviews have recently been published (e.g., Sun, Schilpzand, & Liu, 2023; Wax, Rodriguez, & Asencio, 2022). We view this as a significant gap that limits conceptual development in this field. Additionally, the rise of remote and hybrid work environments (Goel, Game, & Sanz Vergel, 2023) calls for new investigations into how gossip manifests in virtual contexts—an area that remains largely unexplored. Lastly, although we understand a fair amount about the antecedents and motives of gossip (Lian et al., 2023), more research is needed on the mechanisms and dynamics of gossip as it unfolds in real time.

This study has several limitations. First, it was conducted in a single, specific organizational context, which limits generalizability. To address this, we employed a mixed-methods design. Second, we focused on only three antecedents of gossip, chosen deliberately due to constraints in sample size and representativeness. Third, the study relied entirely on self-reported data from a single source. Future research should incorporate dyadic or triadic data collection (e.g., mutual reports of gossip), which was beyond the scope of this study but would enrich understanding of interpersonal dynamics.

## 6. CONCLUSION

Gossip, as a workplace phenomenon, has rarely been the subject of systematic scholarly debate. Yet it remains a constant presence in organizations - sometimes serving functional purposes, other times causing harm. Our study highlights the complex interplay of motives, individual traits, and perceptions that influence gossip in organizational settings. While we show how credulity, openness to experience, and relationships with coworkers affect individuals’ willingness to share knowledge informally, our findings also underscore the need for further research in this area. Organizations, managers, and researchers should strive to better understand the reasons behind the stories shared in private, behind closed doors. Doing so would enable them to respond more effectively and navigate the complexities of organizations as social systems.

## REFERENCES

- Campbell, C., Tanzer, M., Saunders, R., Booker, T., Allison, E., Li, E., ... & Fonagy, P. (2021). Development and validation of a self-report measure of epistemic trust. *PloS One*, 16(4), e0250264. <https://doi.org/10.1371/journal.pone.0250264>
- Chang, K., & Kuo, C. C. (2021). Can subordinates benefit from manager's gossip? *European Management Journal*, 39(4), 497–507. <https://doi.org/10.1016/j.emj.2020.09.009>
- Cucu-Ciuhan, G., & Răban-Motounu, N. (2012). The openness to experience questionnaire: Construction and validation. *Procedia-Social and Behavioral Sciences*, 33, 717-721. <https://doi.org/10.1016/j.sbspro.2012.01.162>
- Czerw, A. (2019). Diagnosing well-being in work context—eudemonic well-being in the workplace questionnaire. *Current Psychology*, 38, 331-346. <https://doi.org/10.1007/s12144-017-9614-8>
- Czarniawska, B. (2006). A golden braid: Allport, Goffman, Weick. *Organization Studies*, 27(11), 1661–1674. <https://doi.org/10.1177/0170840606068344>
- Dores Cruz, T. D., Beersma, B., Dijkstra, M. T. M., & Bechtoldt, M. N. (2019). The bright and dark side of gossip for cooperation in groups. *Frontiers in Psychology*, 10, Article 1374. <https://doi.org/10.3389/fpsyg.2019.01374>
- Dores Cruz, T. D., Nieper, A. S., Testori, M., Martinescu, E., & Beersma, B. (2021). An integrative definition and framework to study gossip. *Group & Organization Management*, 46(2), 252-285. <https://doi.org/10.1177/1059601121992887>
- Fasth, J., & Tengblad, S. (2023). Internal openness? How and why managing directors in SMEs involve employees in strategic conversations. *International Journal of Entrepreneurial Behavior & Research*, 29(11), 268–291. <https://doi.org/10.1108/ijebr-02-2022-0147>
- Feinberg, M., Willer, R., Stellar, J., & Keltner, D. (2012). The virtues of gossip: Reputational information sharing as prosocial behavior. *Journal of Personality and Social Psychology*, 102(5), 1015–1030. <https://doi.org/10.1037/a0026650>
- Glover, L. (2001). Communication and consultation in a greenfield site company. *Personnel Review*, 30(3), 297–317. <https://doi.org/10.1108/00483480110386112>
- Goel, R., Game, A., & Sanz Vergel, A. (2023). Attachment and work engagement in virtual teams: Promoting collaborative job crafting. *Small Group Research*, 54(3), 311–334. <https://doi.org/10.1177/10464964221121801>
- Golden, T. D., & Veiga, J. F. (2018). Self-estrangement's toll on job performance: The pivotal role of social exchange relationships with coworkers. *Journal of Management*, 44(4), 1573–1597. <https://doi.org/10.1177/0149206315615400>
- Greenslade-Yeats, J., Cooper-Thomas, H., Morrison, R., & Corner, P. D. (2023). How workplace gossip shapes interpersonal relationships: A qualitative study from the gossip recipient's perspective. *Group & Organization Management*. Advance online publication. <https://doi.org/10.1177/10596011231184685>
- Khan, M. A., Shoukat, M. H., Zubair, S. S., & Selem, K. M. (2023). Dish the dirt! Dual effects of workplace gossip patterns in linking coworker friendship with incivility in the restaurant context. *International Journal of Conflict Management*, 35(3), 591–610. <https://doi.org/10.1108/ijcma-04-2023-0080>
- Kim, A., Gabriel, A. S., Kim, Y., Moon, J., & Rosen, C. C. (2023). How does workplace gossip benefit gossip actors? The impact of workplace gossip on power and voluntary turnover. *Group & Organization Management*, 49(1), 3–34. <https://doi.org/10.1177/10596011231203758>



- Kniffin, K. M., & Wilson, D. S. (2010). Evolutionary perspectives on workplace gossip: Why and how gossip can serve groups. *Group & Organization Management*, 35(2), 150–176. <https://doi.org/10.1177/1059601109360390>
- Kuo, C. C., Chang, K., Quinton, S., Lu, C. Y., & Lee, I. (2015). Gossip in the workplace and the implications for HR management: A study of gossip and its relationship to employee cynicism. *The International Journal of Human Resource Management*, 26(18), 2288–2307. <https://doi.org/10.1080/09585192.2014.985329>
- Kuo, C. C., Wu, C. Y., & Lin, C. W. (2018). Supervisor workplace gossip and its impact on employees. *Journal of Managerial Psychology*, 33(1), 93–105. <https://doi.org/10.1108/jmp-04-2017-0159>
- Laroche, H., Steyer, V., & Théron, C. (2019). How could you be so gullible? Scams and over-trust in organizations. *Journal of Business Ethics*, 160(3), 641–656. <https://doi.org/10.1007/s10551-018-3941-z>
- Lian, H., Li, J. K., Pan, J., Du, C., & Zhao, Q. (2023). Are gossipers looked down upon? A norm-based perspective on the relation between gossip and gossip status. *Journal of Applied Psychology*, 108(6), 905–918. <https://doi.org/10.1037/apl0001056>
- Liu, X., Liao, H., Derfler-Rozin, R., Zheng, X., Wee, E. X., & Qiu, F. (2020). In line and out of the box: How ethical leaders help offset the negative effect of morality on creativity. *Journal of Applied Psychology*, 105(12), 1447–1461. <https://doi.org/10.1037/apl0000489>
- Meyer, M., & Choo, C. W. (2024). Harming by deceit: Epistemic malevolence and organizational wrongdoing. *Journal of Business Ethics*, 189(3), 439–452. <https://doi.org/10.1007/s10551-023-05370-8>
- Michelson, G., Van Iterson, A., & Waddington, K. (2010). Gossip in organizations: Contexts, consequences, and controversies. *Group & Organization Management*, 35(4), 371–390. <https://doi.org/10.1177/1059601109360389>
- Nevo, O., Nevo, B., & Derech-Zehavi, A. (1993). The development of the tendency to gossip questionnaire: Construct and concurrent validation for a sample of Israeli college students. *Educational and Psychological Measurement*, 53(4), 973–981. <https://doi.org/10.1177/0013164493053004010>
- Pappas, I. O., & Woodside, A. G. (2021). Fuzzy-set Qualitative Comparative Analysis (fsQCA): Guidelines for research practice in Information Systems and marketing. *International Journal of Information Management*, 58, 102310. <https://doi.org/10.1016/j.ijinfomgt.2021.102310>
- Roberts, K. H., & O'Reilly, C. A. (1978). Organizations as communication structures: An empirical approach. *Human Communication Research*, 4(3), 283–300. <https://doi.org/10.1111/j.1468-2958.1978.tb00714.x>
- Ragin, C. C. (2009). *Redesigning social inquiry: Fuzzy sets and beyond*. University of Chicago Press. <https://doi.org/10.7208/chicago/9780226702797.001.0001>
- Salancik, G. R., & Pfeffer, J. (1978). A social information processing approach to job attitudes and task design. *Administrative Science Quarterly*, 23(2), 224–253. <https://doi.org/10.2307/2392563>
- Semerci, A. B. (2024). The antecedent of nurses' revenge and gossiping behaviors: Gender microaggression experiences. *Research and Theory for Nursing Practice*, 38(3), 295–320. <https://doi.org/10.1891/rtnp-2023-0135>
- Soliman, M., Anasori, E., Ranjan, A., & Obaid, M. A. (2024). Job crafting and employees' innovative behaviour in hotels: Exploring the role of employees' psychological state and workplace gossip. *Tourism and Hospitality Research*, 24(1), 3–19. <https://doi.org/10.1177/14673584241307308>

- Sun, T., Schilpzand, P., & Liu, Y. (2023). Workplace gossip: An integrative review of its antecedents, functions, and consequences. *Journal of Organizational Behavior*, 44(2), 311–334. <https://doi.org/10.1002/job.2653>
- Thomas, A., & Gupta, V. (2021). Social capital theory, social exchange theory, social cognitive theory, financial literacy, and the role of knowledge sharing as a moderator in enhancing financial well-being: From bibliometric analysis to a conceptual framework model. *Frontiers in Psychology*, 12, 664638. <https://doi.org/10.3389/fpsyg.2021.664638>
- Wang, Z., Guan, C., Ren, S., & Cai, S. (2022). Workplace ostracism and team members' creativity: The mediating role of self-reflection and moderating role of high-involvement work practices. *Journal of Management & Organization*, 1–19. <https://doi.org/10.1017/jmo.2022.22>
- Wax, A., Rodriguez, W. A., & Asencio, R. (2022). Spilling tea at the water cooler: A meta-analysis of the literature on workplace gossip. *Organizational Psychology Review*, 12(4), 453–506. <https://doi.org/10.1177/20413866221112383>
- Weick, K. E. (1974). Middle range theories of social systems. *Behavioral Science*, 19(6), 357–367. <https://doi.org/10.1002/bs.3830190602>
- Weick, K. E. (1979). *The social psychology of organizing* (2nd ed.). McGraw-Hill. <https://doi.org/10.3917/mana.182.0189>
- Wu, X., Kwan, H. K., Wu, L. Z., & Ma, J. (2018). The effect of workplace negative gossip on employee proactive behavior in China: The moderating role of traditionality. *Journal of Business Ethics*, 148(4), 801–815. <https://doi.org/10.1007/s10551-015-3006-5>
- Zhao, H., & Ma, Y. (2025). How is it going to end? Negative workplace gossip about coworkers, compensatory ethics and gossipers helping behavior toward coworkers. *Personnel Review*. Advance online publication. <https://doi.org/10.1108/pr-04-2024-0316>
- Zhao, L., Khalid, M., Khan, A. K., & Ma, Y. (2024). Negative workplace gossip and knowledge hiding: Roles of duty orientation and psychological entitlement. *Knowledge Management Research & Practice*, 22(2), 198–209. <https://doi.org/10.1080/14778238.2023.2297070>



## ESG REPORTING IMPLICATIONS FOR ROAD CARRIERS' FINANCIAL OUTCOMES

**Desislava Yosifova\*, Magdalena Petrova-Kirova**

*Todor Kableshkov University of Transport, Faculty of Transport Management, Bulgaria*

**Abstract:** Until the end of 2023, European legislation does not impose an obligation but provides freedom to companies whether to implement ESG reporting. The conceptual idea of the study is to verify whether and to what extent non-financial ESG reporting of companies - road transport companies, has an impact on their financial results and subsequent business behavior (of their management and of external stakeholders - contractors and others).

The analyzed sample includes 12 companies: 2 large Bulgarian companies from road freight transport (internationally licensed) and an additional sample of 10 SME- subsidiaries of large foreign companies (when forming control groups for the needs of the difference-in-differences analysis). These companies operate on Bulgarian territory, have ESG reporting and are related to the transport, logistics, courier sectors, as well as the field of communications and telecommunications services. To evaluate the results and test the research hypotheses, value analysis methods, as well as statistical methods and models, were used. The regression model was tested for the absence of multicollinearity, autocorrelation and heteroskedasticity. The data included in the study were processed by Gretl statistical software. A difference-in-differences analysis was conducted using Stata software to trace (possibly confirm) a causal relationship and measure the effect of ESG Reports disclosure. The constructed multiple regression model is based on an accounting-oriented approach focused on operating profit. After performing correlation and regression analysis and according to the constructed models, the presence of a relationship and dependence between the values of the calculated indicators and EVA was verified and established.

**Keywords:** road companies, ESG reporting, corporate sustainability, financial outcomes; regression & correlation dependence.

---

\* Corresponding author: [diosifova@abv.bg](mailto:diosifova@abv.bg)

Desislava Yosifova, ORCID: 0009-0007-1430-6093

Magdalena Petrova-Kirova, ORCID: 0009-0008-3550-6438

## 1. INTRODUCTION

For the purposes of this study, the research sample included a total of 12 /twelve/ enterprises – two large Bulgarian companies that carry out freight road transport and ten small and medium-sized Bulgarian subsidiaries of foreign enterprises as an additional control sample created for the needs of the difference-in-differences analysis.

For the research 7-year period (2017-2023), European and Bulgarian legislation does not oblige the companies included in the sample but provides them with a voluntary opportunity to prepare an ESG report and, accordingly, to choose an existing international standardization base (The European Parliament Directive (EU) 2022/2464, 2022).

## 2. LITERATURE REVIEW

In recent decades, a number of analysts have researched the impact of factors influencing the disclosure of social and environmental information by companies working in various economic industries (Petrova-Kirova & Yosifova, 2024). A large part of the inquiries study factors affecting the extent of information disclosure on environmental and social performance such as enterprises categories based on quantitative criteria (average number of employees, book value of the assets, net sales revenue) various profitability ratios, indicators of financial leverage, commercial reputation (Dyduch & Krasodomska, 2017; Echave, 2010; Szadzińska et al., 2018).

Some of the research conducted confirms while others reject and do not link ESG reporting practices to companies achieving certain financial outcomes. For some companies a direct relationship is established between Return on Assets, Return on Equity and various social and environmental indicators (Churet & Eccles, 2014; Dragu & Tiron-Tudor, 2013; Borodin & Shash, 2019).

In this regard, part of the factors described above is included as variables in an analytical model for the necessities of the study. In order to evaluate the results, the toolkit of financial analysis (accounting-oriented approach and value analytical methods) was used, as well as statistical methods and models.

To improve the quality of the research results, the regression model was tested for the absence of multicollinearity, autocorrelation and heteroskedasticity.

The data included in the study was processed by Gretl statistical software. A difference-in-differences analysis was conducted using Stata software in order to trace (search for and possibly prove) a causal relationship and measure the effect of ESG disclosure.

## 3. METHODOLOGY BASED ON AN ACCOUNTING-ORIENTED APPROACH

According to the research conducted on the possible impact of the picked factors on the scope of disclosed ESG information, the following multiple regression model was built.

$$FP_{it} = \alpha_0 + \alpha_1 ESG_{1it-1} + \alpha_2 SIZE_{2it-1} + \alpha_3 RISK_{3it-1} + \varepsilon_{it} \quad (1)$$

The model construction is based on an accounting-oriented approach focused on the operating profit of the company. The Return on Sales Ratio (ROS) is used as an indicator to measure the efficiency of the company's activity.

**ESG<sub>it-1</sub>** – Disclosure Index (DI<sub>esg</sub>) of environmental and social performance indicators:

$$DI_{\text{esg}} = \sum D_{\text{id}} / \sum D_{\text{i (total)}} \quad (2)$$

$\sum D_{\text{id}}$  – the sum of the number of disclosed environmental and social indicators.

$\sum D_{\text{i (total)}}$  – the sum of the total number of possible environmental and social indicators.

$SIZE_{it-1}$  – size of the company for the previous reporting period. The index is proportional to the book value assets of the company.

$RISK_{it-1}$  – this ratio measures the financial dependence of the company or Financial Leverage Ratio. Correct risk management is a guarantee for successful and sustainable business development (Kolev, 2024).

#### 4. DATA AND RESULTS

Correlation analysis was performed to examine the dependence between financial outcomes (ROS) and disclosure of ESG information (disclosure index DI was used) with a time lag of 1 year.

The obtained result shows a one-way (directly proportional) medium-strength relation between the two variables, with a correlation coefficient of  $r \approx 0.54$  (table 1). Therefore, as the amount of ESG information disclosed in a given reporting year increases, the Return on Sales Ratio for the next reporting year increases.

Table 1. Correlation coefficient

Variables	ROS (y)	NFI (x)
ROS (y)	1,000000	
NFI (x)	0,5377	1,000000

Source: based on own calculations and Gretl Software

In this regard, the influence of three factor variables - disclosure of ESG information, company size and financial leverage for a given reporting period, on the Return on Sales (ROS) for a subsequent reporting period was investigated.

$$ROS_{it} = a_0 + a_1 ESG_{it-1} + a_2 SIZE_{it-1} + a_3 RISK_{it-1} + \varepsilon_{it} \quad (3)$$

In order to test the existence of independence within factor variables and therefore presence or absence of multicollinearity, the following correlation matrix was constructed:

Table 2. Multicollinearity test

Variables	ESG (x)	SIZE (x)	RISK (x)
ESG (x)	1,000000		
SIZE (x)	-0,051121	1,000000	
RISK (x)	-0,490763	-0,060641	1,000000

Source: based on own calculations and Gretl Software

Based on the results obtained from the correlation matrix above, the existence of multicollinearity is rejected. It is summarized that all three factor variables: ESG information (through the disclosure index), company size (with the calculated index) and leverage ratio, can remain in the model proposed above and be analysed.

The value of the Durbin-Watson coefficient based on the calculation results is approximately equal to  $d \approx 2,00$ . Comparing the empirical and theoretical values no autocorrelation was found.

White and Breusch-Pagan (BP) tests were additionally performed using the statistical software (Gretl). The results confirm the absence of heteroskedasticity in the model.

A regression analysis was performed which shows that the empirical significance of the F-criterion exceeds its theoretical significance at  $\alpha = 0.05$ . In this regard, at  $\text{Sig } F < \alpha$ , it should be assumed that more detailed disclosure of ESG information for a given reporting period affects the financial outcomes for the following reporting period(s) to some extent.

## 5. METHODOLOGY BASED ON A VALUE ANALITICAL APPROACH AND DID ANALYSIS

To assess the impact of ESG reporting on the financial outcomes of the company and, respectively, on the value creation over time key ESG indicators are derived for transport and logistics companies. They have been determined as material based on an in-depth analytical review of the annual reports of the sampled companies.

Four analytical models were built to examine the influence of the key ESG indicators on the financial outcomes of the Bulgarian transport companies.

Model 1: Energy consumption within the entity

$$EVA_{it} = a_0 + a_1 ESG_{(E1)it-1} + \varepsilon_{it} \quad (4)$$

Model 2: Relative share of greenhouse gas (GHG) emissions

$$EVA_{it} = a_0 + a_1 ESG_{(E2)it-1} + \varepsilon_{it} \quad (5)$$

Model 3: Number of employee

$$EVA_{it} = a_0 + a_1 ESG_{(S1)it-1} + \varepsilon_{it} \quad (6)$$

Model 4: Improving the qualification of employee

$$EVA_{it} = a_0 + a_1 ESG_{(S2)it-1} + \varepsilon_{it} \quad (7)$$

The results of the analysis carried out in the four models based on a value analytical approach using the economic value-added indicator show the presence of a correlation dependence of different strength and direction (Kasarova, 2013).

Table 3. Summarizing the results of the correlation analysis

Models	Correlation coefficient (r)
1. $EVA_{it} = a_0 + a_1 ESG_{(E1)it-1} + \varepsilon_{it}$	-0.7543
2. $EVA_{it} = a_0 + a_1 ESG_{(E2)it-1} + \varepsilon_{it}$	-0.5186
3. $EVA_{it} = a_0 + a_1 ESG_{(S1)it-1} + \varepsilon_{it}$	-0.7913
4. $EVA_{it} = a_0 + a_1 ESG_{(S2)it-1} + \varepsilon_{it}$	0.6613

Source: based on own calculations and Gretl Software (Damodaran, 2024)

To trace a causality between the disclosure of ESG information and the financial outcomes of the studied Bulgarian companies, a difference-in-differences (DID) analysis was

conducted with the formed control group of subsidiaries from another related economic sector. These are companies from the field of logistics and communication services (related to transport services) which disclose ESG information voluntarily as part of the structure of large foreign companies.

Table 4. Difference-in-differences analysis

ROS_BG	Coefficient	Std. err.	T	P >  t	[95% conf. interval]	
ESG_treated	-.016944	.0300657	-1.70	0.090	-.080101	.0398925
Time	-.047691	.0275040	-1.95	0.045	-.097854	.0005044
DID	.059691	.0395441	1.79	0.071	-.005095	.1402797
Risk	-.019776	.0095249	-2.12	0.031	-.039352	-.0024981
Size	-.005876	.0091581	-0.59	0.454	-.022579	.012786
_cons	.1806171	.0667271	2.51	0.021	.044247	.3150881

Source: based on own calculations and Stata Statistical Software

The DID coefficient reflecting the average effect of the impact of the disclosure of ESG information on the financial outcomes of the companies operating in Bulgaria indicates the existence of a certain positive effect significant at a level of 10%.

## 6. CONCLUSION

➤ Correlation and regression analyses were performed in the research sample and in this regard, a positive, one-way relationship and dependence was established between the disclosed ESG information for a given reporting period and the financial outcomes of the companies in subsequent reporting periods (based on an accounting-analytical approach and a built model).

➤ The annual reports of the companies were studied and key ESG indicators were derived.

➤ After performing a correlation and regression analysis, the existence of a relationship and dependence between the values of the calculated indicators and the economic value added (EVA) of Bulgarian road carriers was verified and established (based on a value analytical approach and built models).

➤ A "difference-in-differences" analysis was conducted using Stata software to investigate the effect of ESG disclosure on the financial outcomes of the studied transport companies. The existence of a causal relationship is observed at a significance level of 10%.

## ACKNOWLEDGMENT

This study was carried out within the research project Market analysis and documentation development for licensing of professions in economic, social and legal sciences and their interaction with Transport Business, funded by Todor Kableshkov University of Transport, session 2025.

## REFERENCES

Borodin, A. Shash, N. Panaedova, G. Frumina, S. Kairbekuly A. & Mityushina, I. (2019). The impact of the publication of non-financial statements on the financial performance of companies with the identification of intersectoral features. *Entrepreneurship and Sustainability*, 7(2), 1666-1685.

- Churet, C. & Eccles, R. (2014). Integrated reporting, quality of management, and financial performance. <https://onlinelibrary.wiley.com/doi/abs/10.1111/jacf.12054>
- Damodaran, A. (2024). Country Risk: Determinants, Measures, and Implications – The 2024 Edition. <https://pages.stern.nyu.edu/~adamodar/pdfiles/papers/countryrisk2024formatted.pdf>
- Dragu, I. & Tiron-Tudor, A. (2013). GRI Compliance and prerequisites of Integrated reporting for Asian-Pacific companies. *Annales Universitatis Apulensis Series Oeconomica*, 15(2), 432-442.
- Dyduch J. & Krasodomska, J. (2017). Determinants of Corporate Social Responsibility Disclosure: an empirical study of Polish listed companies. <http://www.mdpi.com/2071-1050/9/11/1934>
- Echave, O. (2010). Determinants of social and environmental disclosures by Spanish companies. [Conference session]. 2010 Spain. <http://ro.uow.edu.au/cgi/viewcontent.cgi?article=2955&context=commpapers>
- Gretl Statistical Software. <https://gretl.sourceforge.net/>
- Kasarova, V. (2013). The new metrics of corporate financial success. /Новите метрики на корпоративния финансов успех/, Evdemoniya Production Ltd. Sofia.
- Kolev, O. (2024). Methods of risk management in a transport company. *Journal Mechanics Transport Communications*, 22 (3/3), III-16 – III-20.
- Petrova-Kirova & M. Yosifova, D. (2024). Statistical dependencies between non-financial disclosures and ex-post financial performance in the Bulgarian road freight transportation industry. *Journal Transport Problems*, 19(1), 171-184. <https://doi.org/10.20858/tp.2024.19.1.14>
- Stata Statistical Software. <https://www.stata.com/>
- Szadziewska, A. Spigarska, E. & Majerowska, E. (2018). The disclosure of non-financial information by stock-exchange-listed companies in Poland, in the light of the changes introduced by the Directive 2014/95/EU. <https://www.ceeol.com/search/article-detail?id=697461>
- The European Parliament. (2022). Directive (EU) 2022/2464, Official Journal of the European Union. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464>





## INTELLIGENT TRANSPORT SYSTEMS AS A TOOL FOR SPEEDING PREVENTION

Veselin Grozdanov\*

*Todor Kableshkov University of Transport, Faculty of Transport Management, Bulgaria*

**Abstract:** Car traffic on the road network is increasing every year, which leads to accompanying problems with compliance with traffic rules. Road accidents in Bulgaria are an annual unwanted event, which leads to significant material and financial losses, both for individuals and businesses, but burden society with unnecessary costs. The largest number of accidents remains due to incorrect actions of drivers (about 6 thousand on an annual basis), with approximately 28% of them being due to excessive and inappropriate speed.

