UDK: 33
ISSN 2232-8823 (Print)
ISSN 2232-9633 (Online)
pp. 633-1040

Časopis za ekonomiju *i tržišne komunikacije*

Economy and Market *Communication Review*

Country of origin of journals where Chinese computer science articles are published

God./Vol. **XVI** • Br./No. **III** • Septembar/September 2026.

UDK: **33**

ISSN 2232-8823 (Print), **ISSN 2232-9633** (Online)

PANEVROPSKI UNIVERZITET APEIRON

Fakultet poslovne ekonomije
The Excellence School of Management

Emc Review

Časopis za ekonomiju *i tržišne komunikacije*

Economy and Market *Communication Review*

God./Vol. **XVI** • Br./No. **III** • Septembar/September, 2026.

Impressum

Economy and Market Communication Review – **Časopis za ekonomiju i tržišne komunikacije**

International scientific journal of the College of modern management of Pan-European University „Apeiron" in Banja Luka
Međunarodni naučni časopis Fakulteta za poslovnu ekonomiju Panevropskog univerziteta „Apeiron" u Banja Luci

ISSN: 2232-8823 (Print) / ISSN: 2232-9633 (Online) / UDK: 33

PUBLISHER / IZDAVAČ:
PAN-EUROPEAN UNIVERSITY „APEIRON" (PUA), COLLEGE OF MODERN MANAGEMENT
PANEVROPSKI UNIVERZITET „APEIRON" (PUA), FAKULTET POSLOVNE EKONOMIJE
Pere Krece 13, 78102 Banja Luka, BiH/RS, **www.apeiron-uni.eu**

RESPONSIBLE PERSON OF PUBLISHER / ODGOVORNO LICE IZDAVAČA: Darko UREMOVIĆ

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Web design / Web dizajn:
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Printed by / Štampa: MARKOS, Banja Luka

Circulation / tiraž: 300 issues / primjeraka

Journal is referred in (Abstracting and Indexing) / Časopis je naveden u (prikaz apstrakata i indeksiranje):

ip-science.thomsonreturers.com
doaj.org
erihplus.nsd.no
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Index Copernicus value (ICV) for 2021 = 100

EMC Review - Economy and Market Communication Review is placed in the **first category - from 30 to 40 points** ranking list of the categorized scientific journals in the Republika Srpska - 08/13/2018

EMC Review-časopis za ekonomiju i tržišne komunikacije se nalazi u **prvoj kategoriji – od 30 do 40 bodova** rang liste kategorisanih naučnih časopisa u Republici Srpskoj - 13.08.2018.

By Decision of the Ministry of Education and Culture of the Republic of Srpska No. 07.030-053-85-8 / 11, of 23 May 2011, "Economy and Market Communication Review - Časopis za ekonomiju i tržišne komunikacije" Banja Luka, is registrated in the Register of Public Media under serial number 618. The Journal is printing partly by financial support of the Ministry for Scientific and Technological Development, Higher education and Information Society of the Republika Srpska.

Rješenjem Ministarstva prosvjete i kulture Republike Srpske br: 07.030-053-85-8/11, od 23. 5. 2011. godine, "Economy and Market Communication Review - Časopis za ekonomiju i tržišne komunikacije" Banja Luka, upisano je u Registar javnih glasila pod rednim brojem 618. Časopis se štampa uz djelimično financiranje Ministarstva za naučnotehnološki razvoj, visoko obrazovanje i informaciono društvo Republike Srpske.

The journal published twice a year / Časopis izlazi dva puta godišnje
(December and June, from 2011) / (Decembar i juni, od 2011. godine).

Annual subscription / godišnja pretplata:
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https://doi.org/10.7251/EMC2603640A
UDK: 330.322(497.5):[005.334:336.71
Datum prijema rada: 6. februar 2026.
Submission Date: February 6, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 640-655

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

FINANCIAL INNOVATIONS IN THE CROATIAN BANKING SECTOR: THE PERCEPTION OF BANK MANAGERS[1]

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Abstract: In the dynamic environment of the modern financial sector, innovations play an increasingly important role in shaping the business strategies and services of financial institutions. This particularly applies to the banking sector, which is continuously and significantly adapting to technological changes and market demands, thus creating the potential for strengthening financial inclusion. Due to the increasing importance of this topic, the paper clarifies the concept of financial innovations and presents the results of qualitative research based on data obtained through structured interviews with high-level managers of the six largest banks in the Croatian banking sector. The collected data enabled a comparison and analysis of the perception of financial innovations in different banks, which provides a clearer insight into the diversity of bank managers' attitudes in this area, and consequently contributes to understanding the impact of their perception on the formation of business models. The above also contributes to increasing the reliability and credibility of the results obtained. The aim of the research is to determine, based on the analysis conducted, the dynamics and manner in which financial innovations are implemented in banking operations and what their impact is on existing bank business strategies. The results of the research conducted indicate a deep integration of financial innovations into banks' business models and their significant impact on business strategy, internal processes and financial services distribution channels in the Croatian banking sector, which consequently affects the strengthening of the availability of financial services to end users. Financial innovations have also significantly shaped consumer expectations regarding the availability, speed and personalization of financial services. The main conclusion of the paper is that financial innovations are necessary and

1 *This research is part of the FININC project funded by the European Union – NextGenerationEU within the framework of the Call IIP-581-2025.*
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desirable, but their successful implementation requires stronger regulatory support and special attention within the risk management system.

Keywords: financial innovation, digitization, risks, Fintech, financial inclusion

JEL classification: G20, G21, O31, O33

INTRODUCTION

The financial market is characterized by dynamic change and the need for continuous adaptation. Technological progress (digitalization) is associated with the emergence of numerous disruptive innovations which, among other effects, have significantly transformed banking operations and caused changes in the behavior of end users of financial services. In response to these developments, banks worldwide, including those operating in the Croatian banking market, are actively adjusting their business models in order to provide financial services that meet contemporary market demands, thereby also influencing trends in financial inclusion. This includes the development and implementation of financial innovations, which are increasingly becoming a key tool for maintaining competitiveness and relevance in the financial sector, as well as for enhancing the accessibility of financial services. Financial innovations do not represent a temporary response to technological changes, but rather a permanent and growing trend that has recorded strong growth in recent years in both global and national financial markets, and consequently must be taken into account when shaping business strategies.

In the context of the Croatian banking market, the largest banks are introducing innovative digital solutions to respond to market challenges and opportunities, strengthen competitiveness, and attract new customers. However, although the application of financial technologies and other related innovations in banking operations is associated with higher levels of operational efficiency, improved customer experience, and greater customer satisfaction, their effective implementation also requires particular attention to the adequate identification and management of digitalization-related risks, including risks related to financial technology, within governance frameworks, as well as appropriate regulatory coverage. Through the development and implementation of financial innovations, banks are able to respond in a timely and precise manner to the increasingly complex and changing needs of their customers, ultimately maintaining competitiveness in the market. Nevertheless, it should be emphasized that each bank possesses different resources and pursues different strategic objectives, which ultimately influences the specific approaches adopted in the development and introduction of financial innovations into business models and strategies.

This paper therefore focuses on exploring key challenges and opportunities, as well as the specific circumstances that accompany the process of developing and implementing financial innovations within traditional business models. Special emphasis is placed on analyzing the impact of financial services consumers' behavior on the development and implementation of financial innovations, which in a digital environment plays a crucial role in shaping banking products and services with the aim of maintaining or increasing competitiveness. Digitalization, and particularly the digital transformation of banking operations, also leads to rising expectations among financial services users, forcing banks to continuously improve their digital solutions in this context in order to

retain existing and/or attract new clients, as well as potentially include those who are insufficiently served by traditional financial services. To fully understand the challenges and specific features of the development and implementation of financial innovations in banking, it is also necessary to consider the broader context in which they emerge and evolve. Accordingly, by analyzing the processes of development and introduction of financial innovations in the banking sector based on data collected through structured interviews with senior managers of large banks operating in Croatia, this paper contributes to a deeper understanding of their functionality and effectiveness, as well as the benefits and limitations and the risks arising from them, while taking into account the perspectives of all relevant stakeholders (banks, clients, and regulators).

The paper is structured into five sections. Following the introductory section, the second section reviews previous research on the effects of financial innovations in banking operations and discusses the theoretical aspects of financial innovations. The third section explains the data sources and methodology used in the research. An overview of the research results, along with critical analysis and discussion, is presented in the fourth section. The fifth section provides concluding remarks.

INNOVATIONS AND FINANCIAL INNOVATIONS: THEORETICAL OVERVIEW AND LITERATURE REVIEW

Innovation is a broad and complex concept encompassing various approaches and interpretations; however, there is no single definition that precisely delineates the innovation process. The term "innovation" originates from the Latin word innovatus, referring to something new, a novelty, or a change in the existing state (Tolić, Sabljić, & Sabljić, 2022). In literature, innovation is defined in various ways, but it is most understood as a new or significantly improved product, marketing practice, or organizational process. Innovations encompass a wide range of activities, spanning scientific and technological as well as financial and market-related activities, which result in the creation of new or technologically enhanced products and services (Galović, 2016). The purpose of innovation is reflected in the application of new solutions and investments in new research, particularly in the field of financial innovations, with the aim of improving the overall efficiency and organization of business systems. Accordingly, innovations are essential for business modernization and the preservation of competitive advantage in the market.

According to (Đokić, Rašić, & Slijepčević, 2022), an innovation represents a new or improved product, process, or a combination thereof that differs significantly from previous solutions and is either available to potential users or already in use. Moreover, innovations may relate to technological advancement, the introduction of new products and services, as well as changes in management practices and business processes. Knowledge and investment in innovative processes constitute fundamental determinants of competitive advantage. Therefore, firms seeking to maintain market relevance must continuously develop innovations and invest in knowledge. The development of innovations largely depends on effective knowledge exchange, with such dynamics directly influencing the design of products, services, organizational structures, and business models. Furthermore, to ensure that employees are willing and able to experiment, it is necessary to build an environment that fosters innovative behavior (Rončević & Ostojić, 2022).

Within the innovation process, the distinction between innovation and invention is often emphasized. According to (Tidd & Bessant, 2020), invention represents the initial stage involving the development of an idea, whereas innovation is achieved only when that idea is transformed into a practically applicable solution. Additionally, within innovation policy, a prevailing view has long been that innovations develop as the result of a linear process in which they are seen as a direct outcome of investments in research and development (Mršić & Petković, 2020). However, contemporary approaches increasingly emphasize the importance of interactions among various stakeholders, as well as the role of knowledge and technology. In this context, knowledge and technology transfer activities are recognized as key drivers of innovation creation (Muizniece & Cepilovs, 2017). Emphasis is also placed on business model innovation, which is considered one of the most important sources of competitive advantage for organizations aspiring to survive and grow in the contemporary market environment. Consequently, business success is based on an understanding of all elements of the business model, while innovations can be achieved through improvements in content, interconnections, and the management of business activities, for example by introducing new activities (Milovanović, Srhoj, & Krišto, 2017).

Innovations in the financial sector based on modern technologies are increasingly influencing banking operations, whereas academic debate on the impact of Fintech has gained momentum only in more recent years. These changes are closely linked to new patterns of behavior and evolving needs of financial services users. According to the Croatian National Bank (CNB, Bezgotovinske platne transakcije 2024, 2023), an increase in both the number and total value of cashless transactions has been observed, largely driven by more frequent use of payment cards, growth in online payments, and the use of digital wallets. Nevertheless, traditional payment methods, such as credit transfers and direct debits, continue to hold a dominant position in total payment traffic. (Bračun & Turkalj, 2020). emphasize that Croatian banks recognize both the opportunities and threats arising from digital transformation, noting that clients increasingly use digital financial services because of continuous improvements in Fintech products. Accordingly, banks have shifted a significant portion of their operations toward mobile applications tailored to both individual and corporate customers (Klobučić, 2019), which have long been recognized as an effective tool for strengthening financial inclusion (Claessens & Rojas-Suarez, 2016).