The state, represented by the Traffic Police under the Ministry of Interior (Republic of Bulgaria), carries out periodic actions (with some dubious success) to deal with the constantly increasing number of road accidents. The statistics of constantly increasing road accidents are not a precedent only for Bulgaria, but are noticeable on a global scale. Various events are being held in different countries around the world to deal with this negative trend. One of the most promising methods for dealing with this significant problem are intelligent transport systems. Creating innovative transport solutions for sustainable mobility can allow users to reach their destination conveniently, on time, safely, efficiently and with minimal environmental impact. The main directions and goals of implementing ITS in road transport are to achieve safe and secure transport.

**Keywords:** traffic accidents, fatalities, speeding, intelligent transportation systems.

### 1. INTRODUCTION

Car traffic on the road network is growing faster than the infrastructure itself is developing. To cope with the dwindling capacity of the roads, it is necessary to increase the average speed. However, the higher speed of driving vehicles leads to concomitant problems with compliance with traffic rules on the roads. During national or other holidays, when more than two days off are combined during the weekend, a large part of the population undertakes trips from their places of residence to nearby resorts, and from Western Bulgaria they undertake a trip to Greece. The city of Sofia (the capital of Bulgaria) is closer to the Greek Sea than to the Bulgarian Black Sea coast. During these trips on holidays, but not only, a significant number of traffic violations are committed, namely systematic speeding.

---

\* Corresponding author: [vesko\\_vtu@abv.bg](mailto:vesko_vtu@abv.bg)

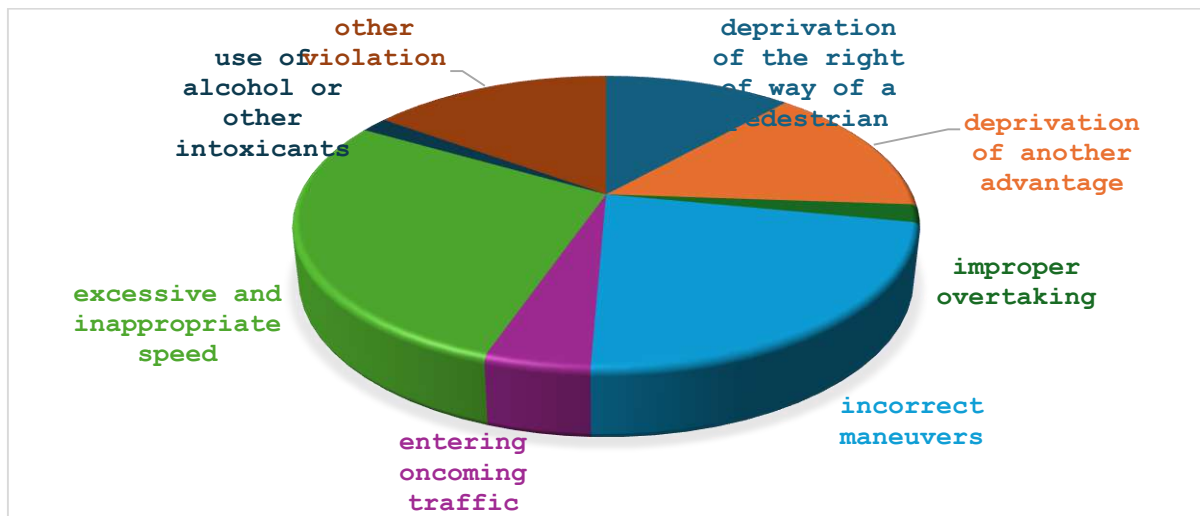
Veselin Grozdanov, ORCID: 0009-0004-3296-790X

## 2. STATISTICAL OVERVIEW

Road accidents in Bulgaria are an annual unwanted event, leading to significant material and financial losses, both for individuals and businesses, but also burdening society with unnecessary costs. In 2022, about 5,400 road accidents were registered on Bulgarian roads, resulting in 427 deaths and 7,300 injuries. Compared to the previous year, the number of road accidents increased by 6.5%, the number of deaths by 21%, and the number of injuries by 7%. The number of accidents due to incorrect actions of drivers remains the highest, with approximately 28% of them due to excessive and inappropriate speed.

*Table 1.* Road traffic accidents, deaths and injuries caused by drivers of road vehicles according to the violations committed (Statistical Yearbook of the Republic of Bulgaria, 2023)

Violations	Road accident		dead		wounded	
	number	%	number	%	number	%
Total	5409	100	427	100	6782	100
deprivation of the right of way of a pedestrian	631	11.7	23	5.4	646	9.5
deprivation of another advantage	782	14.5	33	7.7	1074	15.8
improper overtaking	106	2	9	2.1	152	2.2
incorrect maneuvers	1221	22.6	87	20.4	1527	22.5
entering oncoming traffic	251	4.6	45	10.5	422	6.2
excessive and inappropriate speed	1517	28	158	37	1932	28.5
use of alcohol or other intoxicants	91	1.7	6	1.4	133	2
other violation	810	15	66	15.5	896	13.2



*Figure 1.* Road traffic accidents, deaths and injuries caused by drivers of road vehicles according to the violations committed (Statistical Yearbook of the Republic of Bulgaria, 2023)

## 3. PERIODIC ACTIONS (WITH A CERTAIN DUBLIN SUCCESS) TO DEAL WITH THE CONSTANTLY INCREASING NUMBER OF ROAD ACCIDENTS

To ensure smooth operation and without unnecessary congestion of traffic flows, adequate traffic regulation is necessary to comply with local traffic regulations, such as speed limits at all times of the day.

The state, represented by the Traffic Police under the Ministry of Interior of the Republic of Bulgaria, carries out periodic actions (with some dubious success) to deal with the constantly increasing number of road accidents resulting from failure to comply with road restrictions or

driving at an inappropriate speed. To establish speeding violations, various devices are used to measure the instantaneous speed of individual motor vehicles. Known under the general name automated technical means and speed systems (ATSS). ATSS are devices designed to control compliance with speed limits on the road network in the Republic of Bulgaria and are generally divided into stationary and mobile.

The operation of the ATSS does not require direct service from a law enforcement officer, except for the initial positioning and adjustment of the equipment. All other processes from speed measurement to the preparation of the relevant photo or video material are performed by the device without the participation of a Ministry of Interior officer.



*Figure 2. Movable stationary camera for instantaneous speed detection*

According to the Ministry of Interior of the Republic of Bulgaria, road control throughout the country is carried out by 173 ATSS (Ministry of Interior, 2025):

- 15 stationary speed systems - Functional capabilities of the system are: it works stationary, allows measurement in both directions in day and night mode, allows recording of vehicles. The principle of speed measurement is based on the Doppler effect. In the control calculation, the path that the vehicle has traveled during the time between the two photos in one measurement is determined by photometric processing of the reduction of the license plate. The speed value can be calculated based on this path and the time between the two recordings;

- 148 mobile systems - They are characterized by exceptional functionality and efficiency. Unlike stationary technical means, which can control one or two parameters of automobile traffic simultaneously, mobile technical means have relatively unlimited capabilities;



*Figure 3. Stationary camera for instantaneous speed detection ([бул. „Пејо К. Яворов“ - Google Maps](#) 2024)*

- 8 stationary systems - The stationary system for measuring speed in both directions, which further facilitates the clear identification of the violation through range control on multi-lane roads;
- 1 unit of automatic speed detection system - This is a radar with a wide beam angle, capable of tracking a large number of vehicles simultaneously. The radar used monitors several lanes simultaneously at a distance of up to 150 m in depth. Vehicles are tracked within the radar range and their movement is analyzed;
- 1 piece of average speed control system - This is a radar with a large beam angle, with the ability to track a large number of vehicles simultaneously. The radar used monitors several lanes simultaneously at a distance of up to 150 m in depth. Vehicles are tracked within the radar range and their movement is analyzed.

#### 4. DEVELOPMENT

Technologies used in intelligent transport systems range from simple management measures, such as cameras to measure instantaneous speed, to applications for detecting stopped vehicles or automatic incident detection.

Globalization and digitalization of the new era have changed a number of traditional industries and forms of communication (Kolev & Ananiev, 2019).

In 2025, after long discussions, a tentative move was made to use the built infrastructure of stationary cameras of the "National Toll Administration" at the Road Infrastructure Agency.

The "National Toll Administration" is a specialized unit at the Road Infrastructure Agency, created with the introduction of an electronic system for collecting road fees based on distance traveled for vehicles with a total technically permissible maximum mass over 3.5 tons (TOL) and based on time for passenger cars with a total technically permissible maximum mass up to or equal to 3.5 tons - electronic vignette (National Toll Administration, 2025).

Initially, road vehicles were charged for using the road network of the Republic of Bulgaria through the purchase of vignette stickers. The stickers on the windshields of motor vehicles were replaced with electronic vignettes for all participants in traffic on the Republican road network. Since March 2020. Toll fees replaced electronic vignettes and the charging of vehicles with a total technically permissible maximum mass of over 3.5 tons based on distance traveled.

In order to use the built infrastructure of the "National Toll Administration", it is necessary to make regulatory changes to the Bulgarian legislation. It is envisaged that average speed violations can be established by the bodies of the Ministry of Interior (Republic of Bulgaria) through the technical means of the electronic system of the Road Infrastructure Agency.



Figure 4. Infrastructure of the National Toll Administration ([E80 - Google Maps](#), 2024)



The main directions and goals of the implementation of ITS in road transport are to achieve safe and secure transport. New driver assistance and safety systems have a preventive effect, since more than 90% of road accidents occur due to human error (Nikolova 2017).

Modern cars are equipped with active and passive safety systems while driving. When a motor vehicle enters a section where average speed control is carried out, the tablet in the car displays information about the relevant restriction imposed by road signs and calculates the average speed from the moment of entering this section until leaving it.

The cameras of the National Toll Administration calculate an average speed for the entire section and assume that the movement of motor vehicles is a constant value, while the average speed in the vehicle is calculated every second.

In this way, a driver could monitor his safe movement in a given section. If at a certain moment the maximum permissible (current) speed was exceeded, he could regulate the passage through the second camera by reducing his speed in the remaining measured section.

The calculation of average speed is made only in one place in Bulgaria on the Struma motorway between Sofia (the capital of Bulgaria) and the city of Pernik (a satellite city of Sofia). Every day thousands of workers travel between the two settlements. Figure 5 shows an example of calculating average speed in a vehicle.



Figure 5. Intelligent transport system on board the vehicle (photo of the author from his personal vehicle)

## 5. CONCLUSION

Excessive speed is the cause of most fatal accidents, which is why it is extremely difficult for traffic control authorities to effectively manage excessive speed using traditional approaches.

Prioritizing mobility safety through the use of modern technologies is one of the key factors in reducing road accidents.

For adequate prevention of excessive speed, it is necessary to involve not only the Ministry of Interior (Republic of Bulgaria), but also other state bodies that have certain capabilities and capacity (built with public funds). Such a body is the Road Infrastructure Agency with its division National Toll System.

Connecting vehicles to the transport infrastructure for constant data exchange is the next step in the development of a safe road network not only at the national level, but also globally.

Road safety is built on the following components:

- training of candidate drivers;
- acquired skills by drivers;
- high technologies in the construction of road infrastructure;
- high technologies in automotive manufacturing;
- effective control by the relevant state authorities.

## REFERENCES

- Kolev, O. Ananiev, S. (2019) Logistics platform - Integrated instrument for management and optimization of transport - logistics process in transport. *Scientific Journal Mechanics Transport Communications*. 2019. Vol. 17. No 3. P. III-166 – III-171, ISSN 1312-3823 (print). <https://mtc-aj.com/library/1817.pdf>;
- Ministry of Interior - Traffic police. (2025). Automated technical means for speed control. <https://Automated speed control technologies>;
- National Toll Administration. About us. <https://BG TOLL>.
- Nikolova, Hr., (2017) Intelligent transportation systems, (page 64). Bulgaria. UNWE Publishing Complex;
- Statistical Yearbook of the Republic of Bulgaria . (2023). <https://God2023.pdf>.



## ECOLOGICAL DEBT RISK – HAVE WE ALREADY SPENT OUR RESOURCES FOR 2025?

Marija Panić\*

*University of Belgrade, Technical Faculty in Bor, Serbia*

**Abstract:** Of all the material resources on Earth, the potential for biological regeneration is the most limited. For this reason, it is essential to map all of our demands against biocapacity. Adopting this biological viewpoint makes it evident which strategies are likely to succeed and which are bound to fail. Each year, the Global Footprint Network announces the day the world enters ecological debt, which is an estimate of the point in the year at which we have globally consumed more resources than the Earth can renew in one year. Calculations typically say that global ecological debt day is mid-summer. The ecological debt day of specific countries shows a slightly different assessment, which raises the question of when the global ecological debt day would occur if the world spent on average the same as that particular country. The calculation is done per capita, so countries whose per capita consumption is relatively low have no ecological debt at all. Serbia, which already entered the ecological debt in the middle of spring 2025, consumes resources faster than the world average and somewhat slower than the European Union.

**Keywords:** Global Footprint Network, ecological debt, resources, biocapacity.

### 1. INTRODUCTION

Biocapacity is the most valuable asset. Of all the material resources on Earth, the potential for biological regeneration is the most limited. For this reason, it is essential to map all of our demands against biocapacity (Global Footprint Network, 2025). Our times are unique. Most of us consider our massive reliance on fossil fuels to be normal. It is quite abnormal. Eighty percent of all fossil fuels burned in human history occurred in the previous fifty years. A sustainable approach is better for the economy and mankind, beginning with those who make decisions. Without this perspective, we place our companies, communities, and nations in increasingly unavoidable pitfalls (Wackernagel & Beyers, 2019).

---

\* Corresponding author: [mpanic@tfbor.bg.ac.rs](mailto:mpanic@tfbor.bg.ac.rs)

Marija Panić, ORCID: 0000-0001-7287-758X

In 1995, there was only a basic and approximate estimate of humanity in Canada. Around 1997, more methodical national calculations began to be conducted. In 2003, the Global Footprint Network (GFN) was launched, providing time series dating back to 1961 and yearly updates for almost every nation on Earth. Additionally, unsustainable trends – from utilizing 1.3 Earths in 1995 to using 1.75 Earths today – have persisted almost unchecked. The majority of policymakers continue to overlook or prefer to ignore the fact that humanity, and every country that possesses resources, is endangering its capacity to function in the absence of resource security. Therefore, the task of figuring out how to make the necessity of resource security more apparent to a variety of audiences was set (Wackernagel & Beyer, 2019).

This paper analyzes the entry into ecological debt based on the 2025 edition of National Footprint and Biocapacity Accounts (NFBAs), which provide the core data required for all ecological footprint and biocapacity analysis.

## 2. LITERATURE REVIEW

The productivity of the earth's biological resources, such as lands used for farming, grazing, forestry, and fishing, is known as biocapacity. These spaces can also absorb waste, such as carbon emissions from burning fossil fuels (Global Footprint Network, 2025). However, as the demand for power rises, more available resources must be used.

The ecological footprint quantifies the ecological resources – which correspond to those discussed while establishing biocapacity – necessary to generate the natural resources that a particular population can consume. Therefore, ecological footprint is a demand concept, whereas biocapacity is a supply concept (Sravan & Mishra, 2024).

Numerous research studies have demonstrated that energy production negatively affects the ecological footprint and, in turn, biocapacity (Logan et al., 2021; Ristić et al., 2019). Although the pollutants and increased resource use from industrial power may directly contribute to the biocapacity deficit, this is not to argue that the other sectors that use electricity are completely unaffected. Domestic electricity use is probably going to increase as urbanization increases. The demand for energy in the commercial sector is fueled by the digitalization of enterprises and the growth and diversity of commercial activity. This ultimately accelerates the population's ecological footprint, perhaps surpassing biocapacity and resulting in a deficit.

The significance of sustainable consumption has increased as a result of these worries. The definition of sustainable consumption is “the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations” (Roy, 2021). The foundation of sustainable consumption is a shift in people's habits and lifestyles. According to Dermody et al. (2018), realizing sustainable consumption may result from emerging economies' shift toward global economic development. However, it has been noted that electricity use negatively affects biocapacity by increasing emissions (Feng et al., 2023). Fossil fuels and other resources used to produce power are not the only sources of this growth in emissions. Inappropriate use of electricity is another factor. Therefore, it is essential to consider how to use such electricity efficiently. However, understanding the consequences of a biocapacity shortfall requires more due to the possibility of either national or worldwide biocapacity being exhausted (Gabbi et al., 2021).



The Global Footprint Network (GFN) announces the day the world enters ecological debt yearly. The GFN calculates the time of year when global resource consumption exceeds what the planet can restore in a single year. We know that excessive energy and material consumption in high-income countries contributes to the ecological collapse of the world.

The concept of ecological debt emerged in the early 1990s as a result of social movements spurred by an increasing awareness of environmental issues (Jernelöv, 1992). The ecological footprint and biophysical capacity statistics allow us to determine a country's ecological surplus or deficit (Loh, 2000). Ecological debt and environmental justice have long been associated. When employed as a vehicle to promote a reconsideration of political-economic ties, ecological debt offers a number of advantageous characteristics that can further the worldwide struggle for environmental and social justice (Warlenius et al., 2015).

### 3. DATA AND METHODOLOGY

Originally based in the United States, Belgium, and Switzerland, the *Global Footprint Network (GFN)* is an independent think tank that was established in 2003 as a non-profit charity organization in each of those three nations. Oakland, California, is home to the organization's headquarters. More than 70 partner organizations are part of the network. Its goal is to create and disseminate instruments for promoting sustainability, such as the ecological footprint and biocapacity, which quantify our resource consumption and availability. GFN aims to put ecological boundaries at the forefront of decision-making. It unites economics, policy, and science to transform global resource management and build a sustainable future in which all people can live comfortably on Earth (Global Footprint Network, 2025).

The *National Footprint and Biocapacity Accounts (NFBAs)*, which offer the fundamental information needed for all ecological footprint and biocapacity analyses, are generated annually by GFN. York University's Ecological Footprint Initiative for the Footprint Data Foundation (FoDaFo), founded in 2019, is currently in charge of maintaining them (FoDaFo, 2025). The NFBAs track a country's ecological resource capacity and utilization over time and compute the footprints of over 200 nations, territories, and areas from 1961 to the present, using about 15,000 data points per nation-year. On Earth day (April 22, 2025), the 2025 edition was introduced. More than a dozen nations have used these statistics to shape their policies.

The *Ecological Footprint (EF)* is calculated by measuring the amount of biologically productive land required to meet all humankind's conflicting demands. These needs include areas for growing food, producing fiber, regenerating timber, absorbing carbon dioxide emissions from burning fossil fuels, and making room for constructed infrastructure. Imports are added to a nation's national production, and exports are subtracted to determine its consumption. EF is calculated using the following formula (Global Footprint Network, 2025):

$$EF_C = EF_P + (EF_I - EF_E) \quad (1)$$

where:

- $EF_C$  – ecological footprint of consumption
- $EF_P$  – ecological footprint of production
- $EF_I$  – ecological footprint of imports
- $EF_E$  – ecological footprint of exports

*Earth Overshoot Day (EOD)*, formerly known as Ecological Debt Day, is the day on which human activity has depleted nature's annual budget. Society continues to function in ecological overshoot throughout the remainder of the year by depleting local resource reserves and raising atmospheric carbon dioxide levels.

The date on which the planet's annual biocapacity budget would run out if everyone on Earth lived at the same level of consumption as the citizens of that specific nation is known as *Country Overshoot Day (COD)*. Using the most recent information from the most recent edition of the NFBAs, CODs are released every year in December for the previous year.

According to Global Footprint Network (2025), the day when a country's natural resources are exhausted is calculated by multiplying the number of days in the current calendar year by the difference between the global hectare per capita and the country's biocapacity. Biocapacity is the ability of ecosystems to produce biological material used by humans and to absorb waste materials produced by humans according to a country's current management, while the global hectare defines a country's productivity per capita.

#### 4. RESULTS AND DISSCUSION

December 19, 1987, was the first Earth Overshoot Day (EOD) (Figure 1). In 2014, EOD was August 19; 2015, August 13 (Roppolo, 2014); and 2016, August 8 (Mosbergen, 2016). EOD landed on August 2, 2017, and August 22, 2020. In 2024, EOD fell on August 1.

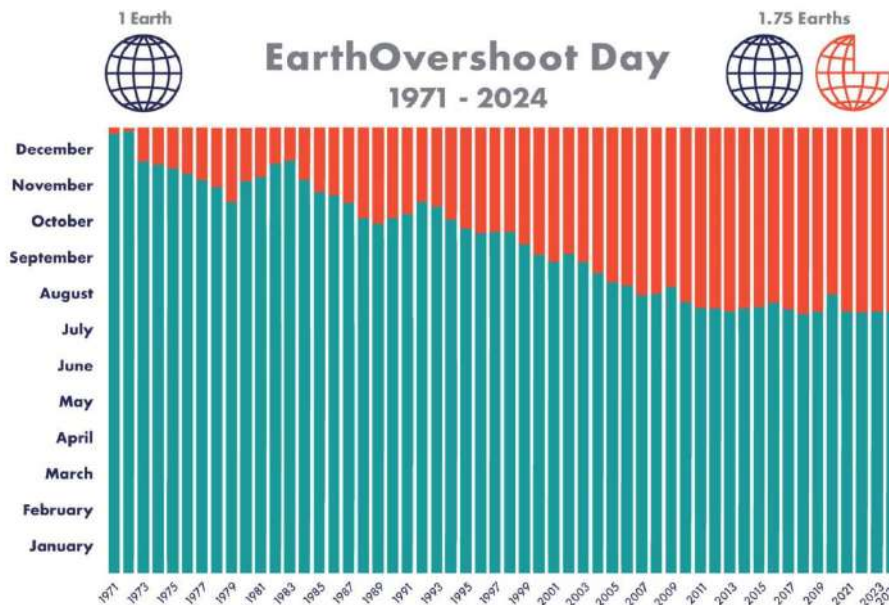


Figure 1. Earth Overshoot Days 1971-2024 (Earth Overshoot Day, 2025)

According to Global Footprint Network (2025) calculations, humanity has already used up all of the planet's renewable resources in one year. As a result, humanity is living "on credit," and 1.75 Earths would be needed to meet everyone's demands.

It is incorrect to infer past EODs based solely on reports from prior years. For example, comparing the date of EOD 2007 as it was determined and publicized at the time with the EOD 2024 would be pointless because the results have been slightly shifted by new findings, such as lower net carbon sequestration by forests, and improved historical data. EOD can be moved by a significant number of days with a change of just a few percent.

#### 4.1. Ecological Footprint

The global ecological footprint analysis provide insight into a country's ecological impact. If a country's ecological footprint is less than its biocapacity, it is considered an ecological reserve. If not, it is functioning with an ecological deficit, as indicated by the proportion of the ecological footprint above the biocapacity. The majority of nations and the entire world are currently experiencing ecological deficits. More than 85% of people on the planet now reside in countries with a global ecological overshoot or deficit.

Table 1 shows Serbia and the countries in the region's ecological footprint for 2025, according to the size of the ecological deficit in relation to the best and worst-ranked countries in the world.