The adoption of sustainable business practices and corporate social responsibility as imperatives of modern business further encourages operations that take social factors into account, including the achievement of social objectives (Sopta Čorić & Čulo, 2025), among which financial inclusion plays an important role. In this context, procedures and decision-making processes related to investments in innovation have been shown to be a significant factor in corporate growth (Sopta, Upravljanje digitalnom transformacijom državnog poduzeća, 2020). (Ulrich-Deiner, Dvoulety, & Špaček, 2023) point out that although the digitalization of banking operations brings greater speed, lower costs, and improved service accessibility, its effects cannot be compared to the deeper and more disruptive changes introduced by the Fintech sector. According to (Parminder, Shivinder, Sood, Grima, & Rupeika-Apoga, 2022), the most pronounced impact of the Fintech sector is observed in retail banking, where an increasing number of users rely on services provided by digital banks such as Revolut.

Consequently, banks are increasingly adopting technologies that enable greater automation, efficiency, and reductions in operating costs. Furthermore, banks are among the largest investors in Fintech solutions, as they perceive them as an opportunity to develop business models that are competitive and aligned with actual market needs (CBA, 2019).

The digitalization of business operations also includes the transfer of customer data to digital storage solutions such as cloud environments, raising concerns related to data security and regulatory requirements in digitalization risk management (information and communication technology risks, Fintech risks, security risks, and others). (Haddad & Hornuf, 2023) therefore warn of legal uncertainty arising from the fact that Fintech companies often operate outside the strictly regulated frameworks applicable to traditional banks. In addition, (Tomić, 2019) highlights security as one of the key challenges associated with financial innovations, with particular emphasis on personal data protection and cybersecurity. Moreover, the Croatian National Bank (CNB, 2019) stresses that while Fintech solutions bring numerous benefits to the financial system, they also pose risks such as fraud, data misuse, and potential threats to the stability of the financial and monetary system. Despite these challenges, in order to maintain competitiveness and ensure business continuity, banks are compelled to adapt their business models and strategies to new market requirements and user needs in terms of developing and implementing financial innovations. However, for these innovations to be effective, it is essential to adequately integrate the risks arising from financial innovations, digitalization, and digital transformation into governance systems, as well as to ensure an appropriate regulatory framework.

DATA AND RESEARCH METHODOLOGY

This section of the paper presents an analysis of bank managers' perceptions of the role, importance, and effects of financial innovations in contemporary banking operations. For conducting this empirical research, the structured interview method was applied in order to obtain insights into the attitudes of senior managers employed in large banks within the Croatian banking sector (large banks defined as banks with a share of assets exceeding 5% of the total assets of the banking sector). At the time of the interviews, the respondents were actively involved in the process of introducing financial innovations within the banks in which they were employed. Accordingly, the research participants consisted of managers from six large banks whose combined assets account for approximately 90% of the total assets of the Croatian banking sector (EUR 76.5 billion out of a total of EUR 84 billion; (CNB, Statistics – Table SV1-h: Data on the Operations of Credit Institutions, as of 31 December 2024, 2025), of which five banks are privately owned and predominantly foreign-owned, while one bank is in domestic state ownership (CNB, 2024 and Table 1).

Table 1. Share of Large Banks in the Total Assets of the Croatian Banking Sector as of 31 December 2024 and Basic Information on the Respondents

	Share of Assets in the Total Assets of the Banking Sector, %	Respondents
B1	25,2	A.N. – senior manager
B2	20,2	Ž.LJ. – senior manager
B3	18,0	I.S. – senior manager
B4	10,2	R.M. – senior manager
B5	9,4	M.V. – senior manager
B6	8,1	V.V. – senior manager
TOTAL B1-B6	91.1%	-

Note: B (1–6) – large banks
Source: authors' based on (CNB, Statistics – Table SV1-h: Data on the Operations of Credit Institutions, as of 31 December 2024, 2025); data collected through interviews

The interviews were conducted using digital communication platforms, Skype and Microsoft Teams, as well as via telephone calls. The interview period lasted from 1 August to 1 December 2024. Personal data obtained during the interviews, including the respondents' names and surnames, length of service within the bank, and specific job descriptions, were protected. The respondents answered previously prepared questions designed to elicit as concrete and precise responses as possible, focusing on the analysis of the impact of financial innovations on banking operations, as well as the potential risks and consequences that such innovations have brought to the market. The collected responses were presented comparatively using comparative analysis in order to facilitate clearer insights and to identify similarities and differences in the respondents' views, with the aim of drawing well-founded conclusions on the subject under study.

The first question required respondents to express their views on current financial innovations present in the banking market, highlighting the prevalence of various financial innovations, their functionalities, and their level of acceptance among users. The second question focused on identifying financial innovations that respondents consider essential for contemporary banking operations. Furthermore, the third question aimed to determine the extent to which financial innovations have transformed banking operations. The fourth question examined the challenges associated with implementing financial innovations within banks' business models, while the fifth question sought to assess the extent to which banks operating in the Republic of Croatia follow global trends in the field of financial innovations. The final, sixth question aimed to identify which financial innovations have been implemented in banks and to determine their effects on banking operations.

RESEARCH RESULTS AND DISCUSSION

The respondents' answers are summarized and comparatively presented in Table 2 and are further elaborated upon in the following sections. The results of the interviews conducted with managers of six leading banks operating in the Croatian banking market reveal a consensus regarding the key role that financial innovations

play in contemporary banking operations. The respondents agree that digital applications and platforms significantly facilitate access to payment services, contribute to business digitalization, and that Croatian banks follow global Fintech trends, with some respondents emphasizing the importance of transaction security and compliance with regulatory requirements.

Based on the research conducted, it can be concluded that the respondents demonstrated a high level of awareness of current developments in the field of financial innovations in the banking sector, with their perceptions being closely linked to their personal experiences and the business practices of the banks in which they are employed.

Table 2. Comparative Overview of Respondents' Answers to the Six Key Questions of the Conducted Interview

	AB1	AB2	AB3	AB4	AB5	AB6
Q1 Which current financial innovations are present in the banking market?	Neobanks with advanced information systems and mobile banking applications (with emphasis on the development of information systems as support for decentralization of cryptocurrencies, e.g. Revolut and Wise), as well as payment transaction applications such as KEKS Pay.	Innovations aimed at risk transfer, credit risk profiling, and flexibility of financial products.	Innovations focused on the development of digital technologies to improve the user experience of payment services and similar applications (KEKS Pay, George, Revolut, and Wise), enabling the personalization of financial services.	Mobile banking applications, other fintech applications/ information systems such as neobanks, with emphasis on investment stimulation (e.g. Revolut, which enables core banking services and direct access to global capital markets and cryptocurrencies).	Mobile banking applications; smart home management or control (digital currencies); adapted credit approval conditions.	Mobile banking applications; emphasis on the universalization/ usability effects of numerous features that offer business users faster alternatives for payment transactions (highlighting the growing popularity of KEKS Pay and Aircash).
Q2 In your opinion, which financial innovation has become indispensable in contemporary banking operations?	Mobile banking.	Financial technology innovations (mobile banking, digital currencies).	Mobile banking.	SEPA systems for cashless payments and P2P digital lending platforms.	Mobile banking for retail customers and internet banking for corporate clients; smart contracts based on blockchain technology.	Advanced software solutions in transaction processing with the aim of data protection and security in transaction execution (e.g. blockchain technology).
Q3 To what extent have financial innovations transformed banking operations?	Financial innovations have enhanced the quality of banking services and facilitated entry for neobanks and ICT firms, resulting in risk management challenges related to digitalization, while also encouraging continuous innovation development.	Financial innovations and digitalization are closely interconnected and have contributed to the transformation of traditional banking into modern banking.	Significant transformation of contemporary banking operations, accompanied by the development of financial innovations particularly emphasized after 2007./2008. crisis, and later further accelerated by the rise of cryptocurrencies and innovation in general.	Financial innovations have changed business models of banks and traditional service delivery methods (banks no longer provide services exclusively through branches, but increasingly through digital financial services).	Traditional methods of transaction execution and service provision are being replaced by more advanced service offerings that exclude traditional bank branches.	Modern banking is shaped by the development of financial innovations, which have led to improvements in efficiency and competitiveness, as well as changes in user behavior regarding financial services.

Q4 Can you describe the challenges of implementing financial innovations in banking operations?	A complex and demanding implementation process.	Continuous monitoring and involvement of management in professional education on the latest Fintech industry trends and their potential positive and negative effects.	Key challenges are encountered at the early stages of digitalization of banking operations; a contemporary challenge is banks' ability to effectively integrate Fintech solutions into business models.	A complex and structured implementation process—the implementation of processes that are "already underway".	A systematic and long-term implementation process that significantly depends on the level of economic development.	Destabilized financial markets in recent years; difficulties in assessing the effectiveness of innovations; complex implementation processes (large investments in infrastructure and employee education).
Q5 Do you believe that banks operating in the Republic of Croatia follow global trends in financial innovations?	Yes, through improving application functionalities in mobile banking, adapting operations to competition, and anticipating the growing popularity of KEKS Pay and Aircash in payment services.	Yes, even though no Fintech solution is considered decisive for banks' dominance in providing the same services (banks are less the sole alternative providers of financial services).	Yes, although scope for further development exists with the aim of maintaining competitiveness, primarily in relation to the presence of Fintech solutions (e.g. international payment solutions such as KEKS Pay).	Yes, but often constrained by financial resources required to conduct comprehensive studies and simulations that would support the assessment of the potential impact of innovations.	Yes, but Fintech companies offer improved solutions at lower prices and with better anonymity in transactions.	Yes, because there is a dedicated department responsible for research, development, and testing of Fintech products and the development of financial innovation projects.
Q6 Which financial innovations were introduced in the bank where you are employed, and how have they influenced banking operations?	Enhancement of mobile application functionalities (e.g. constant communication with a personal banker, use of copper, commodities, and capital market instruments, etc.) and mobile applications for business users (access to tokens, locations, business contacts, exchange rate lists). The innovations are continuous and include risk management related to digitalization and digital literacy.	Improvement of mobile banking application functionalities (contactless payments via Google Pay and Apple Pay applications), expansion of cashless payment options (withCASH savings with withSAVE, money transfers with withPAY, use of digital signatures with withSIGN). Innovations have led to risk mitigation related to digitalization, as well as to the loss of technological personnel (Fintech competition).	Development of mobile banking and modern investment solutions (applications such as George and KEKS Pay), integration of Fintech and RPA solutions. Fintech applications are intended for small entrepreneurs, crafts, and other business entities, resulting in a significant increase in the number of business users.	Improvement of mobile banking application functionalities and OTP e-trader solutions; brokerage services, 3D Secure. Active investment in continuous development in line with market trends, with an emphasis on the importance of quality risk integration into digital risk management systems.	Improvement of existing digital services and mobile banking applications (e.g. opening accounts via mobile applications), introduction of the SuperSmart PBP account, contactless payment enhancements via eCommerce options, online sub-accounts for savings and credit cards, which attracts new clients and increases customer satisfaction.	Improvement of mobile banking application functionalities, enabling contactless payments (e.g. RaiPay) and mobile payments via Apple devices, development of digital wallets, introduction of eBroker services. Digitalization and automation have led to a reduction in the number of jobs.