*Table 1.* Ecological footprint by country 2025 (Open Data Platform, 2025; World Population Review, 2025)

Country	Total ecological footprint (HA)	Ecological footprint per person (HA)	Total biocapacity (HA)	Biocapacity per person (HA/capita)	Ecological reserve or deficit
French Guiana	521K	1.8	26.1M	91.8	4,900%
Suriname	2M	3.4	46.2M	77	2,160%
Guyana	3.6M	4.6	57.1M	71.4	1,460%
Croatia	15.7M	3.8	10.3M	2.5	-53%
Montenegro	2.8M	4.5	1.8M	2.8	-59%
Albania	6M	2.1	3.2M	1.1	-87%
<b>Serbia</b>	<b>26.7M</b>	<b>3.6</b>	<b>14.2M</b>	<b>1.9</b>	<b>-88%</b>
N. Macedonia	6.3M	3	3.2M	1.5	-97%
B&H	14M	4.2	6.8M	2	-100%
Slovenia	11M	5.2	5.2M	2.4	-110%
Singapore	39.9M	6.8	640K	0.1	-6,100%
Nauru	754K	62.1	1.6K	0.1	-46,000%

Serbia faces an ecological deficit (-88%) and an ecological footprint of 26.7M HA, almost double the total biocapacity. Of the countries in the region, it is only in a better position than N. Macedonia, B&H, and Slovenia.

The five countries with the highest ecological footprint (in hectares) are China (5.1B), the USA (2.6B), India (1.5B), Russia (848M), and Brazil (551M). Brazil (219%) and Russia (30%) have ecological reserves, while the rest have ecological deficits: China (-340%), India (-200%), and the USA (-110%).

The incomes and unbalanced resource consumption of China's population are increasing with the country's economy's continued rapid expansion. The ecological footprint of the average American is around half that of the average inhabitant in most European nations. Because of its greater suburban expansion and lack of public transit, the USA consumes more fossil fuels and produces more carbon dioxide per person than most other nations. In addition, Americans use more water and energy per person than people in the majority of similar, industrialized nations. Perhaps the country's pervasive poverty, which prevents many people from having the money to heat their houses or buy cars, is reflected in India's ecological footprint per capita. India has a low biocapacity per person, probably due to its lesser geographical area than China and the USA.

Nonetheless, there is a successful eco-footprint example. Due mostly to decreases in the use of fossil fuels, the UK's ecological deficit, which was the fifth greatest only a few years ago, has decreased by about 30% and is expected to continue to decline.

## 4.2. Country overshoot days and ecological debt days calculations

The preliminary 2025 edition, which was published on Earth day 2025 and is being created by FoDaFo, serves as the basis for the CODs for 2025. Based on the most recent national data, these dates were published in December 2024. They depict the condition in 2023 for the majority of nations. Calculations are modified for a 366-day year rather than 365 in leap years, such as 2024.

The results from 1961 to 2024 are included in the 2025 edition. Because of delays in data reporting, the results from 2022 to 2024 were based on a combination of real data and initial predictions. The list of CODs for 2025 can be seen in Figure 2.

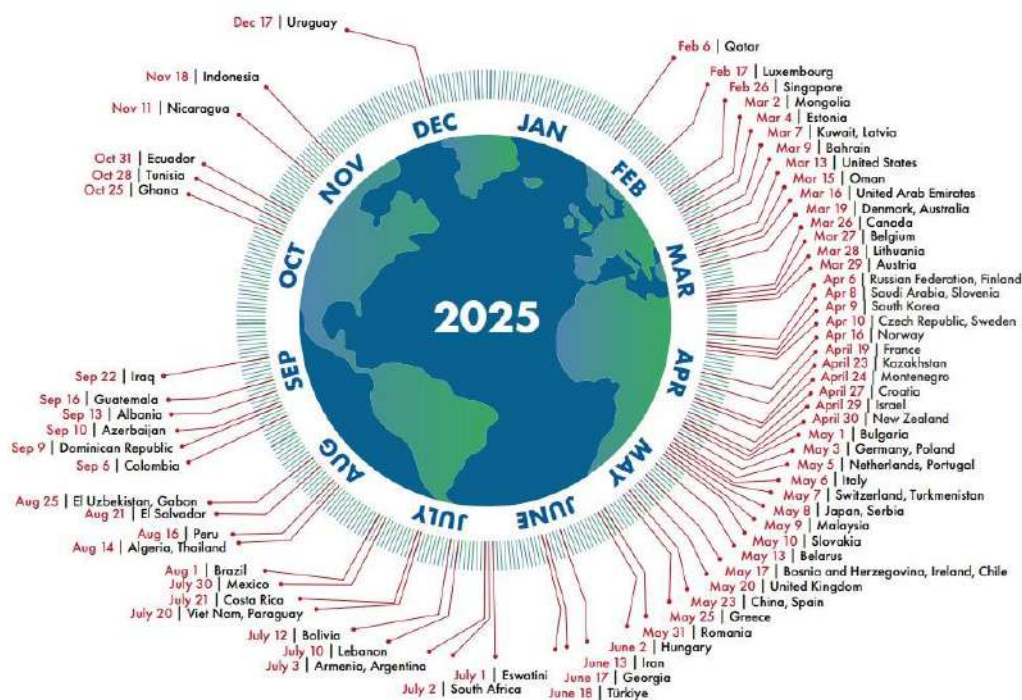


Figure 2. Country overshoot days 2025 (Global Footprint Network, 2025)

The GFN estimates the ecological debt date and evaluates the so-called global ecological debt day – when the world consumes as many resources as the Earth can renew in a year. That date is traditionally announced on June 5 every year, and in previous years, it was in the middle of summer. A specific country's ecological debt indicates when exactly the world would enter ecological debt if it consumed resources like that country on average.

This year, Serbia used up its resources on May 8, which means 15 days earlier than in 2024, when it used up the "annual resources" on May 23, and even 2 months earlier than in 2023, when it "raised" the credit from nature on July 8. This is when Serbia's annual demand and consumption of natural resources exceeded all the Earth can produce or renew throughout the year. So, all the resources nature gave Serbia for 2025 have been used up. This is Serbia's environmental debt date, meaning we live largely at the expense of future years and generations. All resources used after that day are out of balance with the ecosystem. This year, the date has been significantly moved to the detriment of the planet, including people. Since Serbia entered ecological debt on May 8, and the world will enter in mid-summer, Serbia is consuming resources faster and more unsustainably than the world average.

It is a worrying fact that Serbia steps into ecological debt much earlier every year than the previous year. When all the supplies that nature has prepared for us are used up, it means that the next half year is also spent in debt. However, this also has its explanation, which lies in the methodology of calculating the ecological debt towards the planet Earth, which is based on the data of the United Nations. The most important factor of this formula (man) lies in explaining the sudden jump backwards in Serbia regarding the ecological debt. Based on a country's population, the global hectare per capita is determined, and the smaller the country's population, the greater the environmental debt. Since the population census was carried out in Serbia in 2022, it showed that the number of inhabitants is lower compared to earlier periods, so the debt was entered earlier (World Wide Fund for Nature, 2024).

At the planet's level, the day of ecological debt last year was August 2, and the date it will be in 2025 will be announced on June 5. Given that we used up the annual resources in just seven months, humanity lives on unsustainable resources the rest of the year, depleting the planet. The picture would be even more devastating if everyone in the world spent like we do in Serbia. In that case, we would exhaust the available resources. Humanity is currently using nature 1.7 times faster than it can be regenerated. The ecological footprint of people living in countries like Germany and France is nearly twice that of the worldwide average, and if everyone lived as they do, there would need to be 3 to 3.3 Earths.

The European Union entered into ecological debt on April 27, and most of the countries in the region are in a similar framework as Serbia, except for Albania, which will enter into ecological debt on September 13. Based on statistical data, it can be concluded that Serbia has a positive trend concerning the region's countries, where the dates are close to last year's. In April and May 2025, almost all countries of the former Yugoslavia begin to owe the planet. The leaders are Slovenia (April 8), Montenegro (April 24) and Croatia (April 27). B&H entered environmental debt on May 17.

Several factors influence the calculation of ecological debt. One of them is accelerated industrialization, which increases the productivity of a territory but at the expense of natural resources. Industrialization, to the greatest extent, affects the planet's entire ecosystem, which implies the production of large amounts of carbon dioxide that is emitted into the atmosphere. This means that accelerated climate changes are occurring. To produce more food, we are clearing forests, drying up wetlands, and trying to exploit the seas, and these three ecosystems are the biggest absorbers of carbon dioxide. Of course, this does not mean we should carelessly accept this backward movement. On the contrary, now more than ever, we must take action to preserve what nature has given us.

It should be noted that, for example, back in 1971, the planet entered ecological debt on December 25, which means that five decades ago, the Earth had almost enough resources to meet the needs of civilization despite unsustainable production. From then until today, the demand for resources has increased, and we have outgrown the planet with our consumption habits. So far, the worst score, i.e., the earliest date within a year when we entered into ecological debt, was recorded on August 1, 2018, and 2022. During 2020, which was marked by the coronavirus pandemic and the accompanying lockdown measures, we were somewhat more frugal, so we entered into ecological debt globally on August 16.

Some countries do not have an overshoot day. If everyone consumed as those countries did, humanity would not surpass the planet's regenerative capacity in a year if the ecological footprint of that country per person was less than the global biocapacity per person. As a result, these nations are not included in Figure 2. Since data quality differs across UN datasets, some nations are also disqualified because their data is insufficient or untrustworthy.

Figure 2 clearly shows how unequal global consumption is because there are few African countries. For example, they do not even enter into ecological debt because they

consume fewer resources than nature can renew, and an individual's ecological footprint is less than the average global biocapacity per capita. If we all lived like them, the world would not even use the entire annual budget of renewable resources, and one Earth would suffice to meet the needs of humanity. In 2024, these were India, Pakistan, Yemen, Uruguay, and the Democratic Republic of Congo (Buchholz, 2024). The reason for this is more complex due to poverty, lower living standards, and limited access to resources. The reality is that, as long as we have an economic system that requires constant growth, overexploitation of resources will continue.

However, it should be kept in mind that the global picture includes all countries, starting with Qatar, which entered ecological debt only thirty-seven days after the beginning of the year (February 6, 2025), and Luxembourg (February 17), through Serbia, and up to Uruguay, whose ecological debt is forecast on December 17. As with any computation of this magnitude, the analysis has certain limitations. It is delayed by around one and a half years, and there are occasional gaps in the data, particularly for smaller nations.

On the other hand, if the entire global population lived like India, we wouldn't even be in ecological debt, considering that, to satisfy our needs in accordance with theirs, only four-fifths of the Earth would be enough for us. For the Afghans, even less: only two-fifths. This illustrates one of the many layers of injustice of the modern age. The countries of the Global South are, by and large, the least consumers of resources, but despite this, they bear the brunt of environmental degradation, climate change, and other negative impacts of overconsumption.

#### 4.3. Changes due to updated data inputs and due to the country's actual change in consumption levels

It is inaccurate to compare country overshoot days between NFBAs editions. Improvements in underlying data, rather than real changes in consumption, are responsible for some of the differences. The main data input changes include agricultural area data, updated grazing land and cropland statistics, global carbon budget data, revised estimates for marine carbon uptake, and trade classifications and modifications in carbon embodied in trade.

For these reasons, for most countries, the change resulting from changed input data is greater than the change resulting from changes in consumption. To make this clear, Table 2 contrasts actual changes in consumption patterns with the amount of change in overshoot dates caused by modifications in input data and methodology, for Serbia and the countries of the region.

*Table 2.* Country Overshoot Days in 2025 and changes due to updated data inputs and due to country's actual change of consumption levels (Global Footprint Network, 2025)

Country	Country Overshoot Day (2025)	Days earlier than the previous year due to changes in data	Days earlier than the previous year due to changes in consumption
Slovenia	April 8	17	0
Montenegro	April 24	27	4
Croatia	April 27	28	1
<b>Serbia</b>	<b>May 8</b>	<b>15</b>	<b>3</b>
B&H	May 17	-9	0
Albania	September 13	8	-1

## 5. CONCLUSION

Year by year, we are more and more careless towards nature. More carbon dioxide is emitted into the atmosphere than the oceans and forests can absorb. Fish stocks are being depleted faster than they can be replenished. Forests are being cut down unplanned and before they can regrow. The consequences are unprecedented heat waves, devastating forest fires, devastating floods, and dramatic droughts occurring more frequently around the world. It's up to us to stop it and turn it around. If we want the entry date into ecological debt to be later, we must turn to more sustainable development. In the future, we could improve the planet's worrying state by developing sustainable mobility, afforestation, and a transition to renewable energy sources.

The most effective way to start achieving results is to oblige all states to adopt and fully implement Nature Restoration Acts, regulations that will ban the use of single-use plastics and protect 30% of the Earth's surface as planned. It is possible to prevent and slow down the entry into ecological debt through the development of a sustainable economy, energy transition, and increased work on protecting existing resources. Environmental awareness must be raised to a higher level, ecology and economy must be connected, and we must behave more responsibly towards nature and its resources. It is the right time for the profession to unite and respect all laws and strategic documents. Every individual is responsible. That's why it is necessary to carry out primary separation of household waste, recycle, and sparingly use all our resources, especially water, which is the most important.

## ACKNOWLEDGMENT

The research presented in this paper was carried out with the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia within the framework of financing scientific research work at the University of Belgrade, Technical Faculty in Bor, in accordance with the contract with registration number 451-03-137/2025-03/200131.

## REFERENCES

- Buchholz, K. (2024). The Countries With No Earth Overshoot Day. Statista. <https://www.statista.com/>
- Dermody, J., Koenig-Lewis, N., Zhao, A. L., & Hanmer-Lloyd, S. (2018). Appraising the influence of pro-environmental self-identity on sustainable consumption buying and curtailment in emerging markets: Evidence from China and Poland. *Journal of Business Research*, 86, 333-343. <https://doi.org/10.1016/j.jbusres.2017.09.041>
- Earth Overshoot Day. (2025). Past Overshoot Days. <https://overshoot.footprintnetwork.org/>
- Feng, Y., Ahmad, M., & Waseem, L. A. (2023). Analysis of environmental sustainability and economic development from electricity consumption based on the modified spatial Durbin model. *Heliyon*, 9(9), e19755. <https://doi.org/10.1016/j.heliyon.2023.e19755>
- Footprint Initiative for the Footprint Data Foundation (FoDaFo). (2025). <https://www.fodafo.org/>
- Gabbi, G., Matthias, M., Patrizi, N., Pulselli, F. M., & Bastianoni, S. (2021). The biocapacity adjusted economic growth. Developing a new indicator. *Ecological Indicators*, 122, 107318. <https://doi.org/10.1016/j.ecolind.2020.107318>



- Global Footprint Network (GFN). (2025). *National Footprint and Biocapacity Accounts (NFBAs) preliminary 2025 Edition*. York University, FoDaFo, Global Footprint Network. <https://www.footprintnetwork.org/>
- Jernelöv, A. (1992). *Ecological Debt*. Report on How the Ecological Debt Develops if We Do Nothing. SOU 1992:58. (in Sweden)
- Logan, L. H., Gupta, R. S., Ando, A., Suski, C., & Stillwell, A. S. (2021). Quantifying tradeoffs between electricity generation and fish populations via population habitat duration curves. *Ecological Modelling*, 440, 109373. <https://doi.org/10.1016/j.ecolmodel.2020.109373>
- Loh, J. (2000). *Living Planet Report 2000*. Gland: WWF.
- Mosbergen, D. (2016). We've Already Used Up Earth's Resources For 2016 - And It's Only August. HuffPost.
- Open Data Platform. (2025). <https://data.footprintnetwork.org/>
- Ristić, B., Mahlooji, M., Gaudard, L., & Madani, K. (2019). The relative aggregate footprint of electricity generation technologies in the European Union (EU): A system of systems approach. *Resources, Conservation and Recycling*, 143, 282-290. <https://doi.org/10.1016/j.resconrec.2018.12.010>
- Roppolo, M. (2014). Earth's resources in "ecological deficit" for rest of 2014. CBS News.
- Roy, M. (2021). Greening behavior toward sustainable development. *Sustainable Development Strategies – Engineering, Culture and Economics*, 53-90. <https://doi.org/10.1016/B978-0-12-818920-7.00001-3>
- Pravan, C., & Mishra, P. P. (2024). Does electricity consumption impact biocapacity deficit? Evidence from domestic and commercial electricity consumption in India. *The Electricity Journal*, 37(7-10), 107443. <https://doi.org/10.1016/j.tej.2024.107443>
- Wackernagel, M., & Beyers, B. (2019). *Ecological Footprint: Managing Our Biocapacity Budget*. New Society Publishers.
- Warlenius, R., Pierce, G., & Ramasar, V. (2015). Reversing the arrow of arrears: The concept of “ecological debt” and its value for environmental justice. *Global Environmental Change*, 30, 21-30. <https://doi.org/10.1016/j.gloenvcha.2014.10.014>
- World Population Review. (2025). Ecological Footprint by Country 2025. <https://worldpopulationreview.com>
- World Wide Fund for Nature. (2024). Today, Serbia used up its natural reserves for this year! (in Serbian). <https://www.wwfadria.org/>





## THE PRINCIPLE OF SUSTAINABLE DEVELOPMENT IN POLISH TAX SYSTEM

Patryk Kowalski\*

*University of Lodz, Faculty of Law and Administration, Poland*

**Abstract:** The article discusses the issue of the principle of sustainable development and its impact on the Polish tax system. This topic is current due to the global and pan-European tendencies to intensify policies for sustainable development and environmental protection. The aim of the article is to examine what legal instruments the Polish legislator has introduced into the tax law system in two dimensions: ecological tax burdens and ecological tax preferences (reliefs and exemptions). The constitutional origin of the principle of sustainable development is also emphasized.

**Keywords:** sustainable development, ecological tax, environmental tax, pro-ecological taxation, environmentally related tax reliefs and exemptions.

### 1. INTRODUCTION

According to the statement of the Directorate-General of the European Commission, “sustainable development means meeting the needs of the present whilst ensuring future generations can meet their own needs. It has three pillars: economic, environmental and social. To achieve sustainable development, policies in these three areas have to work together and support each other” (Sustainable development in EU trade agreements).

During United Nation Summit on 25 September 2015, the United Nations General Assembly adopted the 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development (Transforming our world: the 2030 Agenda for Sustainable Development, 2015). Agenda 2030 Goal's entered into force on 1 January 2016. The Agenda Goals are as follows: No Poverty, Zero Hunger, Good Health and Well-Being, Quality of Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, Industry, Innovation, and Infrastructure, Reduced Inequalities, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action, Life Below Water, Life on Land, Peace, Justice and Strong Institutions, Partnerships (The Sustainable Development Goals).

---

\* Corresponding author: [patryk.kowalski@wpia.uni.lodz.pl](mailto:patryk.kowalski@wpia.uni.lodz.pl)

Patryk Kowalski, ORCID: 0000-0003-3027-2683

According to the European Commission, the European Union made contribution to the principle of sustainable development in recent years by implementing the Agenda's goals in its practice (policy) (Sustainable Development Goals).

The implementation of the abovementioned goals may consist in the implementation of appropriate tax solutions by the EU Member States. The concept of tax solutions should be understood very broadly, i.e. as the creation of new taxes or a change to the existing ones, or more precisely their structural elements. The introduction of new fiscal burdens on taxpayers who do not implement the assumptions of sustainable development through their activities while reducing the tax burden on taxpayers who implement tasks related to the principle of sustainable development – is related to rewarding the stimulating function (the stimulating function prevails over the fiscal function) (Supera-Markowska, 2021, 24).

## **2. THE PRINCIPLE OF SUSTAINABLE DEVELOPMENT CONSTITUTIONAL GROUNDS**

The principle of sustainable development has its source in constitutional law. As stated in the art. 5 of the Constitution of the Republic of Poland As adopted by the National Assembly on 2nd April 1997 (furthermore: "Constitution"), "The Republic of Poland shall safeguard the independence and integrity of its territory and ensure the freedoms and rights of persons and citizens, the security of the citizens, safeguard the national heritage and shall ensure the protection of the natural environment pursuant to the principles of sustainable development".

The concept of "sustainable development" itself has not been defined in the Constitution. It was included directly in the Act of 27 April 2001 – Environmental Law, and more precisely in art. 3 (50) of this Act. Sustainable development is such socio-economic development in which the process of integrating political, economic and social activities takes place, while maintaining natural balance and the durability of basic natural processes, in order to guarantee the possibility of meeting the basic needs of individual communities or citizens of both the current generation and future generations.

However, following the principle of autonomous interpretation of constitutional concepts, it should be stated that sustainable development included in art. 5 of the Constitution can be understood as a constitutional principle or a principle of state policy (Olejarczyk, 2016, 128–130; Florczak-Wątor, 2016, IV. F.).

The location of art. 5 in the initial regulations of the Constitution, and more precisely in the chapter entitled "The Republic", next to such principles as the principle of a democratic state of law, the principle of the supremacy of the Nation – is intended to emphasize its significant significance. Assigning the rank of a constitutional principle to the discussed concept implies an obligation on the part of the authorities to be guided by it in the implementation of the basic functions of the state specified in art. 5 of the Constitution of the Republic of Poland (the so-called final goals of the state), i.e. independence and inviolability of its territory, ensuring freedom and rights and security of man and citizen and the security of citizens, guarding the national heritage and ensuring environmental protection (Olejarczyk, 2016, 128–130; Florczak-Wątor, 2016, IV. F.).

Art. 5 of the Constitution of the Republic of Poland can also be interpreted in isolation from the constitutional systematics. The lexical interpretation of this provision leads to the conclusion that the principle of sustainable development as a principle of state policy is a norm that requires all bodies (i.e. legislative, executive or judicial) to strive to achieve a state of sustainable development. This approach results in the fact that public authorities should be guided by the guideline in the form of "continuous development", in the process of which the

constitutional social, economic and environmental values should be proportionally balanced. This also means that the principle of sustainable development can function autonomously in relation to the principle of environmental protection (Olejarczyk, 2016, 128–130; Florczak-Wątor, 2016, IV. F.).

It should be emphasized that sometimes the concept of sustainable development is formulated not so much as a principle, but as an interpretative directive. In the case law of Polish administrative courts, it is assumed that when doubts arise as to the scope of obligations, the type of obligations and the manner of their implementation, the principle of sustainable development should be used. It therefore plays a role similar to the rules of social intercourse (Florczak-Wątor, 2016, IV. F., On the principle of sustainable development see also more broadly Hermanowski, 2023).

### **3. ENVIRONMENTAL (ECOLOGICAL) TAX REGULATIONS**

The Polish legislator, implementing the principle of sustainable development as a policy principle, has introduced many legal instruments into tax law that serve to implement this principle. This action is also the manifestation of the stimulating function of taxes. Legislative solutions can be divided into two main types of legal instruments: environmentally related taxes (so-called ecological taxes), environmentally related tax reliefs and exemptions (so-called ecological tax preferences). More about pro-ecological taxation in Poland see here: Goettel, 2015; Bryndziak, 2014; Kielan and Kowalski, 2021; Kozuch, 2012; Ziółko, 2016; Drywa, 2024; Małecki, 2012.

#### **3.1. Environmentally related taxes**

According to the art. 2 (2) of the Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts Text with EEA relevance, environmentally related tax means a tax whose tax base is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment, and which is identified in ESA 95 as a tax. Moreover, based on Eurostat definition, “An environmental tax is a tax on something that has a proven, specific negative impact on the environment. The tax base can be a physical unit, for example litres of gasoline, or a proxy of a physical unit, for example taxes on nuclear power stations. The tax is always a monetary amount, such as euros” (Environmental taxes and subsidies). See more: Supera-Markowska, 2021, 23–41. About environmental tax statistic see more here: Environmental tax statistics - detailed analysis.

##### **3.1.1. Excise tax**

Excise tax is a tax classified as indirect tax, levied only on specific product categories. The purpose of creating excise tax was to limit the consumption of certain goods that are harmful to health or the environment. Another reason is the significant accumulation of profit – low production costs and very high demand (Podatek akcyzowy (akcyza), 2022).

The Act of 6 December 2008 Excise Duty determines the imposition of excise duty on excise goods (energy products, electricity, alcoholic beverages, tobacco products, dried tobacco, electronic cigarette liquids, and novel products) and cars the organisation of trade in excise goods, and labelling with duty stamps (art. 1 sec. 1 in conjunction with art. 2 (1) of Excise Duty Act).

In relation to goods subject to excise tax, the legislator indicated specific taxable activities. For example, in accordance with art. 8 of the Excise Duty Act, the following shall be the object of the imposition of the excise duty: production of excise goods; entry of excise goods in a tax warehouse; import of excise goods with some exclusions, intra-Community acquisition of excise goods, to the exclusion of the intra-Community acquisition effected to a tax warehouse etc.

The tax base in excise tax is linked to tax rates. Both elements are differentiated depending on the subject of taxation. For instance, in the case of energy products, the tax base is their quantity, expressed, depending on the type of product, in litres or kilograms or in energy value. What is more, the tax base for: tobacco products is the number of tobacco products or the number of kilograms, electricity is its quantity expressed in megawatt-hours, gas products is their calorific value (Mastalski, 2021, 400).

As Ł. Dubiński rightly points out, these features of excise tax allow us to assume that, one can speak of a transparent structure of this kind of public levy. The point is that it is clearly specified "what and when" is subject to taxation. Excise tax should be both an effective instrument for conducting state policy (creating budget revenues) and achieving specific socio-economic goals. The legislator may indicate specific goods that will be subject to excise duty, and thus by imposing excise duty on them, he will aim to achieve a fiscal goal while limiting the consumption of a given good as a result of imposing excise duty on it. For environmental effects, such a mechanism is desirable (Dubiński, 2014, 82). Therefore, the key from the perspective of the principle of sustainable development is the subject of taxation and the type of excise good.

### 3.1.2. Environmental levy

Based on the art. 273 of the Environmental Law, the environmental levy is paid for the releasing of gases or dusts to the air; emission allowances and the storage of waste.

The rate of environmental levies and administrative civil penalties depends on: the quantity and type of gases and dusts released to the air; the amount of the environmental levy in the case of emission allowances issued in accordance with the rules laid down in the ETS Act shall be the product of the number of emission allowances issued in a given year for a given operator holding account or a given aircraft operator holding account in the European Union register referred to in Article 8.1 of that Act and the applicable rate of the levies for the introduction of gases or dust into the air for carbon dioxide emissions in the year in which the emission allowances were issued; the quantity and type of waste stored, provided the rate of the elevated levy depends also on the time of storing waste (in the case of the storage waste) (art. 274 of the Environmental Law).

Articles 275 and 276 of the Environmental Law define who is the entity using the environment, obliged to pay environmental levys. The list of these entities is very wide and includes both entities conducting business activities and those that do not conduct such activities, but use the environment to the extent that involves the need to levys. On the other hand, art. 284 sec. 1 of this Act states that the obligation to pay fees arises ex lege, without the need for an administrative body to issue a decision specifying the amount of the obligation (Gruszecki, 2022a, 1, 2).

The fee rates specified in art. 290 sec. 1 of the Environmental Law are maximum rates and therefore they are not directly binding – the obligations of entities using the environment will result from the regulations which the Council of Ministers was obliged to issue (Gruszecki, 2022b, 2). Nevertheless, the upper unit rates of the levies amount to, subject to Article 291 sec.

1: PLN 512,23 per 1 kg of gases or dusts released to the air; PLN 375,25 for depositing 1 Mg of waste in a landfill (Art. 290 of the Environmental Law).

### 3.1.3. Emission fee

The introduction of motor fuels onto the domestic market (activities subject to excise duty whose objects are those motor fuels) shall be subject to a emission fee. Motor fuels subject to the emission fee shall be: motor petrols of CN codes CN 2710 11 45, CN 2710 11 49 and gas oils of CN code CN 2710 19 41 (art. 321a of Environmental Law).

The emission fee shall constitute the revenue of the National Fund for Environmental Protection and Water Management and the Public Bus Transport Development Fund, with 95% of the emission fee being the revenue of the first Fund and 5% of that fee being the revenue of the second one (art. 321b of Environmental Law).

The obligation to pay abovementioned fee applies to the following entities: a manufacturer of motor fuels or an importer of motor fuels, or an entity making an intra-Community acquisition within the meaning of the provisions on the excise duty on motor fuels, or another entity subject to a tax obligation within the scope of excise duty on motor fuels on the basis of excise duty regulations (art. 321c of Environmental Law).

The moment of the obligation to pay the emission fee is the day on which the tax liability for excise duty on motor fuels arises (Gruszecki, 2022c, 2). The emission fee rate for: motor petrols-shall be PLN 80 for 1000 litres; gas oils-shall be PLN 80 for 1000 litres (art. 321f of Environmental Law).

### 3.1.4. Tax on transport vehicles

The tax on transport vehicles is a type of local government tax characterized by the fact that it constitutes income for the municipal budget and may be shaped to a certain extent by the municipal council or the head of a gmina (mayor of a town, president of a city) (Dowgier et al., 2021a, 2).

As indicated in the art. 8 of the Act of 12 January 1991 Local Taxes and Duties Act, tax on transport vehicles is imposed on: heavy goods vehicles with a gross vehicle weight of more than 3.5 tonnes and less than 12 tonnes; heavy goods vehicles with a gross vehicle weight equal or more than 12 tonnes; road tractors and ballast tractors to be used with a trailer or semi-trailer with a gross combination weight from 3.5 tonnes and less than 12 tonnes; road tractors and ballast tractors to be used with a trailer or semi-trailer with a gross combination weight equal or more than 12 tonnes; trailers and semi-trailers with gross combination weight together with a motor vehicle from 7 tonnes and no more than 12 tonnes, excluding those used exclusively to conduct the agricultural activity of a taxpayer of agricultural tax; trailers and semi-trailers with a gross combination weight together with a motor vehicle equal or more than 12 tonnes, excluding those used exclusively to conduct the agricultural activity of a taxpayer of agricultural tax; buses.

It is assumed that the tax liability arises by operation of law, i.e. on the day of the occurrence of an event specified in the act, with which the tax act connects the creation of this liability (Dowgier et al., 2021b, 26). The tax liability in the tax on transport vehicles has been linked to the possession of a specific legal title to the vehicle. Tax obligation is imposed on: natural and legal persons who own (or co-own) transport vehicles; unincorporated organisational units on whose account transport vehicles are registered; persons who are holders of transport vehicles registered in the Republic of Poland as vehicles entrusted by a foreign natural or legal person to a Polish entity (Dowgier et al., 2021b, 1).

The tax obligation starts as of the first day of a month following the month when a transport vehicle was registered in the Republic of Poland, and if a registered vehicle is purchased - as of the first day of a month following the month of purchase. Tax obligation also arises also as of the first day of a month following the month when a transport vehicle was re-admitted after expiry of the period stipulated in a decision of the registration authority on temporary withdrawal of that vehicle from use (art. 9 sec. 4, 4a of the Local Taxes Act).

The tax on transport vehicles is annual. Taxpayers are obliged to submit a declaration for this tax by 15 February of the given tax year (Dowgier et al., 2021b, 26).

Article 10 of the Local Taxes Act specifies the rules for setting rates of tax on transport vehicles – depending on the type of vehicle. The gmina council adopts a resolution on the tax rates for a given tax year (Dowgier et al., 2021c, 1). For example, the annual tax rate per one vehicle cannot exceed, in the case of heavy goods vehicles (with a gross vehicle weight of more than 3.5 tonnes and less than 12 tonnes), depending on gross vehicle weight: more than 3.5 tonnes up to and including 5.5 tonnes - PLN 1020,16; more than 5.5 tonnes up to and including 9 tonnes - PLN 1.701,84; more than 9 tonnes - PLN 2.042,19. In the case of a bus, the annual tax rate per one vehicle cannot exceed, depending on the number of seats apart from the driver's seat: less than 22 seats - PLN 2,411.44; equal to or more than 22 seats - PLN 3,048.71 (art. 10 sec. 1 (1, 7) of the Local Taxes Act).

### **3.2. Environmentally related tax reliefs and exemptions**

In the legal literature, exemptions are defined as a situation in which a specific entity or its activity is subject to the provisions of a tax but have been exempted from it. Moreover, reliefs are mechanisms that reduce the amount of tax. The reduction may result from a reduction in the tax base or in the tax rate or a reduction in the tax amount. Reliefs and exemptions are the basic instruments for implementing specific policies within the stimulating function of taxes (e.g. policy supporting the principle of sustainable development) (Supera-Markowska, 2021, 23–41 quoted from Nykiel, 2002, 20, 23).

#### **3.2.1. Environmentally related tax exemptions**

The Polish legislator has established many ecological tax exemptions. The most important of them are:

1. Article. 21 sec. 1 (129a) of the Act of 26 July 1991 on Personal Income Tax according to which, tax exemptions shall be applied to: benefits, in particular donations and amounts of released loans, received from the funds of the National Fund for Environmental Protection and Water Management or voivodeship environmental protection and water management funds for drafting documentation and implementing a project, including those received from means made available to banks in line with selected Environmental Protection Law provisions;
2. Article 17 sec. 1 (4) of the Act of 15 February 1992 r. on Corporate Income Tax according to which, the following types of income are tax free: subject to paragraph 1c, income of taxpayers whose statutory objectives are activities in the area of science, technological science, education (including university education), culture, physical culture, sport, environmental protection, supporting social initiatives for the construction of roads and telecommunications networks in rural areas and water supply to rural area, charity, health protection and social aid, professional and social rehabilitation of the handicapped and religious worship - the part of income allocated to those objectives;

3. Article 30 sec. 1 of Excise Tax Act, according to which electricity generated from renewable energy sources shall be exempt from excise duty on the basis of a document confirming the redemption of a certificate of origin, within the meaning of the provisions of energy law or the provisions of the Act of 20 February 2015 on Renewable Energy Sources (Journal of Laws of 2021, items 610, 1093, 1873 and 2376);
4. Article 7 sec. 1 (8) of the Local Taxes Act, according to which, the following properties are exempt from immovable property tax: located in national parks or nature reserves and used directly and exclusively to achieve goals in the scope of environmental protection: land located in the areas under strict, active or landscape protection (a); buildings and structures permanently fixed to the ground (b);
5. Article 2 (2) of the Act of 9 September 2000 Tax on Civil Law Transactions, according to which, the tax is not charged on: an agreement for the sale of real property or a perpetual usufruct right concluded in association with the execution of claims arising from the limited use of real property pursuant to environmental protection provisions;
6. Article 12 sec. 1 (8) of the Act of 15 November 1984 on Agricultural Tax according to which, the following are exempt from agricultural tax: ecological areas;
7. Article 7 sec. 1 (1, 3) of the Act of 30 October 2002 on Forest Tax according to which, the following are exempt from forest tax: forests with trees up to 40 years old and ecological areas.

### 3.2.2. Environmentally related tax reliefs

The Polish legislator has also established many ecological tax reliefs. The most important of them are: thermomodernisation and investment reliefs and 0 percent tax rate.

Thanks to the thermomodernization relief, the taxable person who is an owner or a co-owner of a single-family residential building has the right to deduct from the taxable base (established on the basis of the relevant regulations) expenses borne in the tax year for construction materials, equipment and services related to the implementation of a thermomodernisation project in that building, specified in regulations issued pursuant to paragraph 10, which shall be completed in the period of 3 subsequent years counting from the end of the tax year in which the first expense was borne (art. 26h sec. 1 of the PIT Act).

The amount deducted cannot exceed PLN 53,000 in relation to all thermomodernisation projects being implemented in individual buildings of which the taxable person is an owner or co-owner. The amount of expenses is determined on the basis of invoices issued by a VAT taxable person who is not exempted from that tax (art. 26h sec. 2, 3 of the PIT Act).

Moreover, taxpayers of agricultural tax are entitled to the investment relief. This relief allows taxpayers to deduct from the agricultural tax due on land located in the commune in which the investment was made – in the amount of 25% of the investment outlays documented by invoices. Investment relief is granted after the completion of the investment. (art. 13 sec. 2 of the Agricultural Tax Act).

Taxpayers of agricultural tax are entitled to investment relief for expenses incurred on: construction or modernization of livestock buildings used for breeding, raising and maintaining farm animals and facilities for environmental protection (1); purchase and installation of: sprinklers, drainage devices and devices for supplying the farm with water, devices for using natural energy sources (wind, biogas, sun, water fall) for production purposes – if these expenses were not financed in whole or in part with the participation of public funds (art. 13 sec. 1 of the Agricultural Tax Act).

What is more, the VAT tax rate of 0 percent applies to services of sea rescue, supervision over sea and inland navigation safety, and services connected with marine environment protection and the upkeep of port basins and deepwater channels (art. 83 sec. 1 (11) of the Act of 11 March 2004 on Goods and Services Tax).

#### **4. SUMMARY**

Environmentally related taxes and preferences can greatly support the process of implementing the principle of sustainable development in Poland. Economics emphasizes their main task, which is “to send signals to market participants regarding the real social costs of production and consumption of goods and services. In this way, the market economy can, given the resources of our planet, best meet our needs and those of future generations. The key to success is a change in awareness and social acceptance of the use of fiscal tools, which can greatly support the implementation of ambitious environmental protection goals” (Neneman, 2022, 88).

The study of legal institutions constituting the concept of the principle of sustainable development in Polish tax law has led to the following conclusions.

The principle of sustainable development is a principle that occurs both at the international and pan-European level. What is more, it has a constitutional origin. As a policy principle, it has led (and continues to lead, as a result of legislative changes) to the creation of tax regulations for environmental protection. By resigning, in principle, to a certain extent from budget revenues, the legislator stimulates pro-ecological behaviours in society. This is done by means of taxes that are pro-environmental (burdening taxpayers' negative behaviours in the sense of the titular principle) and tax preferences (rewarding taxpayers' positive behaviours in the sense of the titular principle).

As for specific legislative instruments themselves, their catalogue is undoubtedly diverse. The question remains whether it is rich and how Poland compares in this case to other European Union countries. Comparative studies conducted in the future will be helpful in this respect (Świąch-Kujawska, 2023, 29).

#### **ACKNOWLEDGMENT**

This article is an extended version of the paper presented at the international practical scientific conference “Tax Sustainability and Certainty: A Global and Local Approach”, held on October 3, 2024, organized by the Tax Disputes Commission and the Vilnius University Faculty of Law.

#### **REFERENCES**

- Bryndziak, S. (2014). *Opodatkowanie jako instrument polityki ochrony środowiska* [Taxation as an instrument of environmental protection policy]. *Studia Prawno-Ekonomiczne*, Issue XCIII, 25–37. <https://bibliotekanauki.pl/articles/596504> (in Polish).
- Dowgier, R., Etel, L., Liszewski, G., & Pahl, B. (2021a). Art. 1. In R. Dowgier, L. Etel, G. Liszewski, & B. Pahl (Eds.), *Podatki i opłaty lokalne. Komentarz* [Local taxes and charges. Commentary], LEX/el. (in Polish).
- Dowgier, R., Etel, L., Liszewski, G., & Pahl, B. (2021b). Art. 10. In R. Dowgier, L. Etel, G. Liszewski, & B. Pahl (Eds.), *Podatki i opłaty lokalne. Komentarz* [Local taxes and charges. Commentary], LEX/el. (in Polish).



- Dowgier, R., Etel, L., Liszewski, G., & Pahl, B. (2021c). Art. 9. In R. Dowgier, L. Etel, G. Liszewski, & B. Pahl (Eds.), *Podatki i opłaty lokalne. Komentarz* [Local taxes and charges. Commentary], LEX/el. (in Polish).
- Drywa, A. (2024). *Podatki w zrównoważonym rozwoju i zrównoważony rozwój w podatkach. Ujęcie teoretycznoprawne* [Taxes in sustainable development and sustainable development in taxes: A theoretical and legal approach]. *Gdańskie Studia Prawnicze*, 1(62), 35–48. <https://doi.org/10.26881/gsp.2024.1.03> (in Polish).
- Dubiński, Ł. (2014). *Podatek akcyzowy a ochrona środowiska (analiza prawna)* [Excise tax and environmental protection: A legal analysis]. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, 818, *Finanse, Rynki Finansowe, Ubezpieczenia*, 68, 81–89. [http://www.wneiz.pl/nauka\\_wneiz/frfu/68-2014/FRFU-68-81.pdf](http://www.wneiz.pl/nauka_wneiz/frfu/68-2014/FRFU-68-81.pdf) (in Polish).
- Environmental tax statistics - detailed analysis. [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Environmental\\_tax\\_statistics\\_-\\_detailed\\_analysis](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Environmental_tax_statistics_-_detailed_analysis).
- Environmental taxes and subsidies. <https://ec.europa.eu/eurostat/web/environment/information-data/environmental-taxes-subsidies>.
- Florczak-Wątor, M. (2016). Art. 5. In L. Bosek & M. Safjan (Eds.), *Konstytucja RP. Tom I. Komentarz do art. 1–86* [Constitution of the Republic of Poland. Volume I. Commentary on Articles 1–86]. *Legalis/el.* (in Polish).
- Goettel, A. (2015). *Wybrane proekologiczne preferencje podatkowe* [Selected pro-environmental tax preferences]. *Białostockie Studia Prawnicze*, 18, 113–128. [https://repozytorium.uwb.edu.pl/jspui/bitstream/11320/3448/1/BSP\\_18\\_2015\\_Goettel.pdf](https://repozytorium.uwb.edu.pl/jspui/bitstream/11320/3448/1/BSP_18_2015_Goettel.pdf) (in Polish).
- Gruszecki, K. (2022a). Art. 284. In K. Gruszecki (Ed.), *Prawo ochrony środowiska* [Environmental Protection Law]. *LEX/el.* (in Polish).
- Gruszecki, K. (2022b). Art. 290. In K. Gruszecki (Ed.), *Prawo ochrony środowiska* [Environmental Protection Law]. *LEX/el.* (in Polish).
- Gruszecki, K. (2022c). Art. 321d. In K. Gruszecki (Ed.), *Prawo ochrony środowiska* [Environmental Protection Law]. *LEX/el.* (in Polish).
- Hermanowski, K. (2023). *Zasada zrównoważonego rozwoju a prawna ochrona drzew i krzewów* [The principle of sustainable development and the legal protection of trees and shrubs]. *Journal of Modern Science*, 1(50), 292–316. <https://doi.org/10.13166/jms/161527> (in Polish).
- Kielan, Ł., & Kowalski, P. (2021). Legal and financial aspects of implementing the principle of sustainable development in Poland. Empirical research on innovation in Polish family business from the agri-food sector in the Lodz voivodship. In J. Olszewski (Ed.), *Wybrane aspekty badawcze nauk ekonomicznych* [Selected research aspects of economic sciences] (pp. 112–132). (in Polish).
- Kożuch, M. (2012). *Preferencje podatkowe jako narzędzia subsydiowania przedsięwzięć ochrony środowiska* [Tax preferences as tools for subsidizing environmental protection projects]. *Zarządzanie finansami firm – teoria i praktyka. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 271(1), 378–387. <https://bazekon.uek.krakow.pl/rekord/171246335> (in Polish).
- Małecki, P. P. (2012). *System opłat i podatków ekologicznych w Polsce na tle rozwiązań w krajach OECD* [System of environmental fees and taxes in Poland compared to solutions in OECD countries]. *Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie*. (in Polish).
- Mastalski, R. (2021). *Prawo podatkowe* [Tax law]. *Wydawnictwo C.H. Beck*. (in Polish).

- Neneman, J. (2022). W jaki sposób podatki mogą pomóc w ochronie środowiska [How taxes can help protect the environment]. In M. Burchard-Dziubińska (Ed.), *W poszukiwaniu zielonego ładu* [In search of the green deal] (pp. 65–90). Wydawnictwo Uniwersytetu Łódzkiego. <https://doi.org/10.18778/8220-870-2.04> (in Polish).
- Nykiel, W. (2002). Ulgi i zwolnienia w konstrukcji prawnej podatku [Allowances and exemptions in the legal structure of a tax]. Wydawnictwo ABC. (in Polish).
- Olejarczyk, E. (2016). Zasada zrównoważonego rozwoju w systemie prawa polskiego – wybrane zagadnienia [The principle of sustainable development in the Polish legal system – selected issues]. *Przegląd Prawa Ochrony Środowiska*, 2, 128–130. <http://dx.doi.org/10.12775/PPOS.2016.013> (in Polish).
- Podatek akcyzowy (akcyza). 2022. <https://mikroporady.pl/slownik-pojec/podatek-akcyzowy-akcyza>.
- Supera-Markowska, M. (2021). Instrumenty podatkowego wspierania założeń zrównoważonego rozwoju w prowadzeniu działalności gospodarczej [Tax instruments supporting the assumptions of sustainable development in business operations]. In M. Pisz & R. Chęciński (Eds.), *Implementacja zasady zrównoważonego rozwoju do gospodarki i sektora instytucji publicznych* [Implementation of the principle of sustainable development in the economy and the public institutions sector] (pp. 23–31). Uniwersytet im. Adama Mickiewicza w Poznaniu. [http://publikat.home.amu.edu.pl/wp-content/uploads/2020/10/publikacja\\_prawo-6.pdf](http://publikat.home.amu.edu.pl/wp-content/uploads/2020/10/publikacja_prawo-6.pdf) (in Polish).
- Sustainable Development Goals. [https://international-partnerships.ec.europa.eu/policies/sustainable-development-goals\\_en](https://international-partnerships.ec.europa.eu/policies/sustainable-development-goals_en).
- Sustainable development in EU trade agreements. [https://policy.trade.ec.europa.eu/development-and-sustainability/sustainable-development/sustainable-development-eu-trade-agreements\\_en#tsd-review-2021](https://policy.trade.ec.europa.eu/development-and-sustainability/sustainable-development/sustainable-development-eu-trade-agreements_en#tsd-review-2021).
- Święch-Kujawska, K. (2023). Podatkowe instrumenty ochrony środowiska na przykładzie ulg podatkowych związanych z władaniem nieruchomościami [Tax instruments for environmental protection on the example of tax reliefs related to property ownership]. *Prawo Budżetowe Państwa i Samorządu*, 4(11), 9–32. <https://doi.org/10.12775/PBPS.2023.019> (in Polish).
- The Act of 11 March 2004 on Goods and Services Tax. *Journal of Laws* 2024, item 361, official translation by Centrum Tłumaczeń PWN.PL, aktualizacja od 2015 r. Centrum Tłumaczeń i Obsługi Konferencji LIDEX.
- The Act of 12 January 1991 Local Taxes and Duties Act. *Journal of Laws* of 2023, item 70, official translation by Centrum Tłumaczeń PWN.PL
- The Act of 15 February 1992 r. on Corporate Income Tax. *Journal of Laws* 2023, item 2805, further: “CIT” official translation by Centrum Tłumaczeń PWN.PL, aktualizacja od 2015 r. Centrum Tłumaczeń i Obsługi Konferencji LIDEX.
- The Act of 15 November 1984 on Agricultural Tax. *Journal of Laws* 2024, item 1176.
- The Act of 26 July 1991 on Personal Income Tax. *Journal of Laws* 2023, item 226, further: “PIT” official translation by Centrum Tłumaczeń PWN.PL, aktualizacja od 2015 r. Centrum Tłumaczeń i Obsługi Konferencji LIDEX.
- The Act of 27 April 2001 – Environmental Law. Consolidated text *Journal of Laws* of 2024, item 54, official translation by Centrum Tłumaczeń PWN.PL, aktualizacja od 2015 r. Centrum Tłumaczeń i Obsługi Konferencji LIDEX.
- The Act of 30 October 2002 on Forest Tax. *Journal of Laws* 2019, item 888.
- The Act of 6 December 2008 Excise Duty. *Journal of Laws* of 2023, item 1542, official translation by Centrum Tłumaczeń PWN.PL, aktualizacja od 2015 r. Centrum Tłumaczeń i Obsługi Konferencji LIDEX.

- The Act of 9 September 2000 Tax on Civil Law Transactions. Journal of Laws 2024, item 295, further: „CLT” official translation by Centrum Tłumaczeń PWN.PL, aktualizacja od 2015 r. Centrum Tłumaczeń i Obsługi Konferencji LIDEX.
- The Constitution of the Republic of Poland As adopted by the National Assembly on 2nd April 1997. Journal of Laws of 1997, No. 78, item 483, official translation access: <https://trybunal.gov.pl/en/about-the-tribunal/legal-basis/the-constitution-of-the-republic-of-poland>.
- The Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts Text with EEA relevance. Official Journal of the European Union, L 192, 22 July 2011.
- The Sustainable Development Goals. <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>.
- Transforming our world: the 2030 Agenda for Sustainable Development. (2015). <https://www.un.org/sustainabledevelopment/development-agenda-retired/>.
- Ziółko, M. (2016). Podatki ekologiczne w Polsce [Environmental taxes in Poland]. In P. Urbanek & E. Walińska (Eds.), *Ekonomia i nauki o zarządzaniu w warunkach integracji europejskiej* [Economics and management sciences under European integration conditions], *Ekonomia i Zarządzanie w Teorii i Praktyce Series, Volume 9* (pp. 139–149). Wydawnictwo Uniwersytetu Łódzkiego. <https://repozytorium.uni.lodz.pl:8443/xmlui/handle/11089/19741?show=full> (in Polish).