Note: AB (1–6) – answers of respondents from the sample of large banks; Q (1–6) – questions posed during the interviews
Source: authors

In responses to the first question, *"Which current financial innovations are present in the banking market?"*, although the answers were multifaceted, a clear dominance of financial innovations related to payment transactions can be observed, particularly those based on digital technologies (applications/advanced information systems/ software solutions for mobile payments). The basic payment services enabled by these innovations primarily include the execution of payment transactions (including bill payments, parking services, etc.), cash withdrawals at ATMs, contactless payments,

and similar services. At the same time, neobanks offering these services in combination with other advanced applications were identified as key financial innovations due to their ability to facilitate transactions at low cost (AB1). Half of the respondents particularly emphasized the growing popularity of applications such as KEKS Pay for payment transactions (AB1, AB3, and AB6; additionally, Aircash – AB6), primarily due to their cost advantages (e.g. enabling bill payments without additional fees, as well as transaction execution, ATM cash withdrawals, contactless payments, and parking fee payments). The application has achieved wide acceptance among users, partly due to the early openness of its parent bank to cooperation with Fintech companies (since 2016), with the aim of leading the introduction of innovations in banking operations in the Croatian market. It is therefore considered the Croatian counterpart to global Fintech products such as Revolut and Wise (AB3). In addition to basic payment services and easier access to them, these applications also offer access to capital markets and cryptocurrency markets (AB1, AB3, and AB4), with particular emphasis placed on the role of financial asset decentralization enabled through cryptocurrencies and advanced information systems. Nevertheless, the popularity of neobanks providing such services—largely driven by affordable pricing—could be adversely affected by stricter regulation, potentially resulting in higher fees and threatening the sustainability of their business models (AB1). On the other hand, in addition to offering the aforementioned payment and/or investment access services, mobile and/or internet banking applications increasingly incorporate innovative "smart contract" services (AB5; enabling loan approvals via mobile and internet banking applications and utilizing blockchain technology), as well as innovations related to the transfer of credit risk in line with the financial capacity of intermediaries, increased profitability and flexibility of financial products, and the stimulation of long-term investments (AB2). Furthermore, platforms enabling "cloud-based operations" (e.g. digital wallet services) are highlighted as increasingly important financial innovations (AB5), following trends in the development of digital currency markets. In conclusion, cooperation with Fintech companies plays a crucial role in adapting banks' business models (including neobanks) to consumer demands and in the development of financial innovations. Banks operating in the Republic of Croatia largely follow global trends in financial innovations, as evidenced by the availability and widespread user acceptance of the aforementioned payment applications. In 2024, the number of consumers using mobile banking increased by 10.9%, while the number of internet banking users rose by 11.6% compared to the previous year (CNB, Statistics – Table SV1-h: Data on the Operations of Credit Institutions, as of 31 December 2024, 2025).

In responses to the second question, *"In your opinion, which financial innovation has become indispensable in contemporary banking operations?"*, certain content-related differences can be observed, reflecting variations in respondents' perceptions when identifying and weighting risks on the one hand, and the profitability and efficiency of innovations on the other. More than half of the respondents identified and emphasized mobile banking as a key driver of modernization in banking operations, given its leading role in the provision of banking services today. As a result, the scope of activities previously performed by counter staff, as well as the need for physical branches, has been significantly reduced (AB1, AB2, AB3, and additionally internet banking – AB5). More broadly, financial technology innovations in payment services

(mobile banking, digital wallets, etc.) were highlighted as enabling banks to serve a larger number of customers without physical contact (AB2), thereby increasing operational efficiency. In this context, one of the most important innovations contributing to the modernization of banking operations in the Republic of Croatia is the SEPA system (Single Euro Payments Area), launched in 2013 as a matter of national interest. The SEPA system enables cashless euro-denominated transactions for individuals, businesses, and public authorities across 36 countries, using unified models and procedures, standardized payment instruments—SEPA credit transfers and SEPA direct debits—a common legal framework, and shared IT infrastructure for processing payment orders (AB4). The benefits provided by SEPA are particularly significant for corporate clients managing a large number of payment transactions. In addition, P2P (peer-to-peer) digital lending platforms were identified as another important innovation that has disrupted traditional banking business models. As a result, banks have inevitably turned to service optimization, increased engagement of IT specialists, and a stronger focus on service personalization for customers (AB4). Furthermore, the importance of innovations in the form of software solutions that follow market trends and address security risks in payment transactions and investments (e.g. data protection and transaction security) was emphasized, particularly given the ongoing trend toward a cashless society and the digitalization of money (electronic payments and the development of digital currencies). Several respondents noted that cash (banknotes and coins) is expected to gradually disappear from use over the coming decades (AB6). These trends have also been recognized as positive drivers of enhanced financial inclusion for users of financial products and services. In this context, blockchain technology was highlighted as the most important innovation, both as a foundation for the secure development of (centralized) digital currencies (AB6) and as an enabler of smart contract services (AB5). In conclusion, respondents emphasized the importance of timely adaptation of banks' operations to technological changes. Such adaptation not only supports the maintenance of competitiveness, improved management, and increased operational efficiency in terms of profitability, but also enables more effective management of ICT (information and communication technology) and security risks. Ultimately, this contributes to mitigating risks that could otherwise threaten the stability of the financial system (AB3).

In responses to the third question, *"To what extent have financial innovations transformed banking operations?"*, there is broad consensus among most respondents that digitalization and financial technology innovations have been the driving forces behind the transformation from traditional to modern banking over the past three decades, with a more pronounced impact following the 2007/2008 financial crisis. Technological progress in finance has not only transformed traditional banking into contemporary banking, but has also altered the behavior (habits, demands, and expectations) of financial services users. Through digital (and financial) literacy, users increasingly exert pressure for continuous change, improvements, and innovation, thereby further shaping adjustments in banking operations. A frequently highlighted example is the displacement of cheques from use, once a widely applied payment instrument (AB6). Periods of crisis often act as catalysts for innovation due to pressures to reduce operating costs. Accordingly, the momentum of the modern transformation of banking operations and the development of financial innovations—primarily aimed at reducing operating costs and

decentralizing transactions—was further intensified after the 2007/2008 crisis and the emergence of cryptocurrencies (AB3). Financial innovations have exerted the strongest influence on changes in banks' business models, shifting from traditional models based on the provision and distribution of basic financial products and services (e.g. deposits, withdrawals, and fund transfers) in physical bank branches requiring direct contact between customers and bank employees, toward modern models. In this context, a clear trend of moving away from counter-based banking is observed (AB5). Through software-based solutions (applications) and digital communication channels, these modern models enable the growing trend of digital payment transaction execution, the digital provision of an expanding range of financial services, and changes in user behavior. Examples include the replacement of traditional savings instruments such as fixed-term deposits with alternative forms of savings or investments that are now accessible through banking applications (AB4), as well as the emergence of cryptocurrencies and their growing role in payments and investments (AB3). In this manner, financial innovations have significantly enhanced the scope and quality of banking products and services and improved their alignment with user needs. Consequently, respondents emphasized the necessity of continuous investment in the development of financial services in line with contemporary trends and the integration of innovations into existing banking business models (AB1). Furthermore, digitalization enables more efficient monitoring of customer satisfaction (e.g. surveys conducted within mobile applications; AB4). At the same time, however, it exposes neobanks (and their software) to risks inherent in digitalization, such as cyberattacks and data theft (ICT and security risks). Therefore, investment in the protection of information systems is essential to ensuring a high level of operational security and data protection, which in turn justifies the pricing of digital financial services (AB1). Fintech companies are not perceived as a threat to banks, but rather as an opportunity for cooperation. Banks possess sufficient capacity to invest in new technologies and often find it more cost-effective to acquire already tested Fintech solutions than to develop their own, thereby increasing operational efficiency through lower costs, faster and simpler payment processes, and improved customer experience (AB2). It is also expected that increased regulation and restrictions on Fintech companies' independent operations will lead to the sale of technological solutions to banks, as Fintech firms may lack the capacity for autonomous long-term operation (AB1). In conclusion, respondents agree that banking operations (traditional banking) have undergone substantial changes since the 1990s (e.g. continued globalization, re-regulation/deregulation, liberalization of operations, internationalization, etc.). Within the context of this study, modern banking—characterized by the departure from counter-based banking, digitalization of business processes, and digital provision of financial services—has undoubtedly been strongly shaped by the emergence of the internet and the development of financial technology innovations. These developments have enabled both digitalization and the subsequent digital transformation of banking operations, significantly influencing efficiency, competitiveness, and the quality of banking services. In this regard, Fintech companies do not threaten banks' operations or their survival but instead offer opportunities for cooperation and further development of banking activities, while Fintech solutions have unequivocally increased the efficiency of banking operations.

Responses to the fourth question, *"Can you describe the challenges of implementing financial innovations in banking operations?"*, also indicate a consensus that

the implementation of financial innovations represents a complex and highly structured process, which is often financially demanding and time-consuming. The degree and pace of introducing financial innovations within banks are closely linked to the level of economic development of the country in which banks operate. In this regard, the Republic of Croatia is currently at a turning point. The turbulence in financial markets caused by the current geopolitical situation, combined with rising inflation and the consequent restrictive monetary policy in recent years, has slowed the previously dynamic development and implementation of innovations aimed at addressing specific user demands and needs. These needs are already largely met—or can be adjusted to individual users—through financial technologies that enable rapid and efficient processing of large volumes of data and the application of artificial intelligence. As a result, the primary focus of banking operations has shifted toward preserving financial stability amid tighter lending conditions and rising interest rates (AB6). In this context, the emergence of digital platforms offering credit services (P2P lending) over the past several years, as one of the more significant recent Fintech innovations, does not currently pose a serious threat to bank lending activity. However, it has highlighted the importance of continuously monitoring market trends and investing in the development and implementation of financial innovations (AB6), with continuity in this process being clear (AB4). The momentum of financial innovation development and the transformation from traditional banking models—particularly pronounced over the past fifteen years—required substantial initial infrastructure investments and extensive employee education in the context of digitalization. During this period, the key barriers to implementing financial innovations were largely overcome (AB3). Today, however, the main challenge lies in assessing innovation potential and making informed decisions regarding which innovations are cost-effective to implement within banking business models, with efficiency being measured as the ratio between investment costs and the resulting benefits and profitability (AB6), as well as the ability to integrate innovations into existing business models (AB3). The process of developing and implementing financial innovations is therefore assessed as highly complex and structured (AB1, AB4, and AB6), systematic, and often long-term—lasting months or even years—and frequently dependent on the level of economic development (AB3). This process includes conducting market research, whereby specialized teams initially perform in-depth analyses of Fintech market developments, followed by the preparation of studies or implementation strategies that define the necessary steps. Subsequently, strategic decisions regarding financial investments are made, IT experts are engaged (most often through outsourcing), and substantial time and resources are allocated to employee training related to new technologies and innovative products, most commonly through seminars or team-building activities (AB1 and AB4). In this process, particular emphasis is placed on the importance of continuous monitoring and active participation of management in professional training programs focused on the latest Fintech industry trends and their potential impacts—both positive and negative, especially regarding risks and their implications for financial system stability (AB2). Following this, decisions are made concerning the way the innovation will be distributed, while the final stage includes data collection and analysis of the innovation's effects on both bank performance and customer satisfaction (AB1). In conclusion, the implementation of financial technology innovations is a highly complex process, and deci-

sion-making in this area—based on a high-quality assessment of innovation potential, expected efficiency, and continuous monitoring of trends in the financial innovation market — remains one of the greatest challenges for banks. The financial intensity of implementation is often a limiting factor, which can be particularly challenging for banks facing budgetary constraints.

Responses to the fifth question, *"Do you believe that banks operating in the Republic of Croatia follow global trends in financial innovations?"*, likewise indicate a consensus among respondents that banks in the Republic of Croatia largely keep pace with global trends in the development and implementation of financial innovations. This is evidenced, for example, by the establishment of dedicated departments responsible for researching and monitoring current Fintech products, as well as for project development and the implementation of financial innovation processes (AB6). However, limited financial resources often prevent the execution of more comprehensive studies and simulations assessing the potential effects of financial innovations, such as those conducted by leading global banks. An illustrative example is the U.S. investment bank J.P. Morgan, which has introduced AI assistants for its employees, reflecting a strong orientation toward digital transformation and innovation in banking operations (AB4). The continuous development and upgrading of mobile banking applications — which, in addition to payment services, enable customers to conclude contracts such as consumer loans (including the use and monitoring of overdraft facilities) and offer various savings and investment products (fixed-term deposits, investments in mutual funds, etc.; AB1) — represent banks' response to the introduction and widespread adoption of Fintech solutions such as KEKS Pay and Aircash. These applications play an increasingly important role in payment transactions and continue to expand through new functionalities. For example, KEKS Pay enables bill payments with partner entities without fees, offers savings options, and includes loyalty programs for users who conduct transactions via the application (AB3). This demonstrates the successful adaptation of banks' business models to technologically advanced financial products and confirms the maintenance of competitiveness and business sustainability in line with market conditions and evolving customer requirements (AB1). Furthermore, it was emphasized that to date, no Fintech solution has significantly undermined banks' leading position or popularity in providing comparable financial services, not even during the COVID-19 pandemic, which triggered increased interest in the cryptocurrency market and contributed to its rapid growth. Users continue to place greater trust in banks than in alternative financial service providers (AB2). Nevertheless, Fintech companies have been particularly successful because they offer more favorable services than banks — at least until stricter regulation, which will likely result in higher prices, as already emphasized in responses to the first question (AB1). In addition, Fintech solutions enable a higher degree of transaction anonymity, which is appealing to many users, especially those who prefer decentralized transactions (AB5). In conclusion, monitoring trends related to financial innovations is essential, and their implementation is inevitable for maintaining competitiveness, ensuring business sustainability, and supporting the continued transformation of banking operations, while simultaneously strengthening financial inclusion.

Ultimately, the responses to the sixth question, "*Which financial innovations has the bank in which you are employed introduced, and how have they affected the*

bank's operations?", also reveal similar perspectives, given that the respondents represent large banks that compete intensely with one another, making their shared interest in financial innovations unsurprising. In addition to the traditional range of financial services, mobile banking applications stand out in terms of enhanced functionalities, particularly the introduction of contactless payments (e.g. RaiPay), the development of digital wallets, and the implementation of eBroker services, which additionally enable users to monitor real-time stock price movements on the Zagreb Stock Exchange (AB6). According to AB4, particular emphasis is placed on the improvement of functionalities within the OTP mobile banking application ("OTP-ica"), with the OTP-go! campaign launched to promote mobile banking usage. The application also includes a loyalty program, whereby users collect points through app usage that can later be redeemed for retail discounts. Furthermore, the OTP e-trader application enables users to trade various types of financial instruments across nearly all major financial markets. To enhance transaction security, especially in the context of online purchases, the 3-D Secure service has been introduced as an additional layer of customer protection. In AB1, improvements in the functionality of the m-zaba mobile application are highlighted as a means of increasing customer satisfaction, including options such as virtual meetings with a personal banker, taking queue numbers in advance for branch visits, and access to capital market trading. Additionally, enhanced functionalities of a new mobile application tailored to business users are emphasized, providing access to m-token authentication, branch locations, contacts, exchange rate lists, and personalized settings aligned with user priorities. Furthermore, AB2 underscores improvements to mobile banking applications through the introduction of contactless payments via Google Pay and Apple Pay, cardless cash withdrawals using the #withCASH option, automated savings that round purchase amounts up to the nearest unit or multiple of ten through #withSAVE, money transfers to contacts directly from users' contact lists via #withPAY, and the use of digital signatures (#withSIGN), allowing clients to conduct banking services without visiting a physical branch. Similarly, AB3 emphasizes a strong orientation toward anticipating innovations as well as evolving customer demands and needs, particularly in the development of mobile banking and modern digital solutions (George and KEKS Pay applications). For business users, cooperation with FINA led to the development of a Fintech application intended for small entrepreneurs, tradespeople, and other business entities. This solution attracted many new business clients by enabling invoices and offer creation, expense and incoming invoice tracking, integration with bank accounts (automatic display of balances and transactions directly within the application interface), and integration with web shops — allowing automatic generation of invoices and offers based on completed orders and transactions. As a result, business administration is optimized, time savings are achieved, and everyday operations are simplified.

CONCLUSION

The analysis of perceptions held by senior managers employed in the largest banks within the Croatian banking sector enables the formulation of several conclusions that contribute to a deeper understanding of the role and effects of financial innovations in contemporary banking operations. The respondents are aware of the importance of financial innovations for maintaining competitiveness and adapting to

changing market demands, with particular emphasis placed on the role of digital technologies in transforming banks' business models and incorporating sustainability considerations into operations, including their contribution to financial inclusion. Financial innovations are not limited exclusively to technological solutions; rather, they also encompass organizational, process-related, and strategic changes within institutions themselves. The research identified numerous ways in which banks integrate innovations into their day-to-day operations, including the development of mobile applications, digital wallets, cashless payment platforms, and software solutions for analyzing customer behavior and personalizing services. In addition, attitudes toward cooperation with Fintech companies were examined, revealing that respondents recognize the potential of such partnerships while simultaneously emphasizing the need for a clear regulatory framework to ensure the security and stability of the financial system. Furthermore, most respondents perceive digital transformation not as a threat to banks, but as an opportunity for further development, increased efficiency, enhanced customer experience, and strengthened financial inclusion. Respondents also identified changes in consumer behavior as a key driver of innovation, particularly the growing demand for greater accessibility, speed, and simplicity of financial services. Although certain threats arising from the Fintech sector exist, most respondents believe that Croatian banks actively follow global trends and successfully maintain their market positions.

Accordingly, financial innovations are not merely a response to current market trends, but rather a long-term process that shapes the way financial services are provided and the nature of relationships between banks and clients, contributing to the creation of a more transparent and user-oriented financial system. Respondents highlighted the necessity of continuous investment in employee education and monitoring global trends as key prerequisites for successful digital transformation. Moreover, the need for strategic consideration of the long-term effects of financial innovations on the stability and resilience of the banking system was emphasized. In conclusion, financial innovations represent an indispensable element of modern banking, and banks that successfully implement financial innovations while maintaining security, trust, and regulatory compliance have the greatest potential for sustaining competitive operations over the long term.

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https://doi.org/10.7251/EMC2603656V
UDK: 327.88(73:510):339.92(100)
Datum prijema rada: 27. januar 2026.
Submission Date: January 27, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 656-675

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

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Abstract: *This study aimed to examine the extent and evolving nature of China's academic dependency on the United States using the field of computer science as the empirical setting. This analysis is situated within Alatas's framework of intellectual imperialism and academic dependency. The empirical analysis employed scientometric methods using Scopus data from 2016 to 2024, and assessed four dimensions of dependency: reliance on U.S. research ideas (international knowledge spillovers), dependence on U.S. academic employment (high-skilled human capital flows), dependence on U.S. investment in education (comparative R&D financing architecture), and dependence on U.S. media of ideas (economic geography of scholarly publishing). The results show that China's dependence on U.S. research ideas has decreased, with Chinese scholars citing domestic research at increasing rates and showing declining reliance on U.S. publications. The analysis also finds rising return migration of Chinese scientists from the United States, a pattern consistent with a redistribution of high-skilled human capital that strengthens China's national innovation system. Furthermore, evidence suggests that Chinese academic funding is overwhelmingly domestically sourced. Yet persistent structural dependencies remain, particularly in publishing, as Chinese scholars continue to rely heavily on Western, especially U.S. and European, journals for global recognition. Overall, the findings indicate that although China is moving toward greater academic self-sufficiency in this field, it remains highly dependent on Western infrastructures for intellectual recognition. This suggests that the academic relationship reflects partial rebalancing rather than complete decoupling, confirming the leading role of the U.S. in the global academic community. The findings contribute to the literature on technological decoupling, international knowledge spillovers, and the comparative political economy of national innovation systems.*

Keywords: *National innovation systems, Academic dependency, United States-China, International knowledge spillovers, Decoupling*

JEL classification: *P51; P52; O31; O38; O33*

INTRODUCTION

Academia in developing countries often follows and depends on technological and intellectual trends set by major global academic powers (Lee & Chen, 2022). This raises an important question: to what extent can research capacity in developing countries grow to be truly autonomous and attuned to country-specific economic and developmental needs? To address this question, it is important that we better understand the phenomena of intellectual imperialism and academic dependency. Similar to the political and economic imperialism of the past, a new form of imperialism has gained momentum in the contemporary world. A legacy of enduring intellectual colonialism has taken deep root within the academic and innovation structures of developing countries (Alatas, 2003). However, over the last two decades, there has been growing momentum in intellectual decolonization and academic indigenization campaigns, especially in Asia (Tenzin & Lee, 2022). Alongside its rapid economic growth, China has undergone an academic transition. Driven by sustained state R&D investment and industrial policy support, China has strengthened its research infrastructure, attracted global talent, and enhanced international collaboration.

This study aims to examine China's academic dependency on U.S. academia, situating the analysis at the intersection of the national innovation systems, and the political economy of knowledge production. The U.S. is chosen because it is the global leader in knowledge production and has the most developed academic system. The paper uses computer science as the empirical setting, since the United States is at the forefront of this discipline. To explore the recent trends in academic dependency, this paper applies selected dimensions of Alatas framework: Dependence on U.S. research ideas (measured as international knowledge spillovers), Dependence on U.S. employment (measured as international human capital mobility), Dependence on U.S. Investment in Education (measured as comparative R&D financing architecture), Dependence on U.S. Media of ideas (measured as economic geography of scholarly publishing). At the core of this research lies a Scientometric analysis, designed to measure the academic dependency over the period 2016–2024. This timeframe was selected because it marks a critical phase in the political, economic, and technological decoupling between China and the United States. The primary dataset was drawn from Scopus (Elsevier, 2025), one of the world's leading databases of peer-reviewed literature. Our findings both complicate and deepen the understanding of academic dependency as a feature of a national innovation system. Despite the state-driven indigenization efforts within Chinese academia and China's growing position as a potential global hub of knowledge production, its academic system remains deeply reliant on the Western academic core - particularly the United States - for intellectual frameworks, validation, and recognition (Ding & Elliott, 2018). The paper contributes to national innovation system, knowledge management, and the broader literature on academic dependency and intellectual imperialism. The study develops a framework that integrates concepts from the economics of innovation and comparative economic systems with insights from the sociology of knowledge. Applied to the computer science sector, it speaks to current debates on economic competitiveness and U.S.-China decoupling. Furthermore, this paper's findings will indicate whether academia mirrors the broader trend of political and economic decoupling between the United States and China.