## DETERMINANTS OF CO<sub>2</sub> EMISSIONS IN CENTRAL AND EASTERN EUROPE: AN EMPIRICAL PANEL DATA ANALYSIS

Aleksandra Fedajev<sup>1 \*</sup>, Petar Mitić<sup>2</sup>, Aleksandar Zdravković<sup>2</sup>, Gabrijela Popović<sup>3</sup>

<sup>1</sup> University of Belgrade, Technical Faculty Bor, Serbia

<sup>2</sup> Institute of Economic Sciences, Belgrade, Serbia

<sup>3</sup> University Business Academy in Novi Sad, Faculty of Applied Management, Economics and Finance, Belgrade, Serbia

**Abstract:** This paper investigates the impact of GDP growth, regulatory quality, electricity consumption, human development, and research and development (R&D) expenditures on carbon dioxide emissions (CO<sub>2</sub>) in 15 Central and Eastern European (CEE) countries over the period 2002–2020. A three-step empirical strategy is employed, beginning with the specification of a panel data model, followed by diagnostic testing of model residuals, and concluding with the application of multiple panel estimators to ensure robustness of the results. The findings reveal that, with the exception of the Human Development Index (HDI), all other variables show statistically significant associations with CO<sub>2</sub> emissions. In particular, real GDP per capita growth has a strong and consistent positive effect: a one-percentage-point increase in GDP per capita is associated with a rise in CO<sub>2</sub> emissions per capita by approximately 0.3 to 0.35 tons. These results underscore the environmental cost of economic expansion in the region and highlight the critical role of regulatory quality and R&D in designing effective mitigation strategies. The paper contributes to the literature by providing a comprehensive, data-driven assessment of emission determinants in emerging European economies and offers valuable insights for policymakers aiming to align economic growth with environmental sustainability.

**Keywords:** CO<sub>2</sub> emissions, Central and Eastern European countries, environmental costs, economic expansion, effective mitigation strategies.

### 1. INTRODUCTION

Climate change stands as one of the most significant global threats of our time (Wang et al., 2018; Claudelin et al., 2020; Bouman et al., 2020). The increasing pace of environmental

\* Corresponding author: [afedajev@tfbor.bg.ac.rs](mailto:afedajev@tfbor.bg.ac.rs)

Aleksandra Fedajev, ORCID: <https://orcid.org/0000-0002-6974-6631>

Petar Mitić, ORCID: <https://orcid.org/0000-0003-0143-4049>

Aleksandar Zdravković, ORCID: <https://orcid.org/0000-0002-6208-097X>

Gabrijela Popović, ORCID: <https://orcid.org/0000-0002-2652-4860>

degradation, largely driven by human activity and growing energy demands, has placed mounting pressure on governments to develop effective environmental strategies (Zeiger et al., 2019; Akhter et al., 2020). The rising concentration of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases (now well above pre-industrial levels) has sparked serious concerns about the potential for long-term and possibly irreversible ecological damage. Current projections suggest a global temperature increase of at least 1.5°C by the century's end, a scenario that presents serious environmental and socio-economic risks (Valone, 2021; Baek, 2015; Laverde-Rojas et al., 2021).

Despite growing awareness and global efforts, many low- and middle-income countries continue to depend on conventional energy systems, particularly those based on coal, which remains one of the most carbon-intensive sources (Ptak, 2014; Lin et al., 2022; Mahalik et al., 2022). These economies face the dual challenge of pursuing development and poverty reduction, while also needing to limit their environmental footprint (Santos & Forte, 2021; Cansino et al., 2021). The situation is particularly complex because while economic progress is essential for improving quality of life, it often contributes to higher emissions, creating a tension between growth and sustainability.

However, economic development can also open opportunities for environmental improvements. Increased wealth can support the implementation of cleaner technologies and promote knowledge sharing among neighboring countries (Bumpus & Comello, 2017). Additionally, economies undergoing structural transformation (from heavy industry toward less resource-intensive sectors and service-oriented industries) may see a decline in pollution intensity. Romero et al. (2021) has found that industries based on medium and high technology tend to produce fewer emissions compared to those involved in raw material extraction or basic goods production. These structural and technological shifts are seen as vital for achieving a balance between continued economic advancement and environmental preservation.

In this context, regulatory quality plays a pivotal role in steering economies toward sustainable pathways, as stronger institutions are more capable of enforcing environmental standards and guiding investment toward cleaner sectors (Boateng et al., 2024; Kashif et al., 2024). Similarly, improvements in human development (reflected in better education, health, and living standards) can raise public awareness of environmental issues and promote behavioral shifts that reduce ecological footprints (Patel et al., 2024; Khan et al., 2023). Furthermore, investment in research and development (R&D) fosters innovation in energy efficiency, renewable energy technologies, and low-carbon solutions, all of which are crucial for reducing CO<sub>2</sub> emissions without compromising economic growth (Bilgili et al., 2024; Saia, 2023).

Given the persistent reliance on fossil fuels, some experts argue that in addition to transitioning to renewable energy sources (RES), it is critical to invest in technologies capable of capturing and storing carbon before it reaches the atmosphere (Simionescu et al., 2022). Although these technologies remain costly, future advancements may improve their feasibility, particularly for nations with fewer financial resources.

In light of these challenges, identifying the most influential factors affecting CO<sub>2</sub> emissions is vital for shaping effective environmental and economic policies. Previous studies have highlighted several key variables, such as economic growth, institutional quality, energy usage patterns, levels of human development, and investment in research and development, as central to understanding the dynamics of emissions.

This study focuses on analyzing how GDP growth, regulatory quality, electricity consumption, human development, and R&D spending have influenced carbon dioxide emissions across 15 Central and Eastern European (CEE) countries between 2002 and 2020. The novelty of this paper lies in its comprehensive econometric investigation of the key drivers

of CO<sub>2</sub> emissions. While existing literature has often explored these variables in isolation or limited combinations, this study offers an integrated framework that captures both economic and institutional dimensions influencing environmental outcomes. Furthermore, the paper contributes methodologically by employing a three-step empirical strategy. It begins with the specification of a panel data model linking CO<sub>2</sub> emissions to the selected explanatory variables. It then proceeds with a rigorous examination of model residuals to detect potential estimation issues—particularly violations of assumptions such as error independence, homoscedasticity, and exogeneity. Finally, the study enhances the robustness and credibility of its findings by applying multiple panel estimators tailored to the data structure and statistical properties identified. This meticulous approach ensures that the results are not only statistically sound but also policy-relevant, making a meaningful contribution to the empirical literature on sustainable development and environmental governance in emerging European economies.

## 2. LITERATURE REVIEW

Understanding the factors influencing CO<sub>2</sub> emissions is crucial for designing effective environmental and economic policies. Numerous studies have explored the dynamic relationship between CO<sub>2</sub> emissions and variables such as human development, electricity consumption, regulatory quality, economic growth, and R&D expenditures. These factors interact in complex ways, often producing varying effects across different income groups, regions, and institutional contexts.

Developing economies increasingly view green technologies and renewable energy as viable development paths, balancing economic growth with environmental preservation. Environmental taxes serve as effective tools in reducing carbon emissions and promoting sustainable development (Wolde-Rufael & Mulat-Weldemeskel, 2023). However, a comprehensive approach should go beyond taxation to include R&D investment, particularly in the energy sector, to foster innovation and support carbon mitigation strategies (Guzowska et al., 2021). Empirical studies confirm the critical role of R&D in reducing emissions. For instance, Fernández et al. (2018) found that R&D spending significantly contributes to CO<sub>2</sub> emissions reduction in developed countries, while increased energy consumption correlates with rising emissions. Similarly, Tamazian and Rao (2010) also report that increased R&D efforts help mitigate environmental pollution.

Still, the effectiveness of R&D varies. Garrone and Grilli (2010) highlight that while public R&D spending improves energy efficiency, it has limited impact on emission intensity and the carbonization factor, underscoring that R&D alone may not suffice. Kahouli (2018) further emphasizes complex interdependencies among R&D, CO<sub>2</sub> emissions, electricity consumption, and economic growth in Mediterranean countries, identifying unidirectional causality from R&D to emissions and growth. This suggests that R&D drives environmental improvements, albeit within interconnected systems.

Despite its importance, green innovation remains less attractive to private firms due to limited immediate returns, necessitating strong governmental support (Ullah et al., 2023). Lee and Lee (2013) underline the strategic importance of energy R&D for industry competitiveness and the transition away from fossil fuels. This is echoed by Siddiqui and Fleten (2010), who argue that significant investment is required to meet rising energy demands through innovative technologies. In addition, Dmytrenko et al. (2024) found that while environmental policy stringency has varied effects across Europe, R&D expenditure consistently emerges as the most influential factor in reducing greenhouse gas emissions.

In addition to R&D efforts, the role of human development in influencing CO<sub>2</sub> emissions has gained increasing attention in recent empirical studies. Li and Ouyang (2019),

examining China from 1978 to 2015, found an inverted N-shaped relationship between human capital and CO<sub>2</sub> emissions. This suggests that initial improvements in human capital can temporarily increase emissions due to intensified resource use, while long-term effects become beneficial through enhanced efficiency and reduced emission intensity. Similarly, Sezgin et al. (2021) confirmed that in G7 and BRICS countries, human development (alongside stringent environmental policies) contributes to lowering emissions over time. Notably, bilateral causality between human development and CO<sub>2</sub> emissions was identified for countries like Germany, Japan, the UK, and the US, highlighting dynamic interactions.

Khan (2020) emphasized the threshold effect of human capital, arguing that at early development stages, more education may increase pollution, but once a critical level is reached, it fosters environmental awareness and adoption of cleaner technologies. This conditional relationship was validated across 122 countries over the 1980–2014 period. However, not all studies agree. Earlier works by Gangadharan and Valenzuela (2001) and Cole et al. (2005) found that human capital could exacerbate emissions, pointing to varying contextual effects.

Recent findings by Patel et al. (2024) further support these patterns. While high-income countries have used human development to curb emissions, low-income countries still face a U-shaped trajectory, where initial HDI growth increases emissions. Hao (2022) and Opoku et al. (2022) observed that HDI positively influences environmental sustainability in advanced economies. Supporting this, Xu et al. (2024) showed that countries with higher HDI levels have experienced declining per capita emissions. Chen et al. (2022) emphasize that strategic investment in human capital and eco-innovations remains crucial for long-term emission reductions and achieving sustainability goals.

Electricity consumption emerges as another critical factor influencing CO<sub>2</sub> emissions, with effects that vary across countries and contexts. Kwakwa (2021) confirmed the Environmental Kuznets Curve (EKC) hypothesis for Ghana, finding that while electricity consumption itself has an insignificant effect, power crises notably increase CO<sub>2</sub> emissions, highlighting the indirect role of energy reliability. In the Middle East, Al-Mulali and Che Sab (2018) identified a bidirectional Granger causality between electricity consumption, CO<sub>2</sub> emissions, and economic growth, underlining the central role electricity plays in economic activities and environmental outcomes in the region.

In Cameroon, multiple studies affirm a positive linkage between electricity use and emissions. Njoke et al. (2019) reported significant short- and long-run relationships between electricity consumption and CO<sub>2</sub> emissions using ARDL bounds testing. Similarly, Hilaire et al. (2014) found that increases in electricity consumption, urbanization, and economic growth all contribute positively to emissions.

Sectoral perspectives add further nuance. Çıtak et al. (2021), analyzing the Turkish context, found that the relationship between electricity consumption and emissions is not uniform across sectors. While industrial electricity use shows a positive but modest impact, commercial and public service sectors contribute significantly to emissions, whereas residential and transport electricity usage showed minimal effects.

In Kuwait, Salahuddin et al. (2018) observed a consistent positive relationship in both the short and long run between electricity consumption and CO<sub>2</sub> emissions. Conversely, Ahmad et al. (2017) found a negative association in Croatia, suggesting the potential role of clean energy in decoupling electricity use from environmental harm. Supporting these mixed results, Rahaman et al. (2022) identified electricity consumption, alongside FDI and economic growth, as a significant driver of emissions in Bangladesh. Likewise, Salahuddin et al. (2015) confirmed a strong emission-inducing role of electricity use in GCC countries.

The empirical results of Bashir et al. (2022) indicate that transitioning from a carbon-intensive economic growth model to another based on high-tech and renewable energy

consumption is critical for overcoming environmental issues and climate change goals. It remains to be seen how emerging economies will find ways to thrive without generating more carbon emissions. As the primary and manufacturing sectors are still important for these countries, their investment attractiveness may be determined by a less strict regulatory environment with broader pollution limits (Santos & Forte, 2021; Cansino et al., 2021), transforming the lack of environmental protection regulations into comparative environmental advantages. On the positive side, economic growth would make it possible to devote more resources for the adoption of cleaner technologies (Bumpus & Comello, 2017), as well as technological learning processes in neighbouring economies.

Recent literature highlights the crucial role of regulatory quality in achieving environmental sustainability, particularly in the context of reducing CO<sub>2</sub> emissions. Addai et al. (2023), examining Eastern European countries from 1998Q4 to 2017Q4, confirmed a long-run relationship between regulatory quality and environmental sustainability. Their findings emphasize that stronger regulatory frameworks significantly contribute to environmental improvements by curbing fossil fuel use and mitigating unsustainable development.

In the African context, Kwakwa and Aboagye (2024) analyzed data from 32 countries and found that robust regulatory quality, coupled with effective anti-corruption measures and institutional transparency, weakens the positive impact of natural resource consumption on CO<sub>2</sub> emissions. This suggests that well-designed regulations can offset some of the environmental damage associated with natural resource exploitation.

Similarly, Boateng et al. (2023), using data from 63 industrialized countries and system GMM estimation, demonstrated that multiple dimensions of institutional quality—particularly regulatory stringency, licensing procedures, and administrative controls—play a decisive role in reducing carbon emissions. The study reveals that stringent regulations, such as licensing restrictions, have both immediate and sustained positive environmental outcomes.

Contrasting findings emerge in the case of BRICS nations. Adedoyin et al. (2020) observed that while coal rents negatively influence CO<sub>2</sub> emissions, regulations like carbon damage costs paradoxically increase them. This points to the necessity of reinforcing regulatory frameworks if these economies are to align their growth trajectories with low-carbon development.

From a governance perspective, Mahmood et al. (2022) found that regulatory quality and rule of law significantly reduce CO<sub>2</sub> emissions across four South Asian economies, even when accounting for renewable energy and income levels. Likewise, Khan and Rana (2021), and Haldar and Sethi (2021), confirmed that institutional quality contributes to lower emissions by influencing both economic activity and energy consumption behavior in Asian and developing countries.

In summary, the literature consistently emphasizes the complex and interrelated effects of economic growth, human development, electricity consumption, regulatory quality, and R&D expenditures on CO<sub>2</sub> emissions. While economic growth is often linked to higher emissions, its environmental impact can be mitigated by improved human capital, cleaner energy use, and stringent regulatory frameworks. Additionally, R&D expenditures contribute to emissions reduction by fostering innovation and advancing eco-friendly technologies.

### **3. DATA AND METHODOLOGY**

Following the theoretical discussion and literature overview, we proposed the empirical methodology to examine econometrically our research questions, which comprises three steps. First, the econometrical panel model that puts CO<sub>2</sub> emission in relation to the set of our key explanatory variables were specified. Second, the characteristics of model residuals to get



insight into possible estimation issues were examined. Finally, the empirical model using several panel estimators with respect to the characteristics of our data to ensure the reliability of estimates was estimated.

The specified model reads as:

$$CO2_{it} = \beta_0 CO2_{it-1} + \beta_1 GDP_{it} + \beta_2 RQ_{it} + \beta_3 ELFC_{it} + \beta_4 HDI_{it} + \beta_5 RDE_{it} + u_{it} \quad (1)$$

Where

$CO2_{it}$  is CO2 tons per capita;

$GDP_{it}$  is GDP per capita real growth (%);

$RQ_{it}$  is an indicator of regulatory quality from the World Bank WGI database;

$ELFC_{it}$  is growth in electricity consumption (%);

$HDI_{it}$  is change in human development index (%);

$RDE_{it}$  is the research and development expenditures (% of GDP);

$u_{it}$  is a model error.

In the specified model, each variable serves as a proxy for a key economic or institutional factor influencing CO<sub>2</sub> emissions. GDP per capita real growth is used as a proxy for economic expansion, reflecting the pace of development in each country. Regulatory quality, drawn from the World Bank's Worldwide Governance Indicators, captures the institutional and policy environment, indicating the effectiveness of regulations relevant to environmental governance. Electricity consumption growth represents energy use intensity, serving as a proxy for the reliance on electricity as a driver of economic activity. Human Development Index change is used to reflect broader socioeconomic progress, encompassing education, health, and living standards. Lastly, research and development expenditures, expressed as a percentage of GDP, serve as a proxy for technological innovation and investment in eco-friendly solutions. These variables collectively aim to capture the multifaceted drivers of carbon emissions across the CEE region.

To examine the linkages between CO<sub>2</sub> emissions and selected variables, this study utilizes panel data for 15 Central and Eastern European (CEE) countries (Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia, and Ukraine) for the period 2002–2020. Analysing these countries is particularly important given their shared post-transition economic structures, increasing environmental pressures, and integration processes with the European Union. The selected period captures significant economic, regulatory, and technological changes, allowing for a comprehensive assessment of the long-term trends and policy impacts on environmental sustainability.

In addition, the characteristics of model residuals are examined to figure out a proper estimation approach. It is common knowledge that OLS-based estimators require IID distributed errors and exogenous regressors to provide reliable estimates. In the case of panel data modelling, it is typically assumed that model errors are composite, i.e., that model errors can be decomposed into individual effects that capture time-invariant specifics of the panel units  $v_i$  and disturbances  $\varepsilon_{it}$  that follows IID process,  $u_{it} = v_i + \varepsilon_{it}$ . However, when macroeconomic data are modelled, the assumption on IID distributed disturbances typically appears too strong. Therefore, analysis begins with the most general set of assumptions that model error is composite and model disturbances are heteroskedastic, autocorrelated and cross-sectionally dependent and then tested each of these assumptions. To this end, the LSDV model with country dummy variables is estimated and test if they are significant variables. Then, the Hausman test is applied to check if individual effects are fixed or random. Eventually, a set of residual tests is used to examine characteristics of the stochastic process that generates disturbances. The results of the tests are presented in Table 1.

Table 1. Tests of the panel model errors' characteristics

Test	Null	Statistics
Individual effects	All individual effects are equal to zero	F( 13,232) =2.02**
Hausman test	The difference in coefficients is not systematic	chi2(6)=22.14***
Heteroskedasticity (Modified Wald)	All residual variances are equal	chi2 (14)=1933.72***
Autocorrelation (Wooldridge)	Residuals are not first-order autocorrelated	F( 1,13) =21.050***
CSD dependency Breusch-Pagan LM test	Residuals are not cross-sectionally correlated	chi2(91) =88.111
CSD dependency Pesaran	Residuals are not cross-sectionally correlated	z=1.034

**Note:** \*\*\* indicates a 1% significance level.

The result of the F-test on the significance of country dummy variables indicates that individual effects are significant; therefore, the assumption on composite model error is valid. The nature of individual effects in macroeconomic panel models with countries as panel units are typically found to be fixed; as implied by the Hausman test, this is also the case in our model. The results of Wald (Greene, 2000) and Wooldridge (Wooldridge, 2002) tests validate assumptions on heteroskedastic and autocorrelated residuals, as expected. On the other hand, residuals seem to be not cross-sectionally correlated, which opposed intuitive expectations about cross-sectional panel dependency between the countries that belong to certain economic and geographic regions. However, the lack of cross-sectional dependency is robustly indicated by both the Breusch-Pagan LM (Greene, 2000) and Pesaran tests (Pesaran, 2004).

Summarizing findings from tests in Table 1, it appears that model errors are composed of fixed individual effects and heteroskedastic and autocorrelated disturbances. A proper estimation of the panel model, when OLS assumptions on residuals are not valid, is a challenging task, since all panel estimators proposed in the literature have some pros and cons. When fixed effects are present within the model error, the benchmark estimator is an OLS-based fixed effects estimator (FE OLS). The major advantage of the FE OLS estimator is that it produces a consistent estimate of regression coefficients as long as model disturbances are not correlated to the regressors, even in cases where individual effects are correlated with regressors (Wooldridge, 2002). The other advantage is that in cases when model disturbances are heteroskedastic and autocorrelated but not cross-sectionally dependent, the reliability of the inference on the significance of regression coefficients can be simply improved by using generalized Huber-Eicker-White (HEW) corrected residuals (robust to heteroskedasticity and correlation within panel units). The alternative LS-based estimator to FE is the Feasible Generalized Least Square estimator (FGLS), which also produced estimates of residuals robust to heteroskedasticity and autocorrelation. While theoretically more plausible, FGLS seems to lose the reliability of estimation if T is not considerably higher than N dimension of the panel data in the sample (Beck & Katz, 1995).

The main shortcoming of the FE OLS estimator is possible endogeneity issues in the estimation of dynamic panel models when the first lag of the dependent variable is included in the model, which undermines the reliability of the estimates; this issue is known as Nickel bias (Nickell, 1981). However, Nickel bias turns out to be considerable only in cases of "short" panels, i.e., panels in which the T dimension of the panel is very small; increasing T reduces the bias of OLS estimates (Baum, 2013). Since this model is specified in dynamic form, GMM-based estimators are considered as an alternative to LS-based estimators to get insight into the reliability of LS-based estimates. More specifically, Difference (Arellano & Bond, 1991) DIF GMM and System (Arellano & Bover, 1995; Blundell & Bond, 1998) SYS GMM estimators are used in addition to FE OLS and FGLS. The GMM-based estimators utilize moment

conditions to estimate the regression coefficient using the lags of endogenous variables (the first differences and/or levels) as the internal instruments; in the case of DIF GMM, moment conditions are set only for model equation specified in the first differences, while in SYS GMM moment conditions are set for both model equations in difference and level terms. The main advantage of GMM-based estimators over LS is purging endogeneity from the model, while the main drawback is that lags of endogenous variables might be weak instruments. For further discussion on conditions in which GMM-based estimators outperform LS-based estimators, and the pros and cons of DIF GMM vis-à-vis SYS GMM, see, for example, Roodman (2007, 2009) or Li et al. (2021).

#### 4. RESULTS AND DISCUSSION

In line with the methodological discussion, the appropriate model is estimated using four different estimators: FE OLS, FGLS, AB GMM and SYS GMM. In the case of FE OLS estimation, residuals are HEW corrected to address heteroskedasticity and autocorrelation of the residuals. Regarding FGLS, individual effects are removed using country dummies. In order to avoid issues of too many moment conditions, number of dependent variable lags being used as instruments in GMM estimation are collapsed and limited.

The obtained results are presented in the Table 2.

*Table 2.* Results of the defined model

Variable	FE OLS	FGLS	AB GMM	SYS GMM
CO2 (t-1)	0.8240*** (0.0522)	0.8598*** (0.0257)	0.7994*** (0.1294)	0.7827*** (0.1280)
GDP	0.3288*** (0.0989)	0.3519*** (0.0839)	0.3153*** (0.1109)	0.2921** (0.1290)
RQ	-0.0287** (0.0099)	-0.0235 (0.0149)	-0.0678*** (0.0243)	-0.0816*** (0.0259)
ELFC	0.7753*** (0.1286)	0.7296*** (0.0857)	0.8769*** (0.2009)	0.8804*** (0.2018)
HDI	0.9360 (0.8879)	0.2884 (0.5484)	0.7358 (1.2454)	1.0003 (1.1760)
RDE	-0.0333*** (0.0104)	-0.0329*** (0.0104)	-0.0898* (0.0475)	-0.0861* (0.0499)
AR(2) test			-1.33	-1.33
Sargan test			3.69	5.07
Hansen test			3.85	4.91

**Note:** \*\*\* indicates a 1% significance level; \*\* indicates a 5% significance level; and \* indicates a 10% significance level.

The empirical results confirm that economic growth in CEE countries is significantly associated with increased CO<sub>2</sub> emissions, indicating that their development pathways remain heavily dependent on carbon-intensive activities. This is consistent with the findings of Bashir et al. (2022), who emphasized that growth driven by traditional industrial and energy sectors leads to environmental degradation. These results are in line with studies such as Salahuddin et al. (2015), Al-Mulali and Che Sab (2018), and Rahaman et al. (2022), which found a strong positive relationship between economic activity and emissions in emerging and energy-dependent economies.

Similarly, electricity consumption exerts a positive and statistically significant influence on CO<sub>2</sub> emissions, underscoring the continued reliance on non-renewable energy sources across

the region. These findings are aligned with the results of Njoke et al. (2019), Hilaire et al. (2014), and Salahuddin et al. (2018), who reported similar outcomes in developing and fossil-fuel-dominated energy markets. They also confirm earlier evidence from sectoral analyses like those by Çıtak et al. (2021), indicating that electricity use (particularly in the industrial and public sectors) contributes significantly to environmental degradation. On the other hand, they diverge from studies such as Ahmad et al. (2017), which showed a negative correlation between electricity use and emissions in Croatia, where a higher share of renewable energy in the electricity mix may have altered the outcome.

In contrast, regulatory quality is shown to significantly reduce CO<sub>2</sub> emissions, supporting the argument that strong institutional and governance structures play a key role in promoting environmental sustainability. This aligns with the findings of Addai et al. (2023), Mahmood et al. (2022), and Boateng et al. (2023), who emphasized the importance of effective regulations and transparency in achieving environmental goals. These results indicate that, even in transitional economies, robust regulatory frameworks can help limit fossil fuel dependency and enforce environmentally responsible practices. However, they are at odds with studies such as Adedoyin et al. (2020), which identified counterproductive regulatory effects in some BRICS countries, suggesting that policy effectiveness may vary depending on implementation quality and broader governance context.