The rest of the paper is organized as follows. Section 2 presents the key concepts necessary for understanding the latest trends in the global environment and academic dependency theory. In section 3, the research question is developed. The methodology for addressing the research question is presented in Section 4. Section 5 discusses the findings, while Section 6 concludes the paper by highlighting the theoretical and practical implications of the study.

THEORETICAL BACKGROUND

Academia plays a crucial role in enhancing national competitiveness, fostering technological advancement, and driving economic development (Muscio, Quaglione, & Vallanti, 2013). Its influence stems primarily from its core activities of cultivating research-trained graduates. In this context academia's fundamental role is to advance basic research (Grossman, Reid, & Morgan, 2001). Recent trends reveal growing commercial sponsorship of basic research within universities (Fan, Yang, & Yu, 2021). The symbiosis between academic research excellence and the broader economics of academic capitalism has been conceptualized by authors as "strategic research" (Irvine & Martin, 1984). International academic collaboration tends to be more impactful, gain access to broader audiences, and draw on diverse perspectives (Smith, Else, & Crookes, 2014) (Wagner, Park, & Leydesdorff, 2015) (Freeman & Huang, 2015). This can enhance academics' international visibility and recognition while offering commercial sponsors research outputs with potential global market applications and economic returns. Consequently, global integration is contributing to a shift toward global research priorities, sometimes at the expense of national innovation priorities. This is particularly evident in collaborations between developed and developing countries, where underlying asymmetries frequently shape research agendas.

Political economy has recently become a popular conceptual framework for studying global knowledge production in academia. Among the various research frameworks, the most prominent are intellectual imperialism and academic dependency (Galtung, 1967) (Tenzin & Lee, 2024) (Alatas, 2022) (Lee & Chen, 2022) (Tenzin, 2022) (Alatas, 2003). Much like political and economic imperialism, intellectual imperialism reflects structural asymmetries in the global production and circulation of knowledge (Galtung, 1967) between developed and developing countries. This is often referred to as scientific colonialism. Contemporary academic systems often exhibit patterns of dependence, with local scholarship shaped by dominant centers of influence in global innovation networks (Tenzin & Lee, 2022). Alatas describes this as academic dependency, a state in which one academic community's knowledge production is guided and constrained by another (Alatas, 2022). This highlights power imbalances in knowledge production within global innovation networks. Scholars in developing countries often adopt Western frameworks without questioning their relevance to local realities, thereby hindering the development of independent intellectual theories. This dependency is sustained by the dominance of Western publishers, journals, and conferences that supervise the channels of academic recognition. It is further deepened by reliance on imported curricula, pedagogical models, and research funding that often prioritize external agendas over local economic and developmental needs. Confronting these patterns has direct implications for the design of national innovation systems.

The transformation of China's academic system and national innovation system since the late 20th century represents significant academic achievement. This improvement has been driven by a strategic blend of political vision, economic reform, and a persistent quest for modernization. China's academic growth has been both quantitative and qualitative. Since then, state R&D investment rose sharply, alongside a rapid expansion in the number of universities and enrolled students. The government's long-term commitment to invest in research and development has transformed universities into engines of innovation, producing not only vast numbers of graduates but also influential scientific contributions on the global stage. Today, China is a major producer of scientific publications and patents, ranking second only to the United States in research output. Its universities are rising in international rankings, and its academic discourse is expanding beyond Western paradigms toward a more pluralistic, globally engaged model. Yet challenges remain, balancing global integration with national developmental priorities, ensuring efficient allocation of funding, and fostering academic autonomy within a state-led system.

RESEARCH QUESTION

Following the recent emergence of an academic and innovation system improvement in China, a growing body of literature has highlighted the need to critically examine the evolving role and positioning of Chinese academia within the global system of knowledge production (Lee & Chen, 2022) (Tenzin & Lee, 2022) (Tenzin, 2022) (Tenzin & Lee, 2024).

The growing capabilities of Chinese academia are reflected in recent national innovation policies and strategic directions. The Ministry of Education (2020) and the Ministry of Science and Technology (2020) have emphasized that research should primarily serve China's social, economic, and security needs (Office of the Ministry of Science and Technology, 2020). Supported by sustained R&D investments and the rapid expansion of higher education and human capital formation, Chinese universities have emerged as major contributors to global research and active participants in international megaprojects (Zha, 2024). Increasingly, Chinese scholars are publishing independently and establishing diverse global partnerships, reflecting a more confident and autonomous presence in the international academic arena (Lee & Haupt, 2020) (Zha, 2024). However, the notion of China's academic independence remains contested. China's impressive academic and technological progress is deeply intertwined with imitation rather than wholly original innovation (Lu, Liu, Liao, Xu, & Fu, 2022). Their analysis suggests that China's growth has been driven by the strategic adaptation and refinement of foreign technologies, a process that while creative still reflects dependence on external knowledge systems (Han, Jiang, & Mei, 2024) (Bloomberg, 2021). Concerns persist that much of China's research productivity is inflated by state-driven quantity targets rather than genuine scientific breakthroughs. Issues such as low international citation rates, limited cross-border collaboration, and uneven research integrity continue to signal underlying structural weaknesses within China's innovation ecosystem. Despite massive state investment, Chinese universities largely remain peripheral actors in global knowledge networks constrained by rational cost-benefit considerations (König, Storesletten, Song, & Zilibotti, 2022), weak intellectual property regimes (Zheng & Wang, 2012) and enduring cultural and institutional barriers

(Gallagher & Worrell, 2008) (Datta & Mohtadi, 2006). As scientists interviewed by Qiu observe, this bureaucratic, target-oriented governance model restricts researchers' autonomy, discourages curiosity-driven research, and suppresses original scientific innovation (Qiu, 2014).

Alatas contends that the "Global South's" dependence on Western academia extends beyond intellectual subordination and is reinforced by structural mechanisms that privilege Western control over global knowledge production (Alatas, 2022). Western media infrastructures continue to shape this landscape, with Western academia serving as the primary arbiter of scholarly legitimacy. To gain recognition, research must often be published in English and indexed in Western databases (Marginson & Xu, 2023), pressuring non-English-speaking scholars to prioritize international over local outputs (Lee & Chen, 2022). In this regard, developments in China reveal a complex and paradoxical trajectory. On one hand, Chinese academia closely follows global trends, embedding itself within Western-dominated systems of knowledge validation. Chinese research primarily circulates through Western-controlled platforms—English-language journals, citation databases such as the Web of Science and Scopus, and international ranking systems that continue to define global academic prestige (Lee & Chen, 2022). This dependency sustains the dominance of Western epistemic frameworks. On the other hand, China is actively building its own intellectual infrastructure grounded in national priorities and epistemological autonomy. Recent policy initiatives have encouraged scholars to publish in domestic journals and strengthened the country's academic infrastructure through platforms such as CNKI, WanFang Data, VIP Journal Database, and the Chinese Science Citation Database (Lee & Haupt, 2020). The government has introduced mechanisms such as the Breaking the Five-Only campaign, the Double First-Class Programme, and the China University Subject Rankings to promote quality-oriented evaluation and reduce dependence on international benchmarks. However, the transition remains uneven: many institutions continue to prioritize quantitative metrics and international visibility, revealing the enduring tension between reformist aspirations and the inertia of established academic practices (Xu & Li, 2024).

From the perspective of the innovation financing, the historical development of China's higher education system reveals a clear transition from Western-dependent financing toward state-led self-reliance and strategic autonomy. In the immediate aftermath of the Cultural Revolution, particularly during the late 1970s and early 1980s, China's efforts to rebuild its research and educational infrastructure were heavily supported by Western loans, grants, and technical assistance (Alatas, 2022). As a result, Western donors and institutions exercised significant influence over China's educational priorities, embedding a structural dependence on external funding sources and global policy frameworks rather than on domestically generated capital or expertise. From the 1980s onward, however, China began to reorient its academic financing model toward domestic mobilization and state-directed investment. Nevertheless, vestiges of financial dependency persist, particularly through international research collaborations and joint academic ventures that rely partly on co-financing from Western universities, foundations, and multinational research programs. While such partnerships continue to contribute to China's global academic visibility, their scale has gradually diminished in recent years amid intensifying geopolitical tensions and rising skepticism toward

China's political and scientific agenda (Xie, Lin, Li, He, & Huang, 2023). Thus, the contemporary Chinese academic system occupies a dual position: it demonstrates a growing capacity for financial self-sufficiency and centralized coordination, yet remains, albeit to a lesser extent, entangled with Western funding structures that continue to shape certain dimensions of its international engagement.

Another crucial dimension of academic dependence identified by Alatas concerns the mobility of human capital, specifically, the reliance of developing academic systems on foreign training, expertise, and recognition. Bilateral cooperation agreements with the advanced economies facilitated the training of thousands of Chinese scholars abroad through government-funded scholarships and institutional partnerships (Xinhua, 2017). The reliance on Western education systems also produced a persistent structural imbalance. Many of the scholars trained abroad, particularly those in elite programs, chose not to return, resulting in significant and ongoing brain drain (Hu, 2021). Empirical studies show that return decisions are strongly influenced by the prestige of the PhD-awarding institution and the academic standing of potential employers in China (Marini & Yang, 2021). Those who remain abroad often cite the greater research autonomy, superior infrastructure, and more vibrant intellectual environments found in Western universities (Sun, Guo, & Zhang, 2017). At the same time, the past two decades have witnessed a deliberate shift toward independence and domestic capacity-building within China's academic system. The Chinese government has implemented a series of high-profile talent repatriation programs, such as the Young Thousand Talents (Y1000T) scheme, which offers returning scholars competitive compensation, modern research facilities, and considerable autonomy in establishing their own teams (Marini & Yang, 2021). The growing global visibility and prestige of leading Chinese universities have further contributed to reversing the flow of scientific migration (Wang & Bao, 2015) (Li, Lo, Lu, Tan, & Lu, 2023). The dynamics of China's scientific workforce illustrate a direct implication for the economics of innovation.

RQ: To what extent and through which economic mechanisms has China's academic dependency on the United States in computer science evolved during the period of U.S.-China decoupling (2016–2024)?

METHODOLOGY

Data and sample

This study addresses the phenomenon of academic dependence in the Chinese context. Research focuses on the extent to which Chinese scholars depend on U.S. scholars. We chose computer science as a case for examining dependence because it is a highly active and rapidly evolving technology field, and one in which the United States continues to lead. The discipline of computer science originated in the United States and was introduced to China during the final decades of the twentieth century. The diffusion of computer science knowledge into China occurred through multiple channels. Initially, Western companies entered the Chinese market primarily for trade and low-value-added production, but by the 1980s and 1990s, many began transferring their research and development (R&D) operations to China (Von Zedtwitz, 2004). Consequently, most leading global technology firms established a presence in the country. An additional driver of computer science development in China was the

growing number of Chinese students pursuing higher education in the United States (Wang, Mao, Wang, Peng, & Hou, 2013). Recognizing the strategic importance of this field, the Chinese government began to view computer science as a key instrument for achieving global technological leadership. We focus our research on academic dependence because academic researchers play a pivotal role in advancing basic research, which, in turn, serves as the foundation for radical and disruptive innovations (Quaglione, Muscio, & Vallanti, 2015). By assessing this dependence, we aim to determine whether China has transitioned from being a technological imitator to an independent innovator within the global computer science landscape.

To assess dependency, we observed four dependency dimensions proposed by Alatas (2003): dependence on research ideas, dependence on employment, dependence on investment in education, and dependence on the media (Table 1).

Table 1. Operationalization of the four dependency dimensions

Dependency dimension	Economic construct	Indicator and formula	Figure	Data, population and interpretation
Dependence on U.S. research ideas	International knowledge spillovers (co-authorship)	Number of Chinese CS articles in year t with at least one co-author affiliated in country j	Figure 1	**Source**: Scopus **Population**: all CS articles with at least 1 author affiliated with a Chinese institution, 1978–2024. **Interpretation**: A rising number of collaborations with U.S. authors indicates a deepening collaborative tie; a falling share indicates disengagement, which may reflect either reduced dependence or externally imposed decoupling.
Dependence on U.S. research ideas	International knowledge spillovers (via citation)	Citation propensity: The propensity of Chinese papers to cite U.S. papers relative to Chinese papers: $P_{c,u} = \frac{n_{c,u}}{n_{c,c}}$; The propensity of U.S. papers to cite Chinese papers relative to U.S. papers: $P_{u,c} = \frac{n_{u,c}}{n_{u,u}}$; $n_{c,u}$ references from Chinese articles to U.S.-affiliated articles $n_{c,c}$ references from Chinese articles to Chinese-affiliated articles $n_{u,c}$ references from U.S. articles to Chinese-affiliated articles $n_{u,u}$ references from U.S. articles to. US.-affiliated articles	Figures 2 and 6	**Source**: Scopus **Population**: the 2,000 most-cited articles per year, 2016–2024, authored exclusively by Chinese affiliations. (Respectively U.S.) **Interpretation**: Growth of $P_{c,u}$ means Chinese authors draw on U.S. work more than on domestic work. Decline in $P_{c,u}$ means Chinese authors' declining dependence on the U.S. (Respectively, U.S.)

Dependence on U.S. academic employment	High-skilled human capital flows	Normalized return flow: $R_t = \frac{N_t}{mean\ N(2005-2010)}$	Figure 3	**Source**: Secondary data reprinted from Xie et al. (2023) **Population**: Number of U.S.-based Chinese-descendant scientists moving to China in year t and no longer publishing with a U.S. affiliation N_t normalization to the 2005–2010 mean makes fields with different workforce sizes comparable. **Interpretation**: $R_t > 1$ means outflow from the U.S. exceeds the pre-2010 baseline; a rising R(t) indicates falling reliance on U.S. academic employment as a career destination.
Dependence on U.S. investment in education	R&D financing architecture	Number of Chinese CS articles financed by different countries j	Figure 4	**Source**: Scopus **Population**: all CS articles authored exclusively by China-affiliated researchers **Interpretation**: A declining number of funding from Country J indicates growing financial self-reliance.
Dependence on U.S. media of ideas	Economic geography of scholarly publishing	Chinese CS articles published in year t in journals whose publisher is domiciled in country j	Figure 5	**Source**: Scopus **Population**: Chinese CS articles 2016–2024 **Interpretation**: increase in percentage of articles published in country j indicate growing dependence on validation infrastructure (publisher) of country j

Source: Authors' own illustration

MEASURING THE DEPENDENCY OF THE CHINESE ACADEMY ON THE U.S. ACADEMY

Chinese dependence on U.S. research ideas

At the core of this research is a scientometric analysis designed to measure the academic dependency of Chinese scholars on their U.S. counterparts in computer science over 2016–2024. This timeframe was selected because it marks a critical phase in the economic and technological decoupling between China and the United States. The primary dataset was drawn from Scopus (Elsevier, 2025), one of the world's leading databases of peer-reviewed literature. In Scopus, the study applied a strict inclusion criterion, limiting publications to those categorized as "articles," defined as original research or opinion pieces commonly published in peer-reviewed journals (Elsevier, 2020). Only records within the disciplinary domain of computer science were included. Applying successive filters to Scopus records authored exclusively by China-affiliated researchers reduced the initial 11,736,256 documents to 2,060,553 in computer science, 910,802 journal articles, 714,724 English-language articles, and finally 413,619 published between 2016 and 2024. The increasing proportion of articles produced solely by domestic scholars indicates a trend toward greater research self-sufficiency and the emergence of indigenous capacity within

China's computer science community. (A detailed PRISMA diagram can be found in Appendix 1, Table A1)

Dependence on research ideas captures international knowledge spillovers, a significant concept in the economics of innovation. Figure 1 illustrates the pattern of China's international academic collaborations, focusing on partnerships with the United States, the European Union (with and without the United Kingdom), and the United Kingdom individually. The data reveal that the U.S. consistently appears as China's most significant research collaboration partner, indicating China's strong academic dependence on the United States. However, the Figure 1 also reflects the impact of escalating U.S.-China tensions on the academic sphere. Beginning around 2018, coinciding with the onset of political and economic frictions between the two nations, the rate of U.S.-China academic collaboration began to decline and has since stagnated. In contrast, China's collaborations with other international partners, particularly those within the European Union, have continued to expand.

Figure 1. Number of Chinese academic papers in collaboration with selected countries (1978-2024)

Source: Authors' own illustration based on data from Scopus

To quantify academic dependence on ideas, this study measures the propensity of Chinese research articles to cite U.S. publications relative to domestic ones. This selection was made under the rationale that citation frequency reflects the influence of academic knowledge (Kreiman & Maunsell, 2011). Citations are widely recognized as an objective indicator of the acquisition and diffusion of knowledge and ideas (Jaffe & Trajtenberg, 2002). The analytical approach adopted here is based on the measurement model developed by (Han, Jiang, & Mei, 2024). To assess China's academic dependency, we extracted the 2,000 most-cited articles per year in which all authors are affiliated with Chinese institutions; these are referred to as "Chinese articles." Similarly, to evaluate U.S. academic dependency, we identified the 2,000 most-cited articles per year over the same period, authored exclusively by researchers affiliated with U.S. institutions, referred to as "U.S. articles." Scopus permits reference analysis on a maximum of 2,000 documents per query, which necessitated sampling (to mitigate potential sample bias, we conducted a sensitivity analysis, which can be found in Appendix 2). Figure 2 presents the results of the quantitative assessment of Chinese academic dependence. (Details can be found in Appendix 1, Table A2).

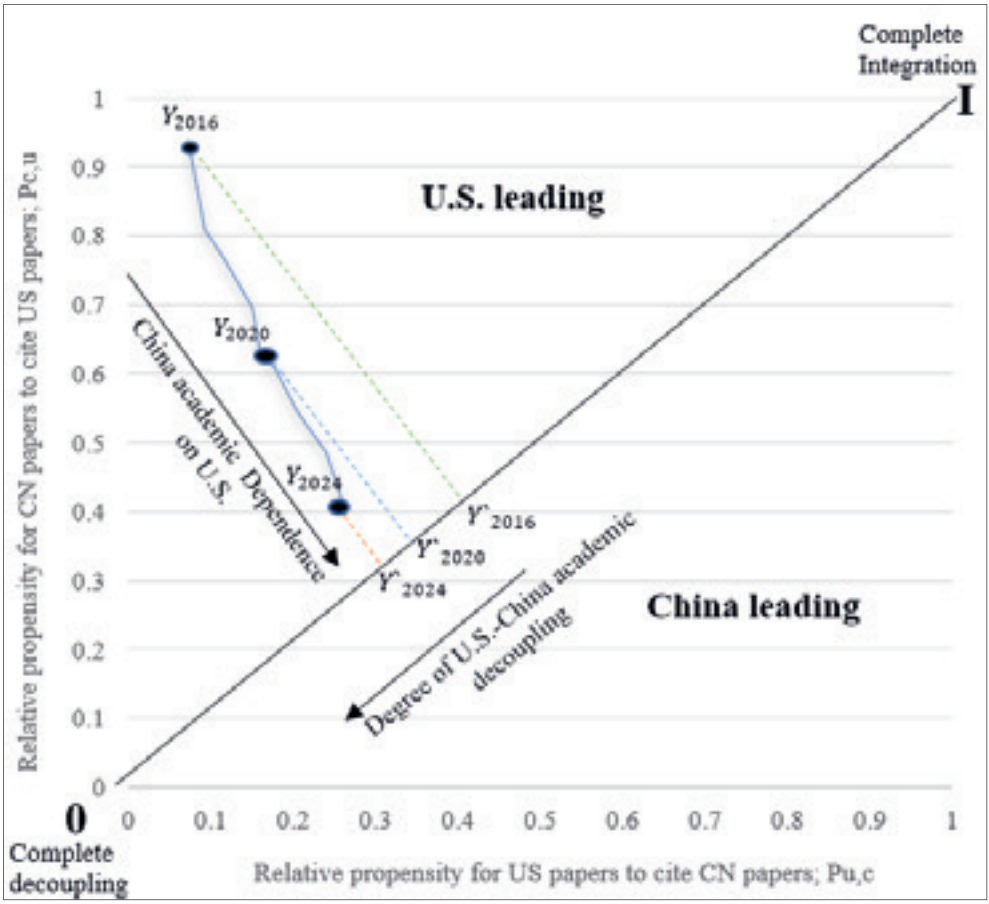

Figure 2. U.S.-China academic decoupling and dependence

Source: Authors' own illustration based on data from Scopus

Figure 2 provides evidence of China's increasing academic self-sufficiency. In 2016, Chinese scholars cited U.S. publications about ten times as often as domestic ones, reflecting a pronounced academic dependence on the United States. Over the past decade, however, this ratio has declined sharply. By 2024, Chinese authors cite U.S. papers only about twice as often as domestic publications. While this indicates that the United States retains its academic leadership and that China's dependence remains, the data suggest a rapid, accelerating reduction in that dependence. Figure 2 also shows the trends in academic decoupling. Growing academic independence is followed by growing academic decoupling. In academic literature, technological decoupling refers to the process by which countries increasingly diverge in technological standards and innovation trajectories, thereby reducing the necessity to build upon each other's research outputs (Han, Jiang, & Mei, 2024) (Zhang, 2023). In this context, "complete decoupling" would mean researchers in each country no longer cite publications from the other, reflecting two self-contained, isolated scientific ecosystems. Conversely, "complete integration" would occur when domestic authors cite foreign and domestic publications with equal probability, implying that knowledge produced

abroad is equally relevant and that no "home bias" exists in the use or recognition of external research.

Dependence on U.S. Employment

Dependence on employment captures international human capital flows. To indicate China's dependence on U.S. employment, we used corroborating secondary evidence rather than our own measurements extracted from (Xie, Lin, Li, He, & Huang, 2023) research. Figure 3 shows a notable increase in the number of returning scholars, both junior and senior, particularly in engineering and computer science. This trend suggests that Chinese academics are increasingly choosing to continue their careers in China rather than in U.S. institutions, reflecting a gradual strengthening of research opportunities, resources, and institutional prestige within China's own higher education system.