Furthermore, R&D expenditures exert a negative and significant effect on CO<sub>2</sub> emissions, highlighting the important role of innovation and technology development in environmental protection. This outcome supports the findings of Fernández et al. (2018), Tamazian and Rao (2010), and Dmytrenko et al. (2024), who identified R&D investment—particularly in the energy sector—as a key driver of emissions reduction. It also reinforces the arguments by Lee and Lee (2013) and Siddiqui and Fleten (2010), who stressed the strategic role of R&D in facilitating the shift away from fossil fuels. Nonetheless, the results contradict Garrone and Grilli (2010), who questioned the efficacy of public R&D in reducing emission intensity, indicating that in CEE countries, innovation policies may be relatively well-aligned with environmental goals.

Unlike the other variables, human development does not show a statistically significant relationship with CO<sub>2</sub> emissions in the context of CEE countries. This may suggest that improvements in education, health, and income have yet to translate into environmental awareness or the adoption of sustainable consumption patterns. While this result contrasts with Sezgin et al. (2021), Li and Ouyang (2019), and Xu et al. (2024), who identified various shapes of the relationship between human development and emissions, it is partially consistent with earlier findings from Cole et al. (2005) and Gangadharan and Valenzuela (2001), who emphasized that the environmental impact of human capital is highly context-dependent. It also supports the idea of a threshold effect (Khan, 2020), where the environmental benefits of human development may emerge only beyond a certain maturity level, which some CEE countries may not have yet reached.

## 5. CONCLUSION

This study assessed the effects of economic growth, human development, electricity consumption, regulatory quality, and R&D expenditures on CO<sub>2</sub> emissions in Central and Eastern European countries. The results indicate that economic growth and electricity consumption significantly increase emissions, pointing to persistent reliance on carbon-intensive practices. Conversely, regulatory quality and R&D expenditures are found to reduce emissions, underlining the importance of institutional governance and innovation in environmental protection. Human development, however, showed no significant impact,

suggesting that its environmental benefits have yet to materialize in the region's current developmental context.

Theoretically, the findings contribute to the broader environmental economics literature by validating the Environmental Kuznets Curve in part, while emphasizing the need to incorporate governance and innovation factors into empirical models of emissions. The observed variation in impacts across variables supports multidimensional explanations for environmental performance and highlights the limitations of purely growth-based or human development-centered models in explaining emissions in transitional economies.

In terms of practical implications, the study suggests that policymakers in CEE countries should direct attention toward strengthening regulatory institutions and boosting investment in green R&D to mitigate emissions. Reliance on economic expansion and increased electricity use without structural transformation will only exacerbate environmental pressures. Integrating sustainability objectives into education and public awareness campaigns may help amplify the long-term environmental benefits of human development, while improving energy efficiency and diversifying the energy mix is essential for managing the carbon intensity of electricity consumption.

Despite offering important insights, the study has certain limitations. The use of aggregated panel data masks potential heterogeneity across countries and sectors. Moreover, the exclusion of key variables such as renewable energy usage, trade-related emissions, and environmental policy stringency limits the ability to capture the full complexity of the emissions drivers. The time horizon and data availability constraints also affect the interpretation of causality and long-term effects.

Future research should address these limitations by incorporating country-specific and sector-specific analyses, as well as a broader set of environmental and technological indicators. Disaggregating the effects of different types of R&D and regulatory instruments could further clarify their roles. Longitudinal case studies and dynamic panel approaches would allow for a deeper understanding of how institutional and innovation factors interact with economic and social development to shape environmental outcomes in the long run.

## ACKNOWLEDGMENT

The research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (No: 451-03-136/2025-03 and 451-03137/2025-03/200131).

## REFERENCES

- Addai, K., Serener, B., & Kirikkaleli, D. (2023). Environmental sustainability and regulatory quality in emerging economies: Empirical evidence from Eastern European Region. *Journal of the Knowledge Economy*, 14(3), 3290-3326. <https://doi.org/10.1007/s13132-022-01000-2>
- Adedoyin, F. F., Gumedé, M. I., Bekun, F. V., Etokakpan, M. U., & Balsalobre-Lorente, D. (2020). Modelling coal rent, economic growth and CO<sub>2</sub> emissions: does regulatory quality matter in BRICS economies?. *Science of the Total Environment*, 710, 136284. <https://doi.org/10.1016/j.scitotenv.2019.136284>
- Ahmad, N., Du, L., Lu, J., Wang, J., Li, H. Z., & Hashmi, M. Z. (2017). Modelling the CO<sub>2</sub> emissions and economic growth in Croatia: is there any environmental Kuznets curve?. *Energy*, 123, 164-172. <https://doi.org/10.1016/j.energy.2016.12.106>

- Akhter, W., Zaman, K., Nassani, A. A., & Abro, M. M. Q. (2020). Nexus between natural and technical disaster shocks, resource depletion and growth-specific factors: evidence from quantile regression. *Natural Hazards*, 104, 143-169. <https://doi.org/10.1007/s11069-020-04163-w>
- Al-Mulali, U., & Che Sab, C. N. B. (2018). Electricity consumption, CO2 emission, and economic growth in the Middle East. *Energy Sources, Part B: Economics, Planning, and Policy*, 13(5), 257-263. <https://doi.org/10.1080/15567249.2012.658958>
- Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, 58(2), 277-297. <https://doi.org/10.2307/2297968>
- Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, 68(1), 29-51. [https://doi.org/10.1016/0304-4076\(94\)01642-D](https://doi.org/10.1016/0304-4076(94)01642-D)
- Baek, J. (2015). Environmental Kuznets curve for CO2 emissions: the case of Arctic countries. *Energy Economics*, 50, 13-17. <https://doi.org/10.1016/j.eneco.2015.04.010>
- Bashir, M. F., Benjiang, M. A., Hussain, H. I., Shahbaz, M., Koca, K., & Shahzadi, I. (2022). Evaluating environmental commitments to COP21 and the role of economic complexity, renewable energy, financial development, urbanization, and energy innovation: empirical evidence from the RCEP countries. *Renewable Energy*, 184, 541-550. <https://doi.org/10.1016/j.renene.2021.11.102>
- Beck, N., & Katz, J. N. (1995). What to do (and not to do) with time-series cross-section data. *American political science review*, 89(3), 634-647. <https://doi.org/10.2307/2082979>
- Bilgili, F., Balsalobre-Lorente, D., Kuşkaya, S., Alnour, M., Önderol, S., & Hoque, M. E. (2024). Are research and development on energy efficiency and energy sources effective in the level of CO2 emissions? Fresh evidence from EU data. *Environment, Development and Sustainability*, 26(9), 24183-24219. <https://doi.org/10.1007/s10668-023-03641-y>
- Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, 87(1), 115-143. [https://doi.org/10.1016/S0304-4076\(98\)00009-8](https://doi.org/10.1016/S0304-4076(98)00009-8)
- Boateng, E., Annor, C. B., & Amponsah, M. (2023). Assessing the role of regulatory quality, favouritism, administrative requirement and licencing restriction in curtailing carbon emissions. *Journal of Public Affairs*, 23(1), e2845. <https://doi.org/10.1002/pa.2845>
- Boateng, E., Annor, C. B., Amponsah, M., & Ayibor, R. E. (2024). Does FDI mitigate CO2 emissions intensity? Not when institutional quality is weak. *Journal of environmental management*, 354, 120386. <https://doi.org/10.1016/j.jenvman.2024.120386>
- Bouman, T., Verschoor, M., Albers, C.J., Böhm, G., Fisher, S.D., Poortinga, W., Whitmarsh, L., & Steg, L., (2020). When worry about climate change leads to climate action: How values, worry and personal responsibility relate to various climate actions. *Global Environmental Change*, 62, 102061. <https://doi.org/10.1016/j.gloenvcha.2020.102061>
- Bumpus, A., & Comello, S. (2017). Emerging clean energy technology investment trends. *Nature Climate Change*, 7(6), 382-385. <https://doi.org/10.1038/nclimate3306>
- Cansino, J. M., Carril-Cacia, F., Molina-Parrado, J. C., & Román-Collado, R. (2021). Do environmental regulations matter on Spanish foreign investment? A multisectorial approach. *Environmental Science and Pollution Research*, 28(41), 57781-57797. <https://doi.org/10.1007/s11356-021-14635-6>
- Chen, S., Sohail, M. T., & Yang, M. (2022). Examining the effects of information and communications technology on green growth and environmental performance, socio-

- economic and environmental cost of technology generation: A pathway toward environment sustainability. *Frontiers in psychology*, 13, 999045. <https://doi.org/10.3389/fpsyg.2022.999045>
- Çıtak, F., Şişman, M. Y., & Bağcı, B. (2021). Nexus between disaggregated electricity consumption and CO2 emissions in Turkey: new evidence from quantile-on-quantile approach. *Environmental and Ecological Statistics*, 28(4), 843-860. <http://dx.doi.org/10.15640/jibe.v2n3a8>
- Claudelin, A., Uusitalo, V., Hintukainen, I., Kuokkanen, A., Tertsunen, P., Leino, M., & Linnanen, L. (2020). Increasing positive climate impact by combining anti-consumption and consumption changes with impact investing. *Sustainable Development*, 28(6), 1689-1701. <https://doi.org/10.1002/sd.2117>
- Cole, M. A., Elliott, R. J., & Shimamoto, K. (2005). Industrial characteristics, environmental regulations and air pollution: an analysis of the UK manufacturing sector. *Journal of environmental economics and management*, 50(1), 121-143. <https://doi.org/10.1016/j.jeem.2004.08.001>
- Dmytrenko, D., Prokop, V., & Zapletal, D. (2024). The impact of environmental policy stringency and environmental taxes on GHG emissions in Western and Central European countries. *Energy Systems*. <https://doi.org/10.1007/s12667-023-00651-7>
- Fernández, Y. F., López, M. F., & Blanco, B. O. (2018). Innovation for sustainability: the impact of R&D spending on CO2 emissions. *Journal of cleaner production*, 172, 3459-3467. <https://doi.org/10.1016/j.jclepro.2017.11.001>
- Gangadharan, L., & Valenzuela, M. R. (2001). Interrelationships between income, health and the environment: extending the Environmental Kuznets Curve hypothesis. *Ecological Economics*, 36(3), 513-531. [https://doi.org/10.1016/S0921-8009\(00\)00250-0](https://doi.org/10.1016/S0921-8009(00)00250-0)
- Garrone, P., & Grilli, L. (2010). Is there a relationship between public expenditures in energy R&D and carbon emissions per GDP? An empirical investigation. *Energy policy*, 38(10), 5600-5613. <https://doi.org/10.1016/j.enpol.2010.04.057>
- Greene, W. (2000). *Econometric Analysis*. New York: Prentice-Hall.
- Guzowska, M. K., Kryk, B., Michalak, D., & Szyja, P. (2021). R&D spending in the energy sector and achieving the goal of climate neutrality. *Energies*, 14(23), 7875. <https://doi.org/10.3390/en14237875>
- Haldar, A., Sethi, N. (2021), Effect of institutional quality and renewable energy consumption on CO2 emissions- an empirical investigation for developing countries. *Environmental Science and Pollution Research*, 28(12), 15485-15503. <https://doi.org/10.1007/s11356-020-11532-2>
- Hao, Y. (2022). Effect of economic indicators, renewable energy consumption and human development on climate change: An empirical analysis based on panel data of selected countries. *Frontiers in Energy Research*, 10, 1–19. <https://doi.org/10.3389/fenrg.2022.841497>
- Hilaire, N., Hervé, K. F., & François, K. (2014). Atmospheric pollution and economic growth in Cameroon. *Journal of International Business and Economics*, 2(3), 171-187.
- Kahouli, B. (2018). The causality link between energy electricity consumption, CO2 emissions, R&D stocks and economic growth in Mediterranean countries (MCs). *Energy*, 145, 388-399. <https://doi.org/10.1016/j.energy.2017.12.136>
- Kashif, U., Shi, J., Naseem, S., Dou, S., & Zahid, Z. (2024). ICT service exports and CO2 emissions in OECD countries: the moderating effect of regulatory quality. *Economic Change and Restructuring*, 57(3), 94. <https://doi.org/10.1007/s10644-024-09685-y>
- Khan, H., Weili, L., & Khan, I. (2022). Institutional quality, financial development and the influence of environmental factors on carbon emissions: evidence from a global



- perspective. *Environmental Science and Pollution Research*, 29, 13356–13368. <https://doi.org/10.1007/s11356-021-16626-z>
- Khan, M. (2020). CO2 emissions and sustainable economic development: New evidence on the role of human capital. *Sustainable Development*, 28(5), 1279-1288. <https://doi.org/10.1002/sd.2083>
- Khan, M., Rana, A. T., & Ghardallou, W. (2023). FDI and CO2 emissions in developing countries: the role of human capital. *Natural Hazards*, 117(1), 1125-1155. <https://doi.org/10.1007/s11069-023-05949-4>
- Kwakwa, P. A. (2021). The carbon dioxide emissions effect of income growth, electricity consumption and electricity power crisis. *Management of Environmental Quality: An International Journal*, 32(3), 470-487. <https://doi.org/10.1108/MEQ-11-2020-0264>
- Kwakwa, P. A., & Aboagye, S. (2024). Addressing Africa's carbon dioxide emission: the role of natural resources, control of corruption, voice and accountability and regulatory quality. *Management of Environmental Quality: An International Journal*, 35(7), 1437-1460. <https://doi.org/10.1108/MEQ-11-2023-0381>
- Laverde-Rojas, H., Guevara-Fletcher, D. A., & Camacho-Murillo, A. (2021). Economic growth, economic complexity, and carbon dioxide emissions: The case of Colombia. *Heliyon*, 7(6), e07188. <https://doi.org/10.1016/j.heliyon.2021.e07188>
- Lee, K., & Lee, S. (2013). Patterns of technological innovation and evolution in the energy sector: A patent-based approach. *Energy Policy*, 59, 415-432. <https://doi.org/10.1016/j.enpol.2013.03.054>
- Li, J., Ding, H., Hu, Y., & Wan, G. (2021). Dealing with dynamic endogeneity in international business research. *Journal of International Business Studies*, 52, 339-362. <https://doi.org/10.1057/s41267-020-00398-8>
- Li, P., & Ouyang, Y. (2019). The dynamic impacts of financial development and human capital on CO2 emission intensity in China: an ARDL approach. *Journal of Business Economics and Management*, 20(5), 939-957. <https://doi.org/10.3846/jbem.2019.10509>
- Li, Z., Zhou, Y., & Zhang, C. (2022). The impact of population factors and low-carbon innovation on carbon dioxide emissions: A Chinese city perspective. *Environmental Science and Pollution Research*, 29(48), 72853–72870. <https://doi.org/10.1007/s11356-022-20671-7>
- Lin, C., Zhang, L., & Zhang, Z. (2022). The impact of the rise of emerging economies on global industrial CO2 emissions: Evidence from emerging economies in regional comprehensive economic partnership. *Resources, Conservation and Recycling*, 177, 106007. <https://doi.org/10.1016/j.resconrec.2021.106007>
- Mahalik, M. K., Le, T. H., Le, H. C., & Mallick, H. (2022). How do sources of carbon dioxide emissions affect life expectancy? Insights from 68 developing and emerging economies. *World Development Sustainability*, 1, 100003. <https://doi.org/10.1016/j.wds.2022.100003>
- Mahmood, H., Hassan, S., Tanveer, M., & Ahmad, A. R. (2022). The effects of rule of law, regulatory quality, and renewable energy on CO2 emissions in South Asia. *International Journal of Energy Economics and Policy*, 12(6), 16-21. <https://doi.org/10.32479/ijeep.13468>
- Nickell, S. (1981). Biases in dynamic models with fixed effects, *Econometrica*, 49 (6), 1417–1426.
- Njoke, M. L., Wu, Z., & Tamba, J. G. (2019). Empirical analysis of electricity consumption, CO2 emissions and economic growth: Evidence from Cameroon. *International Journal of Energy Economics and Policy*, 9(5), 63-73. <https://doi.org/10.32479/ijeep.7915>



- Opoku, E. E. O., Dogah, K. E., & Aluko, O. A. (2022). The contribution of human development towards environmental sustainability. *Energy Economics*, 106, 1–15. <https://doi.org/10.1016/j.eneco.2021.105782>
- Patel, N., Kautish, P., & Shahbaz, M. (2024). Unveiling the complexities of sustainable development: An investigation of economic growth, globalization and human development on carbon emissions in 64 countries. *Sustainable Development*, 32(4), 3612-3639. <https://doi.org/10.1002/sd.2846>
- Patel, N., Kautish, P., & Shahbaz, M. (2024). Unveiling the complexities of sustainable development: An investigation of economic growth, globalization and human development on carbon emissions in 64 countries. *Sustainable Development*, 32(4), 3612-3639. <https://doi.org/10.1002/sd.2846>
- Pesaran, M. H. (2021). General diagnostic tests for cross-sectional dependence in panels. *Empirical economics*, 60(1), 13-50. <https://doi.org/10.1007/s00181-020-01875-7>
- Ptak, M. (2014). Norwegian tax system from the point of view of climate change policy. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 9(1), 71-89.
- Rahaman, M. A., Hossain, M. A., & Chen, S. (2022). The impact of foreign direct investment, tourism, electricity consumption, and economic development on CO2 emissions in Bangladesh. *Environmental science and pollution research*, 29(25), 37344-37358. <https://doi.org/10.1007/s11356-021-18061-6>
- Romero, J. P., & Gramkow, C. (2021). Economic complexity and greenhouse gas emissions. *World Development*, 139, 105317. <https://doi.org/10.1016/j.worlddev.2020.105317>
- Roodman, D. (2007). A short note on the theme of too many instruments. *Center for Global Development Working Paper*, 125(10.2139).
- Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The stata journal*, 9(1), 86-136. <https://doi.org/10.1177/1536867X0900900106>
- Saia, A. (2023). Digitalization and CO2 emissions: Dynamics under R&D and technology innovation regimes. *Technology in Society*, 74, 102323. <https://doi.org/10.1016/j.techsoc.2023.102323>
- Salahuddin, M., Alam, K., Ozturk, I., & Sohag, K. (2018). The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO2 emissions in Kuwait. *Renewable and sustainable energy reviews*, 81, 2002-2010. <https://doi.org/10.1016/j.rser.2017.06.009>
- Salahuddin, M., Gow, J., & Ozturk, I. (2015). Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in Gulf Cooperation Council Countries robust?. *Renewable and Sustainable Energy Reviews*, 51, 317-326. <https://doi.org/10.1016/j.rser.2015.06.005>
- Santos, A., & Forte, R. (2021). Environmental regulation and FDI attraction: a bibliometric analysis of the literature. *Environmental Science and Pollution Research*, 28, 8873-8888. <https://doi.org/10.1007/s11356-020-11091-6>
- Sezgin, F. H., Bayar, Y., Herta, L., & Gavriltea, M. D. (2021). Do environmental stringency policies and human development reduce CO2 emissions? Evidence from G7 and BRICS economies. *International Journal of Environmental Research and Public Health*, 18(13), 6727. <https://doi.org/10.3390/ijerph18136727>
- Siddiqui, A., & Fleten, S. E. (2010). How to proceed with competing alternative energy technologies: A real options analysis. *Energy Economics*, 32(4), 817-830. <https://doi.org/10.1016/j.eneco.2009.12.007>

- Simionescu, M., Strielkowski, W., & Gavurova, B. (2022). Could quality of governance influence pollution? Evidence from the revised Environmental Kuznets Curve in Central and Eastern European countries. *Energy Reports*, 8, 809-819. <https://doi.org/10.1016/j.egy.2021.12.031>
- Tamazian, A., & Rao, B. B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy economics*, 32(1), 137-145. <https://doi.org/10.1016/j.eneco.2009.04.004>
- Töbelmann, D., & Wendler, T. (2020). The impact of environmental innovation on carbon dioxide emissions. *Journal of Cleaner Production*, 244, 118787. <https://doi.org/10.1016/j.jclepro.2019.118787>
- Ullah, R., Ahmad, H., Rehman, F. U., & Fawad, A. (2023). Green innovation and Sustainable Development Goals in SMEs: The moderating role of government incentives. *Journal of Economic and Administrative Sciences*, 39(4), 830-846. <https://doi.org/10.1108/JEAS-07-2021-0122>
- Valone, T. F. (2021). Linear global temperature correlation to carbon dioxide level, sea level, and innovative solutions to a projected 6 C warming by 2100. *Journal of Geoscience and Environment Protection*, 9(03), 84. <https://doi.org/10.4236/gep.2021.93007>
- Wang, K., Yan, M., Wang, Y., & Chang, C. P. (2020). The impact of environmental policy stringency on air quality. *Atmospheric Environment*, 231, 117522. <https://doi.org/10.1016/j.atmosenv.2020.117522>
- Wang, S., Leviston, Z., Hurlstone, M., Lawrence, C., & Walker, I. (2018). Emotions predict policy support: Why it matters how people feel about climate change. *Global Environmental Change*, 50, 25-40. <https://doi.org/10.1016/j.gloenvcha.2018.03.002>
- Wolde-Rufael, Y., & Mulat-Weldemeskel, E. (2023). Effectiveness of environmental taxes and environmental stringent policies on CO2 emissions: the European experience. *Environment, Development and Sustainability*, 25(6), 5211-5239. <https://doi.org/10.1007/s10668-022-02262-1>
- Wooldridge, J.M. (2002). *Econometric Analysis of Cross Section and Panel Data*. Cambridge MA: MIT Press.
- Xu, H., Gao, Y., Wang, C., Guo, Z., Liu, W., & Zhang, D. (2024). Exploring the nexuses between carbon dioxide emissions, material footprints and human development: an empirical study of 151 countries. *Ecological Indicators*, 166, 112229. <https://doi.org/10.1016/j.ecolind.2024.112229>
- Zeiger, B., Gunton, T., & Rutherford, M. (2019). Toward sustainable development: A methodology for evaluating environmental planning systems. *Sustainable Development*, 27(1), 13-24. <https://doi.org/10.1002/sd.1852>



## DESIGNING THE SKANDIA NAVIGATOR TO MANAGE INTANGIBLE CAPITAL: WHAT RELEVANCE FOR MOROCCAN INDUSTRIAL COMPANIES?

Issam Bahnini\*, Sanae Benjelloun

*Sidi Mohamed Ben Abdellah University, Faculty of Legal, Economic and Social Sciences of Fez, Morocco*

**Abstract:** In this article, we investigate how the intangible capital of Moroccan industrial companies is managed using Skandia Navigator. In a knowledge-based economy, intangible assets such as skills, innovation and customer relations play a role in value creation. However, their management remains complicated, with traditional tools, especially for companies with little analytical skills. This study aims to design the Skandia Navigator and analyze how it can help companies to manage their intangible capital effectively. The methodology is based on a case study conducted at Alpha, a Moroccan industrial company. To collect data, we opted for direct physical observation, document analysis and interviews with managers. The results indicate that using Skandia Navigator optimizes the management of intangible assets by providing a clear and integrated view of performance. The Skandia model has been adapted for the company with five strategic axes: financial, customer, process, innovation and development, and human. This model enables the company to align its day-to-day activities with its strategic objectives, increase employee satisfaction and strengthen customer relations. This study guarantees the Skandia Navigator's effectiveness as an indispensable tool for managing intangible capital in Moroccan industrial companies.

**Keywords:** Skandia Navigator, intangible capital, human capital, organization capital, relational capital

---

\* Corresponding author: [issam.bahnini@usmba.ac.ma](mailto:issam.bahnini@usmba.ac.ma)

Issam Bahnini, ORCID: 0009-0005-8266-3848

Sanae Benjelloun, ORCID: 0009-0003-2793-2895

## **1. INTRODUCTION**

In a knowledge-intensive world, companies risk failing at one of the most critical challenges: leveraging their intangible assets. Central to value creation in a world with skills and knowledge at the heart, innovation and customer relationship resources constituting intangible capital, competitiveness is also anchored upon. Therefore, companies must integrate intangible assets into their business management strategies to stay competitive in the long term.

In answering this call, the article discusses the Skandia Navigator developed by Leif Edvinsson, considered one of the pioneers in intangible capital management. This tool includes five focuses to measure and manage intangible capital, and it is presented as a strategic instrument that handles intangibles effectively. This study aims to apply this tool to upgrade the management of intangible resources in a Moroccan industrial company, Alpha. Our Research question is: How do you design a Skandia Navigator to enable a company to manage its intangible assets effectively? In this sense, we seek to assess the efficacy and applicability of this model for Moroccan companies, especially those of industrial origin.