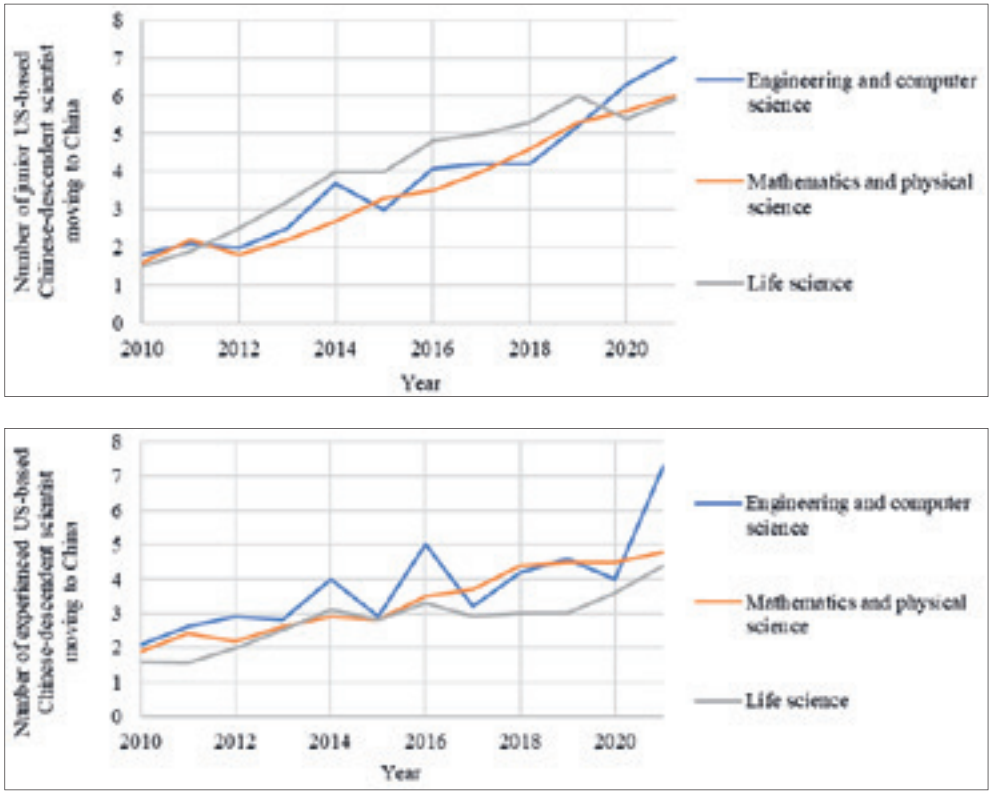

Figure 3. Trends in junior/experienced Chinese scientists migrating from the U.S. to China

Source: Reprinted from (Xie, Lin, Li, He, & Huang, 2023)

Dependence on U.S. Investment in Education

Dependence on investment in Education captures an R&D financing architecture. This dimension captures the financing of the Chinese national innovation system. Figure 4 shows the number of Chinese research projects financed by funds from China, the U.S., and other countries. Figure 4 indicates that Chinese academia is predominantly financed through domestic state sources, reflecting a model of centrally coordinated

national investment in higher education and research. Significant growth is especially evident from 2015 onward.

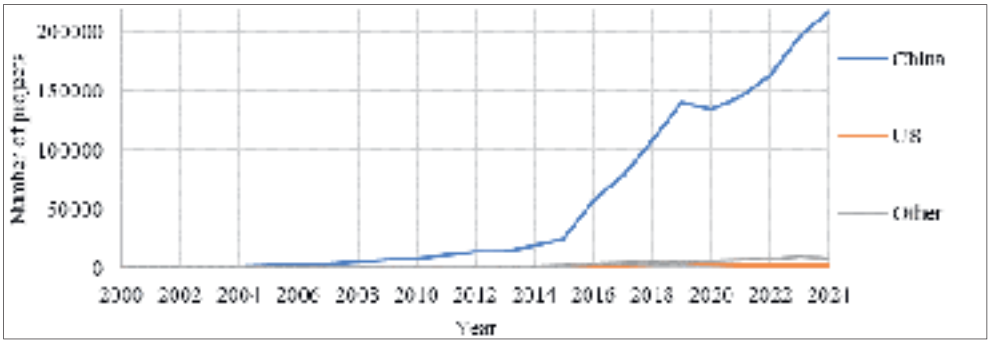

Figure 4. Number of projects financed by funds from China, U.S., and other countries

Source: Authors' own illustration based on data from Scopus (Elsevier, 2025)

Dependence on the U.S. Media

Dependence on the Media captures the economic geography of scholarly publishing – validation infrastructure. Figure 5 illustrates the changing distribution of countries where Chinese scholars publish their articles between 2016 and 2024. During the early years (2016–2018), most Chinese articles appeared in China-based journals, accounting for the highest share (around 35–40%). However, this proportion steadily declined, while publications in U.S. journals grew sharply, peaking around 2019–2020. After 2020, the U.S. share slightly decreased but remained significant. Meanwhile, publications in Swiss- and Netherlands-based journals (MDPI and Elsevier) rose considerably after 2021, reflecting the growing role of these outlets in hosting Chinese research. The shares of the UK and other countries remained relatively stable but low throughout the period. Overall, the trend suggests a gradual internationalization and diversification of Chinese scholarly publishing, with a shift from domestic to Western (especially U.S. and European) journals.

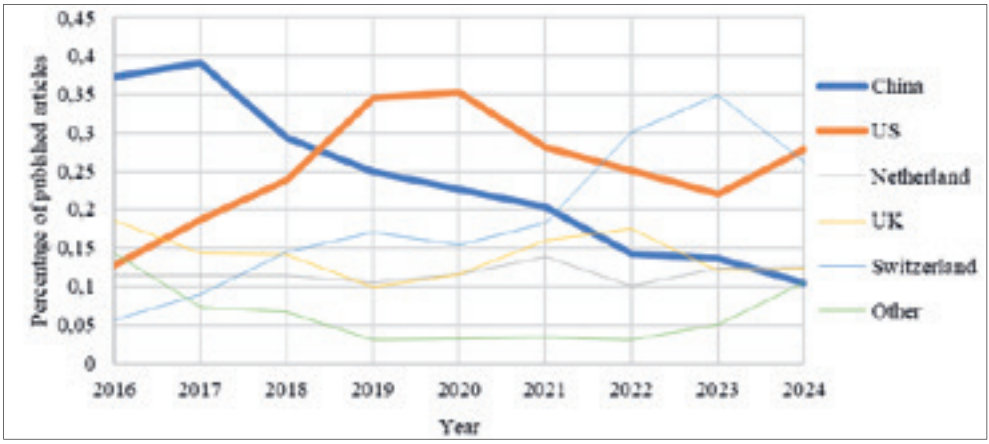

Figure 5. Country of origin of journals where Chinese computer science articles are published

Source: Authors' own illustration based on data from Scopus (Elsevier, 2025)

DISCUSSION

This research yields ambiguous findings regarding U.S.-China academic dependence in computer science. The study reveals that citations of U.S. articles in Chinese publications are declining, suggesting a growing trend of Chinese academic independence. These findin+gs align with earlier results by (Han, Jiang, & Mei, 2024), who found that China's technological reliance on the U.S. is declining. The trend of declining academic dependence coincides with the implementation of the China Initiative in the U.S. Chinese researchers may have increasingly relied on local research inputs, thereby fostering more basic research within China. However, certain findings do not confirm this trend in China (Chen, Zhang, & Miao, 2023). According to them, U.S.-China tensions negatively affected innovation in the Chinese ICT industry. This reflected the negative effect of increasing independence on Chinese creativity. Furthermore, our analysis shows that a growing number of Chinese publications in the top 1% cited publications might reflect an increase in originality and creativity in Chinese academic research (Elsevier, 2025). Furthermore, our analysis reveals that citations of Chinese articles in U.S. publications are growing. However, despite the decline, this research indicates that the United States still holds a dominant position in the U.S.–China academic relationship.

According to Alatas framework of academic dependence, reliance on "Western media" constitutes a clear manifestation of Western intellectual imperialism (Alatas, 2022). The results of this analysis indicate a growing trend of Chinese authors publishing in "Western" journals, particularly those based in the United States and Switzerland (Elsevier, 2025). While this reflects a degree of conformity with the U.S.-dominated academic system, it also signals growing recognition of Chinese scholarly work. This points to a paradox in government academic policies. On the one hand, the government promotes academic dependence on Western media. Publications in SCI or SSCI-indexed journals serve as key measures of performance for academic promotion and rewards in Chinese universities (Gu & Levin, 2021); (Xu, Rose, & Oancea, 2021). On the other hand, recent policy initiatives have encouraged scholars to publish in domestic journals and strengthened the country's academic infrastructure through platforms such as CNKI, WanFang Data, VIP Journal Database, and the Chinese Science Citation Database (Lee & Haupt, 2020), reflecting the government's devotion to freeing itself from Western media dependence.

The Chinese government is the dominant financial patron of its own research system, channeling substantial investment through initiatives such as Project 211 (1995), Project 985 (1998), and the Double First-Class Initiative (2017). This financial independence is reflected in co-authorship data: only 4% of U.S.–China co-authored publications rely solely on U.S. funding, while 44% are co-funded by Chinese sources and 32% by other international partners (Lee & Haupt, 2020), suggesting that U.S. collaboration now functions primarily as a channel for knowledge exchange and international visibility rather than financial support. Recent U.S. restrictions on federal funding for research involving Chinese institutions (U.S. Department of Justice, 2020) have further accelerated this decoupling, reinforcing China's growing financial and institutional self-reliance.

The tendency of Chinese scholars to seek academic positions within U.S. universities reflects the historically greater concentration of research opportunities, re-

sources, and institutional prestige in the American higher education system (Sun, Guo, & Zhang, 2017). This dominance is reinforced by dense networks of collaboration abroad and "hygienic" conditions in academia (competitive salaries, generous budgets, and ample grant opportunities) that continue to draw and retain Chinese scholars in Western institutions (Cañibano & Woolley, 2015). However, other study results suggest that Chinese academics are increasingly choosing to continue their careers in China rather than in U.S. institutions for over a decade already (Xie, Lin, Li, He, & Huang, 2023). This trend accelerated further, driven by the U.S.'s China Initiative in 2018. Even dual affiliation between the U.S. and China dropped sharply by 2021. This trend is particularly evident in engineering and computer science academics. Furthermore, the Chinese government is making growing efforts to repatriate its academics. The government offered generous working conditions, reduced teaching load, strong research funding, and resources to build a team (Chen & Du, 2023) (Marini & Yang, 2021). Where certain authors emphasize cultural and familial motivations, as well as the rise in prestige of Chinese universities, as the main reasons (Zhao, Liu, & Yan, 2024) (Hu, 2021). Encouraging internationalization of China's academic ecology will facilitate further progress of academic careers in China (Li & Xue, 2021).

CONCLUSION

Since the U.S.–China Science and Technology Agreement (Agreement between the United States of America and the People's Republic of China on Cooperation in Science and Technology, 1979), Chinese academic collaboration with U.S. researchers has taken off. However, in the last 10 years, the trend has lost momentum. Academic collaboration has mirrored broader trends of geopolitical and economic decoupling. This led to strategic reorientation of Chinese researchers toward broader cooperation with other Western nations, especially within Europe (Lee & Haupt, 2020) (Zha, 2024). Simultaneously, the Chinese government is making growing efforts to repatriate its academics. The paper not only contributes to the existing literature but also introduces a new research trajectory within the academic dependency and intellectual imperialism framework. While the academic dependency framework has traditionally been used to study knowledge flows in broader academic contexts, this study extends it to a high-technology sector central to the economics of innovation, comparative national innovation systems, and contemporary debates on technological decoupling. Furthermore, this paper's findings illustrate that, within computer science, China's academic ascent represents not a clean break from Western intellectual structures but rather a partial rebalancing within a still-asymmetric global system of knowledge production. This suggests that, in computer science, academic integration between the world's two leading national innovation systems does not fully mirror the broader trend of political and economic decoupling between the United States and China, and it confirms the U.S. as a global academic leader. This study measures academic dependency within a single discipline, and the findings should not be read as describing China's academic system as a whole. Computer science is atypical in several respects relevant to the measures used here: it is unusually English-dominant, it has been a priority target of Chinese state investment, and its knowledge cycles are short, so citation patterns adjust faster than in fields with longer theoretical horizons. Computer science therefore constitutes a hard case for the dependency thesis rather than a representative one, which

makes the persistence of publishing dependence documented here more, not less, notable. Extending the analysis across disciplines is a natural next step.