## **2. LITERATURE REVIEW**

### **2.1. Intangible capital**

#### **2.1.1. Attempt at definition:**

Intangible capital is a vague concept, as it has been defined differently by different authors and researchers. Indeed, in the literature we find a variety of definitions, such as:

“Intangible capital is everything that cannot be touched but can make money for the company” (Stewart, 1991)

“Intangible capital is a knowledge asset that can be converted into value (Edvinsson & Sullivan, 1996). It is about creating and supporting connectivity between expertise, experience and skills inside and outside the organisation” (Cabrita & Bontis, 2008).

“Intangible capital is the possession of knowledge, practical experience, organizational technology, customer relations and professional skills that give a company a competitive edge in the marketplace” (Edvinsson, 1997).

“Intangible capital is knowledge that can be transformed into future benefits and includes resources such as ideas, inventions, technologies, designs, processes and software” (Sullivan Jr. & Sullivan Sr., 2000).

“Intangible capital is defined as the totality of a company’s capabilities, knowledge, culture, strategy, processes, intellectual property and relational networks that create value or competitive advantages and help a company to achieve its objectives” (Hsu & Fang, 2009).

Based on these definitions, intangible capital is know-how, resources, skills, processes, relationships and intangibles that companies hold and need to create an economic value edge.

#### **2.1.2. Components of Intangible Capital:**

One of the most complex steps is identifying intangible capital, which includes a set of different and specific dimensions. This diversity offers a rich and nuanced perspective on an organisation’s intangible assets, providing a valuable framework for assessing its overall value and performance.

Thus, the intangible capital can be broken down into three components: Human capital, which includes the skills, knowledge and experience of individuals within the company. Organisational capital is subdivided into innovation and process capital, including organisational structures and information systems. In this regard, Edvinsson has defined it as “All that’s left when the employees go home”. The third component is the relational capital, which comprises relations with the company’s customers and external stakeholders (Edvinsson, 1997; Sveiby, 1997).

An often-overlooked aspect of developing intellectual capital is the interdependence of different types of knowledge and their impact on each other’s value and performance within an organisation (Seemann et al., 2000). Edvinsson (1997) highlights that the components of intellectual capital are interconnected and continuously interact. Building on this idea, Stewart (1997) asserts that intellectual capital is not just the sum of its parts; its value arises from the synergy and dynamic interplay among its three main dimensions: Structural, customer, and human capital.

Thus, in their article, Abdelhai and Lebzar (2018) conducted an exploratory case study within the company LMDC to understand the interaction between intangible capital components. By examining the link between human, organizational and relational capital. It turns out that these elements are linked. Human capital, with the skills and know-how of employees, enables internal operations to be fine-tuned. Organizational capital supports the organization and dissemination of this knowledge. At the same time, relational capital enables the integration of external information that strengthens the organization and the skills of its members. These three components work together to enhance the company's performance and learning.

This study indicates that intangible capital is an integrated system in which all the elements are interdependent and that the advantage it provides is a sustainable competitive advantage for the company. According to this framework, the interaction of intangible capital components determines the company's capacity to produce and create value. By bringing these components together, organisations can leverage their internal know-how on a large scale, becoming integrated and linked to the outside world for innovation, customer satisfaction, and dominance over the competition.

Therefore, we conclude that organizations must identify and nurture these relationships between the different elements of intangible capital to survive and succeed in a dynamic environment.

## **2.2. Skandia Navigator**

Many tools and approaches have been developed to work with intangible capital to ensure strategic governance of these assets and to manage them effectively and comprehensively. One such tool is Skandia Navigator, which organizes and evaluates a company's intangible assets. This part looks at this tool and the stages involved in its design and implementation.

### **2.2.1. Presentation of the tool:**

The Skandia Navigator is an important leap in strategic management. It was developed by Leif Edvinsson and Michael Malone in 1997 and uses intangible capital as a core element of value creation. Structured around five interdependent focuses, this model follows a temporal (past, present, future) and systemic logic, symbolised by the architectural metaphor of a “house” (see figure below) (Bontis, 2001). At the top, the financial focus reflects past performance using

traditional indicators such as return on investment or net margin. What sets it apart, however, are the other four focuses, which highlight the intangible performance factors.

The walls of the house, representing the Customer and Process focuses, anchor the company in the operational present. The Customer focus assesses current satisfaction and the depth of partner relationships, reflecting the company's relational capital. At the same time, the Process focus measures the effectiveness of organisational routines, a key element of structural capital. The base of the model, embodied by the Innovation & Development focus, projects the organisation into the future using forward-looking indicators such as R&D expenditure, the patent portfolio and skills renewal rates. This forward-looking dimension sets Skandia Navigator apart from traditional tools by explicitly preparing for future disruptions (Edvinsson, 1997).

The Human focus is at the centre of this conceptual structure, which Edvinsson describes as “the living soul of the organisation”. This transversal focus encompasses individual skills, collective learning dynamics, cultural alignment, and the capacity for disruptive innovation. Its centrality underlines that intangible value emerges from interactions between employees and other assets (Bontis, 2001).

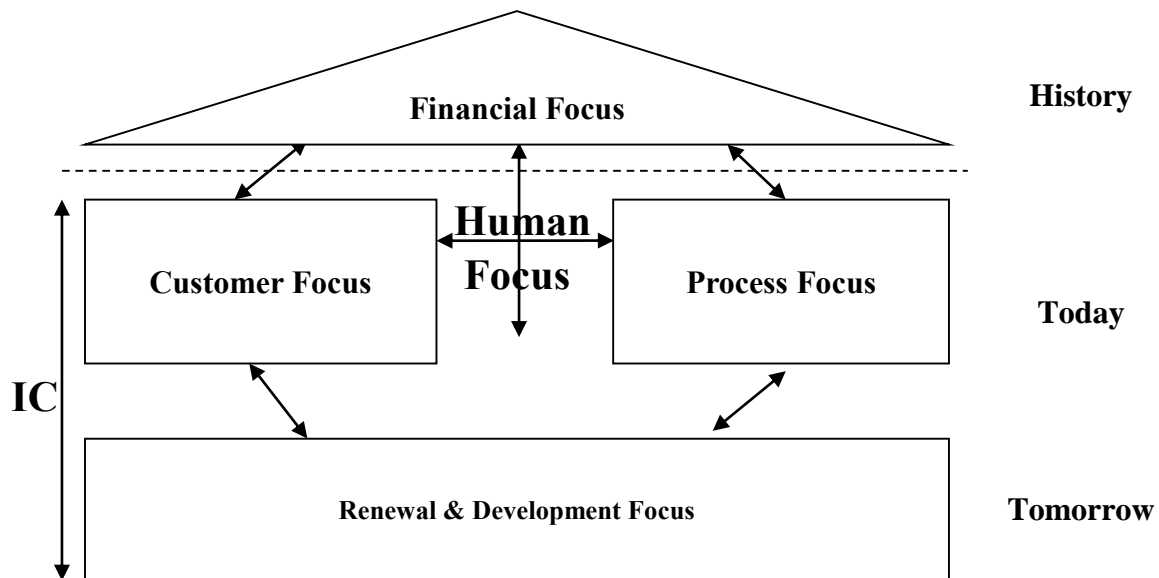


Figure 1. Presentation of the Skandia Navigator (Edvinsson, 1997)

### 2.2.2. Steps of conception

In their article “Implementing Strategic Planning with the Skandia Navigator,” Ryden and Bredahl (2003) outline the steps necessary to develop the Skandia Navigator. The process starts with a model and requires a clearly defined company vision before implementation. This model transforms the company’s vision and strategy into measurable indicators and activities. It is broken down into several steps to ensure a practical and straightforward translation process.

Combining these steps within a strategic framework enables the organisation to develop in an organised and measurable way. Firstly, a foundation of core values creates a solid organisational culture early on, linking day-to-day behaviour to long-term strategy. Secondly, a clear vision and strategic objectives leave nothing to be desired. The organisation can then measure itself using success factors and indicators to make progress in the areas where progress is significant. Furthermore, where the visualisation of objectives and implementation timetables is envisaged, these indicators should accompany them to monitor performance continuously;

we need to have action plans to implement the agreed objectives. Finally, dissecting the cause-and-effect relationships between the strategic plan's different aspects will help us stay on track and adjust actions if we deviate.

In short, these strategic steps will enable the organisation to stay on track and adapt its actions according to the results. Defining objectives, measures and the action plan should be done similarly so that objectives are managed consistently and efforts and resources are used effectively.

### **3. METHODOLOGY**

#### **3.1. Progress of the study**

Our theoretical framework was enhanced by an exploratory study, using the case study method, which involves systematically collecting sufficient information about a person, event, or social system to enable the researcher to understand how it operates or manifests in real-life situations (Chevalier et al., 2018). According to Yin (2003), the case study helps address research questions of the "what," "how," and "why" types, especially when research conditions demand avoiding manipulation of variables and when access to both dimensions of the phenomenon and its context is limited.

For our study, we completed a six-month internship at Alpha Company. This involvement allowed us to employ various methodological techniques to collect diverse and rich data for our work. Specifically:

First, we witnessed the daily activities across all company departments through direct observation. This enabled us to comprehend the tasks and missions of each department and the interactions among teams, leading to a holistic understanding of the organization's operations, beyond just formal procedures.

We then conducted six semi-structured interviews with managers from several departments, including management controllers, human resources and the IT team. These interviews provided essential data for our research.

Finally, the company's internal documents, such as annual reports, organisation charts, etc., are essential for understanding its strategy and internal workings.

#### **3.2. Field of Study and Approach Used for Design**

Alpha, a Moroccan industrial company, struggles to find appropriate tools to monitor and maintain intangible assets. Production metrics are what most managers seem to monitor and can often overlook the more important areas of employee morale, staff motivation, innovation and customer satisfaction. Compounding this problem is the management control department of finance management accounting, which is overly focused on financial data. In addition, today's dashboards are more often than not mere rituals and are rarely, if ever, used in practice. For Alpha, Skandia Navigator's solution responds directly to this need.

The implementation strategy begins with analyzing the company's environment using the SWOT matrix to determine the strengths, weaknesses, opportunities and threats that influence its activities. We followed this up with an analysis of the current strategy, looking at the mission, vision and values. We then tightened up the company's strategy. This has enabled us to formulate an integrated strategic vision that supports the organisation's long-term objectives. We mapped this vision as a goal-oriented objective on the Alpha strategy map, which is essential for explaining the relationships between the performance drivers. In the next

step, we established key performance indicators (KPIs) by strategic dimension; these are very important for assessing the effect/impact of our initiatives.

#### 4. RESULTS AND DISCUSSION:

Table 1. Skandia Navigator of Alpha Company

Financial Focus	Customer Focus	Process Focus	Renewal & Development Focus	Human Focus
Return on Investment	Number of Clients	Employee satisfaction level regarding computers	Training expenses per employee (activity 1)	Motivation index
4,69%	1 Client	95%	11.000 MAD	44.67%
Investment in IT	Customer satisfaction rate	Computers per employee	Number of training sessions per employee (activity 1)	Leadership index
2.000.000 MAD	99%	1 computer	1 Formation	58%
Revenue per employee	Total number of product returns	Staff workload	Training duration per year (activity 1)	Turnover rate
234744,18 MAD	1 return	205.000.000 MAD	1 year	1.37%
Value added per employee	Number of complaints rate	Staff workload relative to Revenue	Training expenses per employee (activity 2)	Absenteeism rate
72671,48 MAD	10 complaints	27,26%	20.000 MAD	4.42%
Total assets per employee	Complaint resolution rate	Number of contracts per employee	Number of training sessions per employee (activity 2)	Average years of service in the company
164100,51MAD	96%	3203	30 Formations	10 years
	Market share	Estimated value of obsolete IT equipment	Training duration per year (activity 2)	Number of female managers
	36,87%	250.000 MAD	60 days	13 females
			Number of employees under 40 years old	Number of managers
			2100 employees	71 managers

Analysing various indicators for Alpha Company highlights several key aspects of its performance across different domains.

**Financial Aspect:** Indicators such as revenue per employee (234,744.18 MAD), value added per employee (97,203.64 MAD), and assets per employee (655,102.04 MAD) demonstrate efficient use of human resources and solid profitability. A return on investment (ROI) of 4.69% and an IT investment of 2,000,000 MAD underscore the company's commitment to improving infrastructure to support innovation and growth.

**Customer Aspect:** The company excels with a low merchandise return rate (one per year) and fewer than 10 complaints annually, reflecting high product quality. Customer satisfaction is at 99%, with fast delivery times. Additionally, its market share of 36.87% far exceeds the 15-20% target, indicating a dominant position in the industry.



**Internal Process Aspect:** The company boasts efficient IT equipment (one PC per employee) and a skilled IT team (14 members). The personnel expenses of 205,000,000 MAD and a personnel cost to revenue ratio of 27.26% indicate significant investment in human resources.

**Innovation and Development Aspect:** The company invests in employee training, with substantial spending on seamstresses and administrative staff. A young workforce (2,100 employees under 40) is an asset for innovation and adaptation to new technologies. The company employs 3,203 people, divided as follows: 2,817 on permanent contracts, 206 on fixed-term contracts, and 180 interns. This distribution shows a preference for stability with a majority on permanent contracts, reflecting a long-term talent retention strategy. Fixed-term contracts provide flexibility for temporary needs, while internships represent an investment in training future talent.

**Human Aspect:** The company has 3,202 employees, including 71 managers, but the proportion of female managers is low (18.30%). The leadership index is 58%, and although employee motivation is low (44.67%), an average tenure of 10 years indicates notable employee loyalty, despite challenges related to turnover and absenteeism.

Based on the results obtained from designing the Skandia Navigator and calculating the key indicators we selected, it can be stated that they provide leaders with a transparent and comprehensive view of intangible asset management at all levels. This enables them to make more informed decisions, seamlessly align daily activities with long-term goals, and accurately assess progress. All this is made possible through the integration of five dimensions with both financial and non-financial indicators. Therefore, our findings indicate that the Skandia Navigator can be considered an effective tool for managing intangible capital at the Alpha Company.

At this point, we can address our issue: “How do you design a Skandia Navigator to enable a company to manage its intangible assets effectively?”. The Skandia Navigator helps Alpha Company to effectively manage its intangible capital by providing a single interface for intangible capital management. By combining financial and non-financial indicators, this tool integrates a company's day-to-day management with its strategic objectives, increases employee comfort and commitment, enhances customer loyalty, facilitates innovation and contributes to fund performance. The Skandia Navigator forms the basis of any sound strategy around managing Alpha's intangible assets and is essential to its long-term success and competitive advantage. For the Alpha Company team to operate effectively and implement the Skandia Navigator, it is also essential to make several recommendations. Start with Skandia Navigator: The most important tool for directing performance management in the company. Managers should leave no stone unturned in explaining the value of Skandia Navigator and how it radically affects business performance. The recommended approach is to proceed in stages, to minimise the effects of change and get the team to embrace this new management practice, encouraging employee engagement in using Skandia Navigator to do real work to achieve the organisation's goals. The fact that employees know how using Skandia Navigator will improve their day can be a motivating factor and help achieve the organisation's objectives. Secondly, the strategy needs to be communicated. Managers should schedule regular meetings to explain the company's strategy in detail, highlighting the objectives and each employee's specific role in achieving them. Introducing a reward system, such as bonuses, is important to recognise and motivate teams to meet or exceed targets.

Thirdly, it is recommended that Skandia Navigator be integrated with appropriate software to facilitate the rapid visualisation, analysis and interpretation of key performance indicators. This integration will enable managers and employees to monitor progress effectively, identify trends and deviations, and make informed real-time decisions. Easy access

to critical data will help Alpha adjust its operational strategies and focus on achieving its long-term goals.

## 5. CONCLUSION

This study highlights the strategic role of intangible assets for companies, in particular the under-exploited or poorly understood intangible capital assets in Morocco and its industrial sector. The use and valuation of intangible assets was explored using the Skandia Navigator model on the Alpha company called Skandia Navigator. The dual financial and non-financial indicators integrate performance orientation by providing a comprehensive view of the business's health, going beyond conventional measures to gauge relative success in the business, focusing on issues such as employee satisfaction, customer loyalty, and innovation.

I hope this model will apply to Alpha, as it shows that Skandia Navigator correctly records and monitors the intangible capital that occurs, enabling better management of consistency that aligns with Alpha's vision of direction. However, specific recommendations would need to be implemented to communicate the strategy to all employees, a progressive plan to reduce resistance, and integration of the model into software tools for a more visual and standardised analysis.

The results of this study open up some intriguing prospects for the future. Conducting a similar analysis for other Moroccan companies and several Skandia Navigator sectors would be interesting. This could shed light on where this model fits about others and where it should or should not be applied.

Advanced technologies in artificial intelligence and big data management systems can improve the analysis of Skandia Navigator indicators. By transforming data in real time using these technologies, companies can be much quicker in predicting and reacting in the market by automating certain analytical activities. Finally, what effect would Skandia Navigator have on corporate culture? Another thought-provoking point. Integrating intangible capital into a company's strategy could change how employees and managers perceive the value of their contributions and the role of intangible assets in an organisation's success. This transition could lead to more collaborative, innovative and employee-centred performance management practices.

## REFERENCES

- Abdelhai, S., & Lebzar, B. (2018). Exploration des composantes du capital immatériel: Etude de cas d'une entreprise suisse. *International Journal of Innovative Research in Human Sciences*, 2, 022-032.
- Bontis, N. (2001). Assessing knowledge assets : A review of the models used to measure intellectual capital. *International Journal of Management Reviews*, 3(1), 41-60. <https://doi.org/10.1111/1468-2370.00053>
- Cabrita, M. D. R., & Bontis, N. (2008). Intellectual capital and business performance in the Portuguese banking industry. *International Journal of Technology Management*, 43(1/2/3), 212. <https://doi.org/10.1504/IJTM.2008.019416>
- Chevalier, F., Cloutier, L. M., & Mitev, N. (Éds.). (2018). *Les méthodes de recherche du DBA*. Editions EMS.
- Edvinsson, L. (1997). Intellectual capital : The proven way to establish your company's real value by measuring its hidden brainpower. London : Piatkus. <http://archive.org/details/intellectualcapi0000edvi>

- Edvinsson, L., & Sullivan, P. (1996). Developing a model for managing intellectual capital. *European Management Journal*, 14(4), 356-364. [https://doi.org/10.1016/0263-2373\(96\)00022-9](https://doi.org/10.1016/0263-2373(96)00022-9)
- Erik Sveiby, K. (1997). The intangible assets monitor. *Journal of Human Resource Costing & Accounting*, 2(1), 73-97. <https://doi.org/10.1108/eb029036>
- Hsu, Y.H., & Fang, W. (2009). Intellectual capital and new product development performance : The mediating role of organisational learning capability. *Technological Forecasting and Social Change*, 76(5), 664-677. <https://doi.org/10.1016/j.techfore.2008.03.012>
- Rydén, M., & Bredahl, A.-C. (2003). Implementing strategic planning with the skandia navigator. *Controlling*, 15(3-4), 169-174. <https://doi.org/10.15358/0935-0381-2003-3-4-169>
- Seemann, P., De Long, D., Stucky, S., & Guthrie, E. (2000). Building intangible assets: A strategic framework for investing in intellectual capital. In D. Morey, M. T. Maybury, & B. Thuraillingham (Éds.), *Knowledge Management* (p. 85-98). The MIT Press. <https://doi.org/10.7551/mitpress/4075.003.0011>
- Stewart, T. A. (1991, June 3). BRAINPOWER Intellectual capital is becoming corporate America's most valuable asset and can be its sharpest competitive weapon. The challenge is to find what you have—And use it. Gable News Network Money. [https://money.cnn.com/magazines/fortune/fortune\\_archive/1991/06/03/75096/](https://money.cnn.com/magazines/fortune/fortune_archive/1991/06/03/75096/)
- Stewart, T. A. (1997). Intellectual capital: The new wealth of organizations. Brealey.
- Sullivan, P. H. Jr., & Sullivan, P. H. Sr. (2000). Valuing intangible companies – An intellectual capital approach. *Journal of Intellectual Capital*, 1(4), 328-340. <https://doi.org/10.1108/14691930010359234>
- Yin, R. K. (2003). *Case study research: Design and methods* (4. ed., [Nachdr.]). Sage.



## THE IMPACT OF PROCESS AUTOMATION ON MANAGEMENT CONTROL AND THE PERFORMANCE OF TOURISM COMPANIES: A BIBLIOMETRIC ANALYSIS

Sissah Safae\*, Hmioui Aziz

*University Sidi Mohamed Ben Abdellah, National School of Business and Management,  
Morocco*

**Abstract:** In today's increasingly competitive and digitalized tourism environment, companies face complex challenges in managing resources, optimizing spending and keeping customers satisfied. Process automation is a strategic response to these challenges, optimizing operational efficiency and minimizing margins for error. In this context, management control, an essential element of organizational performance, takes full advantage of automation, in particular by optimizing data collection and analysis. However, although automation offers undeniable opportunities, its impact on the performance of tourism companies has not yet been systematically studied. The aim of this study is to analyse the impact of automation on management control and the performance of tourism companies through a bibliometric analysis of scientific research publication trends.

**Keywords:** Bibliometric analysis, management control, performance, automation, tourism companies.

### 1. INTRODUCTION

The tourism industry, known for its dynamic and rapidly changing environment (Brown & al., 2020), is increasingly leveraging technological advancements to enhance operational efficiency and business performance (Buckley, 2011). Among these advancements, (Asadullah & Raza, 2016) process automation has emerged as a critical driver of transformation. Process automation (Gasser & Westhoff, 2012) refers to the use of technology to streamline and perform repetitive tasks (Tussyadiah, 2020), such as customer service, booking management, and data processing, that were once handled manually. By automating these tasks, (Ivanov, 2020) tourism companies can reduce operational costs, improve accuracy, and enhance productivity. However, the widespread adoption of automation in this sector raises important questions

---

\* Corresponding author: [safae.sissah@usmba.ac.ma](mailto:safae.sissah@usmba.ac.ma)

Sissah Safae, ORCID: 0009-0008-9220-3150  
Hmioui Aziz, ORCID: 0000-0002-9032-4978

regarding its impact on management control systems and overall company performance (SISSAH & Hmioui, 2025).

The effects of process automation extend beyond operational improvements (Ivanov, 2020) to significantly influence management control systems. Traditional management control methods (Fordyce & al., 1986), often reliant on manual reporting and oversight, are evolving to accommodate real-time data processing and automated decision-making. This evolution (Langfield, 1997) makes it possible to measure company performance, allocate resources efficiently and, of course, stay abreast of market trends. As a result, (Sissah & Hmioui, 2025) managers are empowered with better tools to oversee performance, ensure quality control, and make strategic decisions that drive business growth.

Moreover, the adoption of automation in tourism companies (Buhalis, 2019) enhances customer satisfaction by improving the quality of services offered. Automated systems (Ivanov, 2020) can also offer personalized experiences. This, of course, can (Buhalis, 2019) enhance the company's reputation and improve its competitive position in the market relative to its competitors (Santos & al., 2020).

However, while process automation offers numerous advantages, it also presents challenges that need addressing. (Llale & al., 2020) The integration of automation requires significant investments in technology, training, and system maintenance. Furthermore, (Ivanov & Webster, 2019) tourism companies must carefully balance automation with the human touch, ensuring that customer relationships and personalized services are not lost in the pursuit of efficiency. With this in mind, it becomes essential to ask the following question: To what extent does the integration of automation in management control processes help improve tourism performance? In order to answer this question, we adopt a bibliometric analysis of the literature, utilizing the SCOPUS database and focusing specifically on scientific articles related to the subject.

## 2. LITERATURE REVIEW

The impact of process automation on management control and performance in tourism companies is a growing area of interest (Siguencia & Halemba, 2019); especially as digital technologies continue to evolve. Process automation significantly optimizes management control systems, which are essential for guiding, supervising and assessing business operations. Automation enables seamless monitoring of performance measurement (Lane & Stone, 2006) indicators within tourism businesses, such as customer satisfaction rates. It also keeps all data up-to-date, enabling managers to act and make decisions quickly. Furthermore, (Bright, 1958) automation enables tasks to be carried out and completed rapidly, minimizing errors and fluctuations in the service provided.

Another advantage of automation is its ability to simplify and streamline data collection and review, saving time on one hand, and keeping reports up to date on the other. Therefore, thanks to automation, (Mohamed & al., 2022) managers can deal with problems more effectively, keeping staff costs under control and reducing the need for human intervention.

The performance of tourism companies (Corne & Peypoch, 2020), in terms of profitability, customer satisfaction, and operational efficiency, is also positively impacted by automation. Automated processes (Wu & al., 2023) reduce the time needed for routine tasks, such as booking, payment processing, and customer communication, improving overall operational efficiency. (Buhalis, 2019) This efficiency enables tourism businesses to be effective and efficient, (Garavaglia, 2009) optimizing the use of resources and enhancing the customer experience with personalized offers based on data collected using digitalized tools.

Moreover, automation facilitates decision-making based on data collected with the help of digitalized tools (Garces & al., 2023) that are capable of predicting changes in customer behaviour, enabling tourism companies to modify their pricing strategies and adjust them in response to demand.

(Siguencia & Halemba, 2019) examine how automated tools can effectively manage tourism services, and they also stress the importance of communication between industry stakeholders in order to benefit from the positive influence of this automation.

Another significant study by (Buhalis, 2019) explores the broader impact of technology on the tourism industry, including how it affects management control and performance. The paper discusses how technological innovations connect tourism stakeholders, enabling co-created value for travelers across all travel stages. (Sinulingga & al., 2024) It predicts that Ambient Intelligence (AmI) Tourism will drive future industry transformations, reshaping structures, processes, and practices, which in turn influences service innovation, strategy, management, marketing, and competitiveness.

Furthermore, (Ivanov & al., 2017) delve into the challenges faced by tourism and hospitality companies when adopting service automation and robots. Their paper examines the implications of automation across various sectors within the industry, providing insights into how these technologies might affect management control and company performance.

These studies collectively suggest that process automation significantly impacts management control and performance in tourism companies by necessitating new communication strategies, enabling co-creation of value, and presenting challenges in adoption and implementation.

However, the initial investment (Domowitz & Steil, 1999) required to implement automated systems can be significant, both in terms of financial cost and time, especially for small tourism businesses. Also, employees (Breton & Bossé, 2002) need training to adapt to the new automated tools, which also requires high training-related costs. Another disadvantage is the risk associated with cybersecurity issues. Indeed, if companies are interested in using automated tools, they need to be aware of security systems to avoid data breaches or cyber-attacks.

In brief, (Vochozka & al., 2020) automation enhances the management control process to improve the performance of tourism businesses by improving decision-making, increasing customer satisfaction and reducing the time spent on tasks performed by managers. However, implementing these automated tools requires massive investment, as do the costs of training staff to keep up to date with the new system, and the risks associated with cybersecurity.

### **3. DATA AND METHODOLOGY**

In this research paper, we analyze articles that discuss the impact of the automation of management control on tourism performance. To collect the necessary data, we utilized the Scopus database, searching for articles, abstracts, and keywords that include the three key terms relevant to our study: management control, tourism performance, and automation. The initial search yielded 25,075 documents related to this topic.

Following the data collection, we began filtering the results to focus exclusively on research within the disciplines of Business, Management, and Accounting, as well as Economics, Econometrics, and Finance, as these are the core areas of interest for our research. Additionally, to account for temporal relevance, we excluded any articles published in 2025, thus eliminating the potential bias of time. Furthermore, we restricted our search to open-access documents to ensure accessibility and transparency. After applying these filters, the final dataset consisted of 181 articles.

The retrieval procedure used for this study was as follows: ( TITLE-ABS-KEY ( management AND control ) AND TITLE-ABS-KEY ( tourism AND performance ) OR TITLE-ABS-KEY ( automation ) ) AND ( LIMIT-TO ( SUBJAREA , "BUSI" ) OR LIMIT-TO ( SUBJAREA , "ECON" ) ) AND ( EXCLUDE ( PUBYEAR , 2025 ) ) AND ( LIMIT-TO ( OA , "all" ) )

The selected articles will be analysed using VOSviewer, a software tool for visualizing bibliometric networks.

## 4. RESULTS AND DISCUSSION

### 4.1. Evolving Research Trends in the Automation of Management Control and Tourism Performance

The figure shows the trend in the publication of scientific articles on the subject of automation, management control and tourism performance. The results show a fluctuating curve, with ups and downs in the number of articles published. The year 2024 showed a remarkable drop compared to previous years, which could indicate a temporary slowdown in interest in the subject (Otley, 2003). Analysis of the curve also shows that the first article published on this subject dates back to (Bailey Jr & al., 1982), marking the beginning of research in this specific field.

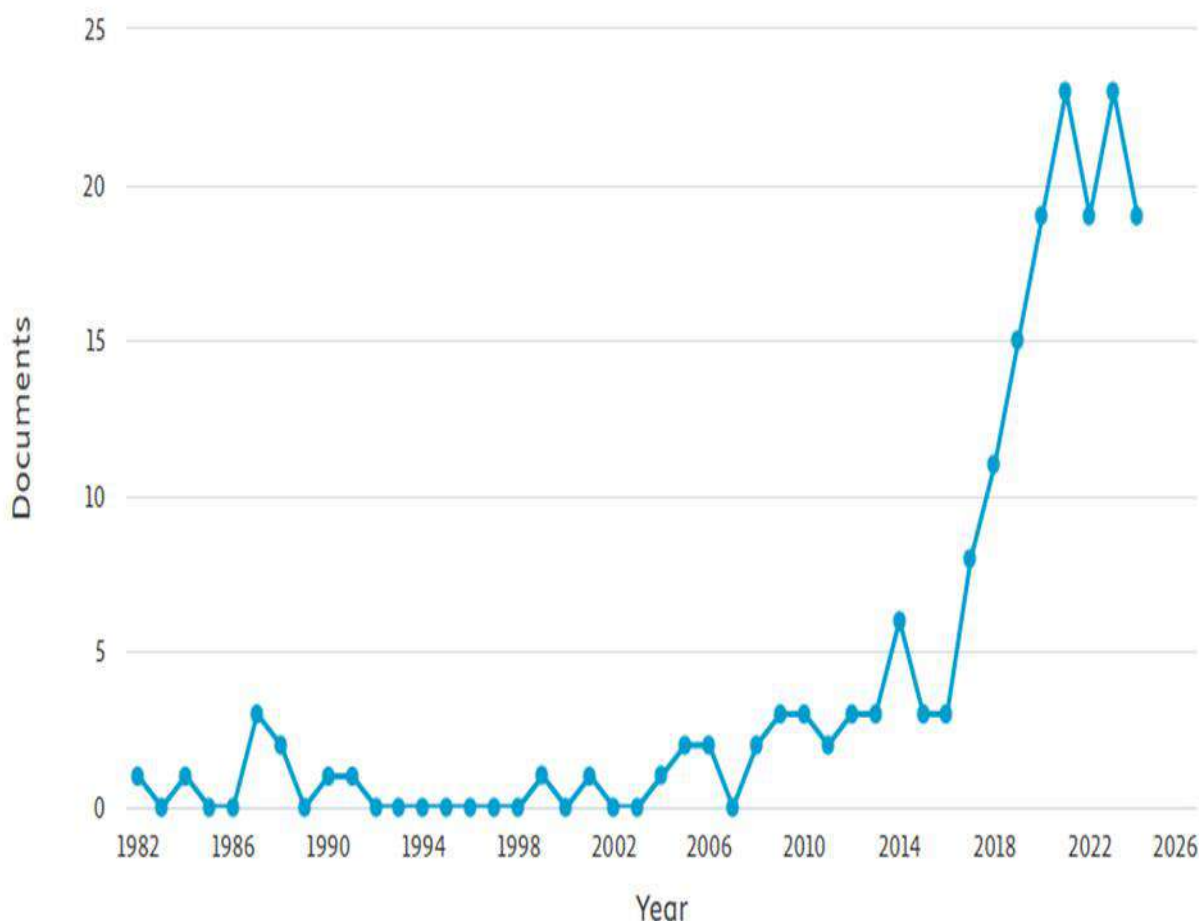


Figure 1. Publication trend

#### 4.2. Most Influential Authors in the Field of Management Control Automation and Tourism

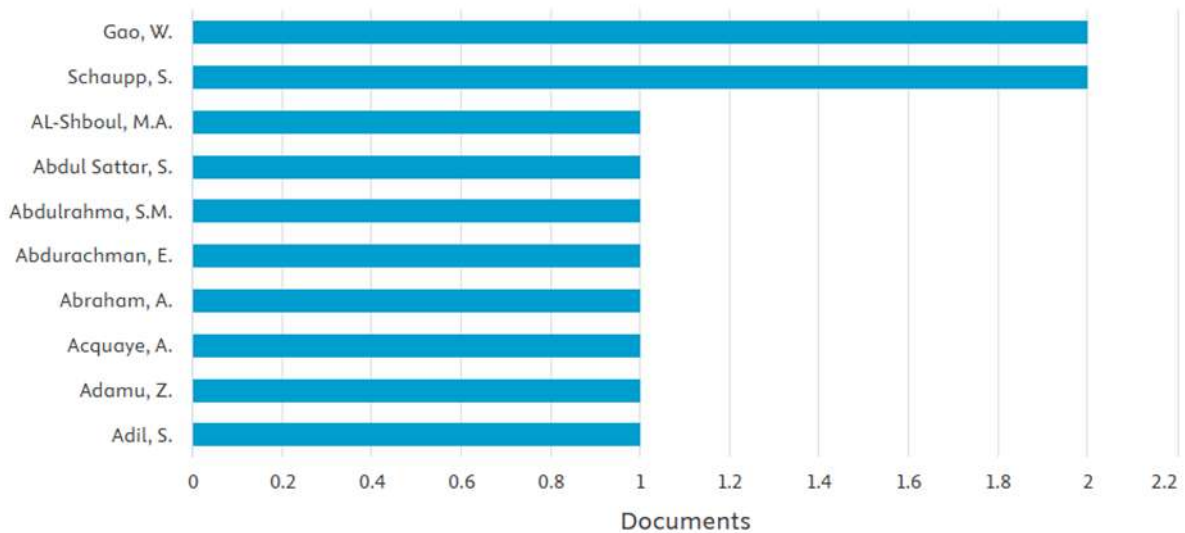


Figure 2. Most productive authors

The figure shows the most productive authors in terms of scientific publications on this topic according to data collected from the Scopus database. The results reveal that the majority of authors have published between one and two articles indexed in Scopus, indicating that the number of highly productive authors in this field remains relatively low. This could suggest (Asadullah & Raza, 2016) that research in this field is still emerging, or that researchers' interest in the subject remains relatively concentrated on a small group of authors.

#### 4.3. Country-Specific Contributions to the Automation of Management Control in Tourism

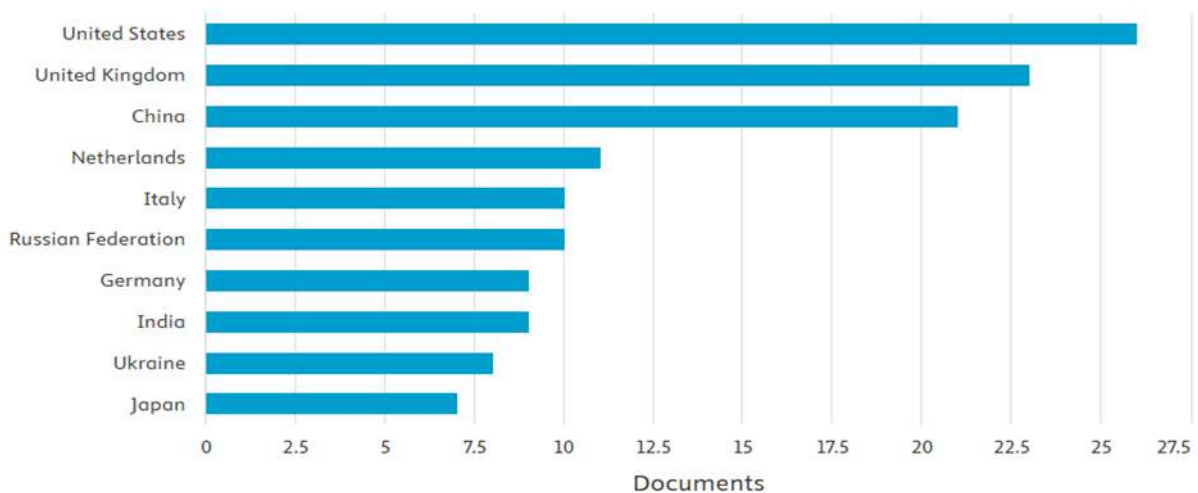


Figure 3. Most productive countries



The figure shows the most productive countries in terms of scientific publications on this theme. The results show that the USA is the leading country in this field, with 26 articles published, followed by the UK with 23 articles. China is in joint third place with 21 publications, while the Netherlands is in fourth place with 11 articles. Other countries, such as Italy and Russia, share fifth place with 10 articles each. Germany and India follow with 9 publications, and Ukraine has 8 articles. Finally, Japan is one of the most productive countries, with 7 publications.

These results suggest that (Flowerdew, 2012) English-speaking countries, in particular the USA and the UK, dominate research in this field, while other nations, notably China and European countries such as the Netherlands, Italy and Russia, also contribute significantly. The geographical diversity of publications shows a growing worldwide interest in management control automation and tourism performance, with notable contributions from Asia, Europe and North America.

#### 4.4. Bibliographic Coupling of Countries

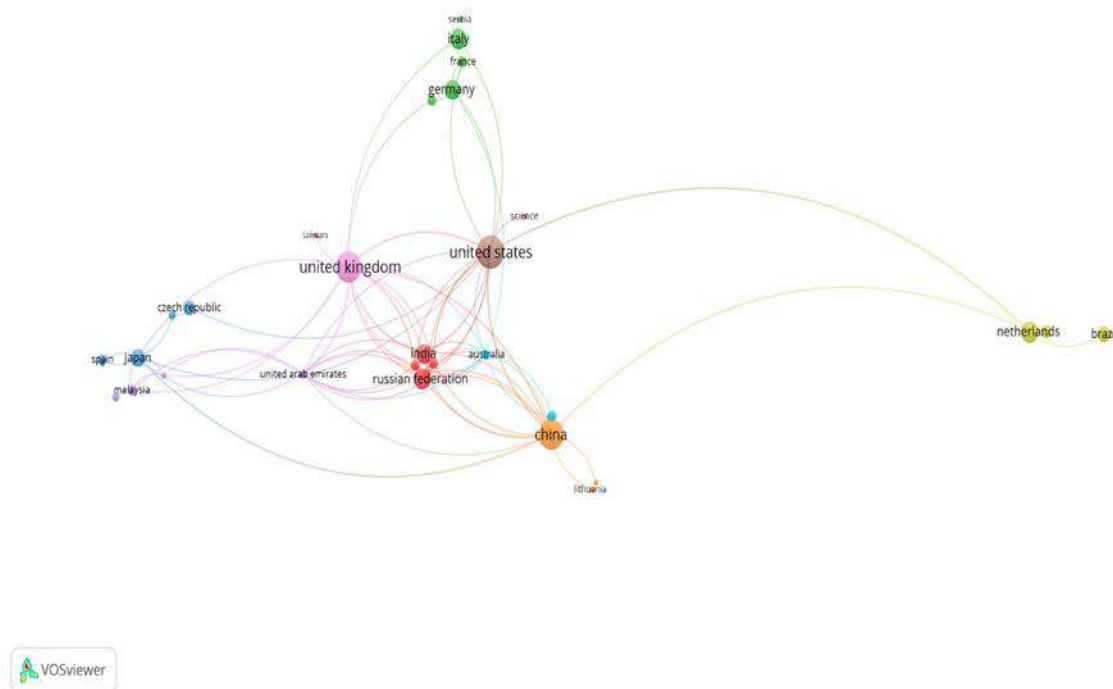


Figure 4. Bibliographic Coupling of Countries

The figure shows the bibliographic links between countries, created using VOSviewer software. The results show 9 different clusters, each represented by a different color. (Donthu & al., 2021) These groups bring together countries that share similar scientific interests and concerns in this field. For instance, countries belonging to the same group may collaborate closely on research related to the impact of automation on tourism performance, or the integration of specific technologies into management control. These bibliographic links (Alsharif & al., 2020) highlight international collaboration networks and help identify regions



since (Bailey Jr & al., 1982) , although fluctuations have been observed over the years, with a notable drop in 2024. This dynamic (Asadullah & Raza, 2016) suggests that research is still developing, with periods of high scientific activity and others marked by a slowdown.

The results concerning the most productive authors and countries show a concentration of research in countries such as the USA, the UK and China, which are among the main contributors to this field (Flowerdew, 2012). This geographical distribution demonstrates a growing global interest in the challenges of automation in the tourism sector, but also the need for international collaboration to tackle complex challenges on a global scale.

The bibliographic (Alsharif & al., 2020) matching of countries revealed by VOSviewer makes it possible to identify clusters of countries that share common scientific interests, thus fostering international collaborations. These clusters underline the dynamics of cooperation in research on issues such as process automation, cybersecurity and risk management in the tourism industry.

Analysis of keyword co-occurrence highlights dominant themes (Donthu & al., 2021) , such as risk management, cybersecurity, process control, intelligent buildings and traffic management. These areas show that automation in the tourism sector is not limited to technical aspects alone, but also encompasses issues relating to safety, operational efficiency and resource optimization. What's more, these keyword clusters offer interesting prospects for the future, by identifying emerging topics that could become hot topics for future research.

In conclusion, the study demonstrates the growing importance of automation in management control and tourism performance (Bright, 1958), as well as the emergence of new challenges and opportunities for researchers and professionals in the sector (Llale & al., 2020). The results also underline the importance of a multi-dimensional approach (Sainaghi & al., 2017), integrating advanced technologies, risk management and safety, to meet the complex needs of modern tourism.

## REFERENCES

- Alsharif, A. H., Salleh, N. O. R. Z. M. D., & Baharun, R. O. H. A. I. Z. A. T. (2020). Bibliometric analysis. *Journal of Theoretical and Applied Information Technology*, 98(15), 2948-2962.
- Asadullah, M., & Raza, A. (2016, November). An overview of home automation systems. In 2016 2nd international conference on robotics and artificial intelligence (ICRAI) (pp. 27-31). IEEE.
- Bailey Jr, A. D., Gerlach, J., McAfee, R. P., Whinston, A. B., & Watson, D. J. (1982). OIS Technology and Accounting: Partners in Conflict. In *Data Base Management: Theory and Applications: Proceedings of the NATO Advanced Study Institute held at Estoril, Portugal, June 1–14, 1981* (pp. 275-305). Dordrecht: Springer Netherlands.
- Breton, R., & Bossé, É. (2002, October). The cognitive costs and benefits of automation. In *NATO RTO-HFM Symp: The role of humans in intelligent and automated systems*.
- Bright, J. R. (1958). *Automation and management*. Boston: Division of Research, Graduate School of Business Administration, Harvard University.
- Brown, P., Ly, T., Pham, H., & Sivabalan, P. (2020). Automation and management control in dynamic environments: Managing organisational flexibility and energy efficiency in service sectors. *The British Accounting Review*, 52(2), 100840. <https://doi.org/10.1016/j.bar.2019.100840>
- Buckley, R. (2011). Tourism and environment. *Annual review of environment and resources*, 36(1), 397-416. <https://doi.org/10.1146/annurev-environ-041210-132637>

- Buhalis, D. (2019). Technology in tourism - from information communication technologies to eTourism and smart tourism towards ambient intelligence tourism: a perspective article. *Tourism Review*, 75 (1), 262-272. <https://doi.org/10.1108/TR-06-2019-0258>
- Corne, A., & Peypoch, N. (2020). On the determinants of tourism performance. *Annals of Tourism Research*, 85, 103057. <https://doi.org/10.1016/j.annals.2020.103057>
- Domowitz, I., & Steil, B. (1999). Automation, trading costs, and the structure of the securities trading industry. *Brookings-Wharton papers on financial services*, 2, 33-92.
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285-296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Flowerdew, J. (2012). *English for research publication purposes*. The handbook of English for specific purposes, 301-321. <https://doi.org/10.1002/9781118339855.ch16>
- Fordyce, W. E., Brockway, J. A., Bergman, J. A., & Spengler, D. (1986). Acute back pain: a control-group comparison of behavioral vs traditional management methods. *Journal of behavioral medicine*, 9, 127-140. <https://doi.org/10.1007/BF00848473>
- Garavaglia, J. A. (2009). Full automation in live-electronics: advantages and disadvantages. In *Proceedings of the 15th International Conference on Auditory Display, ICAD* (pp. 18-22).
- Garces, D., Bhattacharya, S., Gil, S., & Bertsekas, D. (2023, May). Multiagent reinforcement learning for autonomous routing and pickup problem with adaptation to variable demand. In *2023 IEEE International Conference on Robotics and Automation (ICRA)* (pp. 3524-3531). IEEE.
- Gasser, T. M., & Westhoff, D. (2012, July). BASt-study: Definitions of automation and legal issues in Germany. In *Proceedings of the 2012 road vehicle automation workshop. Automation Workshop*.
- Ivanov, S. H., Webster, C., & Berezina, K. (2017). Adoption of robots and service automation by tourism and hospitality companies. *Revista Turismo & Desenvolvimento*, 27(28), 1501-1517. <https://ssrn.com/abstract=2964308>
- Lane, S., & Stone, C. A. (2006). Performance assessment. *Educational measurement*, 4, 387-431.
- Langfield-Smith, K. (1997). Management control systems and strategy: a critical review. *Accounting, Organizations and Society*, 22(2), 207-232. [https://doi.org/10.1016/S0361-3682\(95\)00040-2](https://doi.org/10.1016/S0361-3682(95)00040-2)
- Llale, J., Setati, M., Mavunda, S., Ndlovu, T., Root, D., & Wembe, P. (2020). A review of the advantages and disadvantages of the use of automation and robotics in the construction industry. In *The Construction Industry in the Fourth Industrial Revolution: Proceedings of 11th Construction Industry Development Board (CIDB) Postgraduate Research Conference 11* (pp. 197-204). Springer International Publishing.
- Mohamed, S. A., Mahmoud, M. A., Mahdi, M. N., & Mostafa, S. A. (2022). Improving efficiency and effectiveness of robotic process automation in human resource management. *Sustainability*, 14(7), 3920.
- Moral-Muñoz, J. A., Herrera-Viedma, E., Santisteban-Espejo, A., & Cobo, M. J. (2020). Software tools for conducting bibliometric analysis in science: An up-to-date review. *Profesional de la Información*, 29(1). <https://doi.org/10.3145/epi.2020.ene.03>
- Otley, D. (2003). Management control and performance management: whence and whither?. *The British Accounting Review*, 35(4), 309-326. <https://doi.org/10.1016/j.bar.2003.08.002>

- Sainaghi, R., Phillips, P., & Zavarrone, E. (2017). Performance measurement in tourism firms: A content analytical meta-approach. *Tourism Management*, 59, 36-56. <https://doi.org/10.1016/j.tourman.2016.07.002>
- Santos, F., Pereira, R., & Vasconcelos, J. B. (2020). Toward robotic process automation implementation: an end-to-end perspective. *Business Process Management Journal*, 26(2), 405-420. <https://doi.org/10.1108/BPMJ-12-2018-0380>
- Siguencia, L. O., & Halemba, P. (2019). Automation of management processes. In E3S Web of Conferences (Vol. 132, p. 01020). EDP Sciences. <https://doi.org/10.1051/e3sconf/201913201020>
- Sinulingga, S., Nasution, V. A., Meutia, A., Indra, S., Kesuma, F. T., & Marpaung, J. L. (2024). Automated and Measured Managerial Systems in the Management of Independent Tourism Villages: A Case Study of Parsingguran II Village, Polung Subdistrict, Humbang Hasundutan Regency. *Jurnal Pengabdian Masyarakat Bestari (JPMB)* 3(9), 527-540. <https://doi.org/10.55927/jpmb.v3i9.11334>
- Sissah, S., & Hmioui, A. (2025). Leveraging digitalization for management control and performance - Bibliometric analysis (2013-2023). *Multidisciplinary Reviews*, 8(7), 2025208. <https://doi.org/10.31893/multirev.2025208>
- SISSAH Safae, & Hmioui Aziz. (2025). Mastering Management Control to Optimize SME Performance: A Bibliometric Review. *International Journal of Innovative Science and Research Technology* (IJISRT), 10(2), 149-155. <https://doi.org/10.5281/zenodo.14891761>
- Tussyadiah, I. (2020). A review of research into automation in tourism: Launching the Annals of Tourism Research Curated Collection on Artificial Intelligence and Robotics in Tourism. *Annals of Tourism Research*, 81, 102883. <https://doi.org/10.1016/j.annals.2020.102883>
- Vochozka, M., Horák, J., & Krulický, T. (2020). Advantages and disadvantages of automated control systems (ACS). In *Digital Age: Chances, Challenges and Future 7* (pp. 416-421). Springer International Publishing. [https://doi.org/10.1007/978-3-030-27015-5\\_50](https://doi.org/10.1007/978-3-030-27015-5_50)
- Wu, F., Sorokina, N., & Putra, E. D. (2023). Customers satisfaction on robots, artificial intelligence and service automation (RAISA) in the Hotel Industry: A comprehensive review. *Open Journal of Business and Management*, 11(3), 1227-1247. <https://doi.org/10.4236/ojbm.2023.113069>