Acknowledgement

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process. During the preparation of this work, the authors used Grammarly and ChatGPT in order to check grammar, improve clarity, style, readability, and flow. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the published article.

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Appendix 1

Table A1. PRISMA diagram

	No. of documents	Filter
Initial Query	11,736,256 documents	Only CN authors (ensure that knowledge is exclusively CN)
	2,060,553 documents	Computer science (Field)
	910,802 documents	Only articles (Type of document)
	714,724 documents	Only English language (Language)
	413,619 documents	2016-2024 (Time)
References analysis for each year separately (2016-2024)		
Year 2016	2000 documents	Sample (Most cited documents)
	67,987 documents found	Total number of references in the sample
	19,722 documents found	U.S. references
We did the same analysis for each subsequent year: 2017; 2018; 2019; 2020; 2021; 2022; 2023; 2024		

Source: author

Table A2. Sensitivity analysis

Sample: 2000 most cited		
Year	U.S. Propensity to cite CN papers	CN Propensity to cite U.S. papers
2024	0.260540818	0.408238868
2023	0.240697057	0.483959311
2022	0.205875466	0.545740466
2021	0.176627894	0.61011183
2020	0.16019224	0.627524833
2019	0.15069874	0.694685444
2018	0.115187693	0.769220246
2017	0.091955392	0.808137496
2016	0.074640024	0.929619271
Sample: Random		
Year	U.S. Propensity to cite CN papers	CN Propensity to cite U.S. papers
2024	0.198431974	0.446593533
2023	0.162802335	0.518576826
2022	0.144713675	0.559264548
2021	0.127174365	0.605690537
2020	0.111179415	0.662195037
2019	0.089549525	0.668041088
2018	0.085789348	0.782932275
2017	0.074776224	0.833606005
2016	0.054692522	0.882621143

Source: author

Appendix 2

This diagram uses (Han, Jiang, & Mei, 2024) methodology to measure academic decoupling and dependence. The vertical axis ($P_{c,u}$) is a proxy of the propensity for Chinese academic papers to cite a U.S. papers relative to citing a Chinese one. The horizontal axis ($P_{u,c}$) is a proxy of the propensity for U.S. academic papers to cite a Chinese papers relative to citing a U.S. one.

Formula 1. Citation propensity

$$P_{c,u} = \frac{n_{c,u}}{n_{c,c}}; \qquad P_{u,c} = \frac{n_{u,c}}{n_{u,u}}$$

Source: Adopted from Han, Jiang, & Mei (2024)

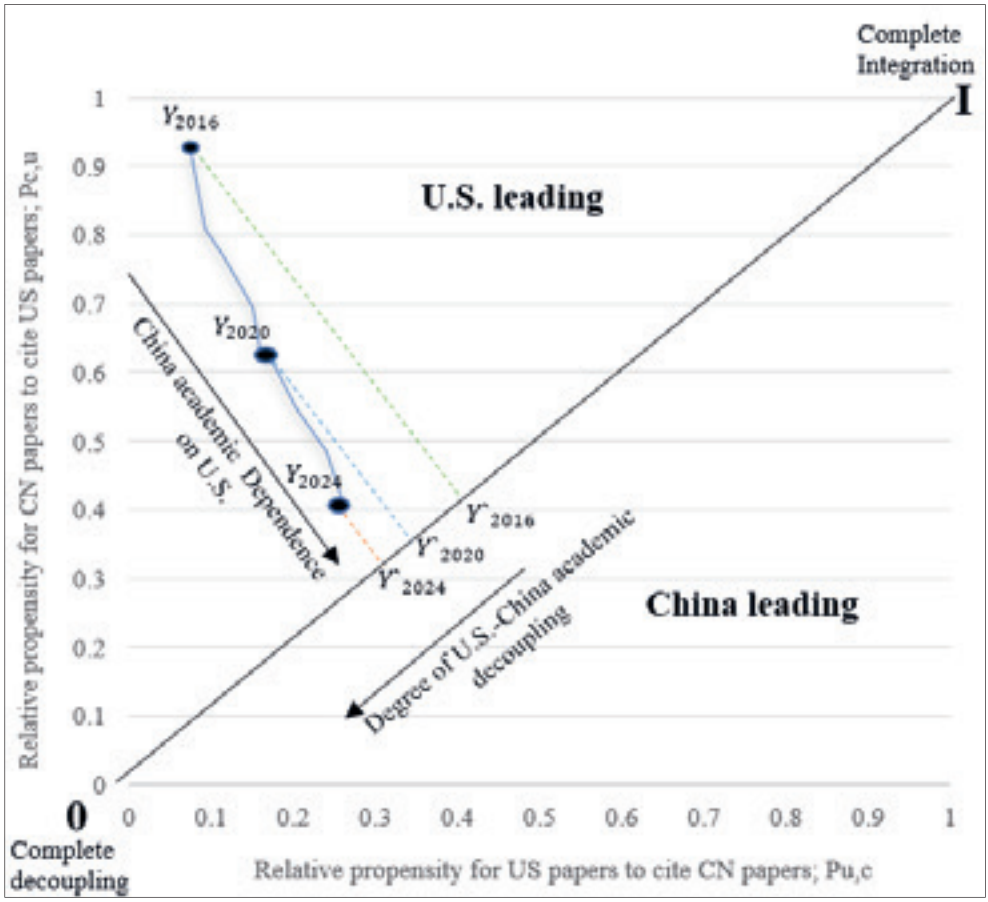

Figure 6. U.S.-China academic decoupling and dependence

Source: Authors' own illustration based on data from Scopus (Elsevier, 2025)

In the expressions above, $n_{c,u}/(n_{c,c})$ denotes the number of citations from Chinese papers to U.S. papers compared to Chinese papers, and $n_{u,c}/(n_{u,u})$ is defined analogously. Reflecting the state of parity, the 45-degree line is defined as the "par line." The triangular area above (below) the 45-degree line is defined as "U.S.-leading" ("China-leading") region. Projecting point $\boldsymbol{Y_{2016}}$ onto the 45-degree line, we decompose the vector $\boldsymbol{Y_{2016}I}$ into two orthogonal vectors $\boldsymbol{Y_{2016}\ Y'_{2016}}$ and vector $\boldsymbol{Y'_{2016}I}$ (i.e., the projection of vector $\boldsymbol{Y'_{2016}I}$ on the par line) captures the degree of U.S.-China academic decoupling. The vector $\boldsymbol{Y_{2016}\ Y'_{2016}}$ (i.e., the rejection of vector $\boldsymbol{Y_{2016}I}$ from the par line) reflects China's academic dependence on the U.S. A more detailed explanation of methodology can be found in research paper of (Han, Jiang, & Mei, 2024).

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https://doi.org/10.7251/EMC2603676S
UDK: 338.242.2:316.323(497.11)
Datum prijema rada: 8. decembar 2025.
Submission Date: December 8, 2025
Datum prihvatanja rada: 7. septembar 2026.
Acceptance Date: September 7, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 676-689

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

LEADERSHIP DYNAMICS IN A DEVELOPING ECONOMY: FROM TRANSITION TO POST-TRANSITION (2011–2025)

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Abstract: *This study examined differences in perceived leadership behaviors between two independent samples of respondents from organizations in Serbia surveyed in 2011 and 2025, corresponding to the transition and post-transition periods examined in the study. Using a repeated cross-sectional design and the same leadership measurement instrument in both surveys, the study compared aggregate transformational and transactional leadership and their constituent dimensions. The results indicate statistically significant lower scores in 2025 for core transformational leader behavior, high performance expectations, contingent punishment behavior, and the aggregate transformational and transactional leadership measures. In contrast, supportive leader behavior was significantly higher in the 2025 sample, although the difference was limited in magnitude. No statistically significant between-sample differences were found for intellectual stimulation or contingent reward behavior. High performance expectations showed the largest difference among the individual leadership dimensions and was the only dimension with a medium effect size. Overall, the findings reveal selective rather than uniform between-sample differences and show that aggregate leadership measures should be interpreted alongside their constituent behaviors in comparisons between the 2011 and 2025 samples.*

Keywords*: Leadership, Transformational leadership, Transactional leadership, Leadership behaviors, Organizational Change*

JEL Classification: *M12, M54, P30*

INTRODUCTION

Contemporary organizations operate in conditions characterized by rapid and complex shifts arising from digitalization, technological advancement, globalization, and changes in work models. These processes shape the organization of work and

communication within organizations, leading to the redefinition of the leader's role and employee expectations. The literature highlights that contemporary leadership encompasses a broader set of interpersonal and adaptive competencies rather than merely hierarchical supervision and control (Yukl & Gardner, 2020), while other scholars emphasize the leader's role in guiding change, fostering motivation, and engaging in development-oriented leadership practices (Northouse, 2021).

In Serbia, the transition and post-transition periods provide distinct socio-economic and organizational contexts for examining leadership. The transition environment was characterized by major changes in ownership structure, including the privatization of state enterprises and the entry of foreign companies into the Serbian market (Nikolić, Vukonjanski, & Terek, 2012); (Nikolić, Vukonjanski, Szabó, Nedeljković, & Terek, 2015). The 2011 and 2025 survey years therefore represent two temporally separated points within distinct stages of Serbia's socio-economic and organizational development. The distinction between the transition and post-transition contexts provides a substantively relevant basis for comparing perceptions of leadership across the two survey years.

Empirical studies in Serbia have examined transformational and transactional leadership across different organizational settings (Nikolić, Vukonjanski, & Terek, 2012) and reported relationships between leadership behaviors and financial performance, organizational commitment, and organizational innovation (Nikolić, Vukonjanski, Szabó, Nedeljković, & Terek, 2015); (Jovanović, Pavlović, & Vukonjanski Srdić, 2024). Despite this body of research, empirical evidence directly comparing leadership perceptions across widely separated survey years remains limited. Existing studies predominantly examine leadership within individual study periods, leaving limited evidence on whether perceptions of transformational and transactional leadership behaviors differ between independent samples surveyed at substantially different points in Serbia's socio-economic development. The transition and post-transition contexts of 2011 and 2025 therefore provide a relevant setting for such a comparison.

In this context, this study contributes to the understanding of leadership in Serbia through a repeated cross-sectional comparison of two independent samples surveyed in 2011 and 2025 using the same leadership measurement instrument. The aim of the study is to identify between-sample differences in perceptions of transformational and transactional leadership behaviors across the two survey years and to consider these differences within the transition and post-transition contexts represented by the two survey periods. The comparison specifically examines whether between-sample differences at the aggregate transformational and transactional levels are reflected consistently across their constituent leadership dimensions.

LITERATURE OVERVIEW

Among the most influential theoretical frameworks of leadership are those that distinguish between transformational and transactional leadership behaviors. Transformational leaders inspire followers through a clear vision, stimulate innovativeness, provide individualized support, and intellectually challenge employees, directing them toward shared organizational goals (Bass & Avolio, 1994). In contrast, transactional leaders establish clear expectations and employ performance-based rewards, along with corrective mechanisms, to maintain stability and clarity of roles within the organization (Antonakis & House, 2014). Different organizational culture profiles were char-

acterized by varying combinations of transformational and transactional leadership qualities (Bass & Avolio, 1994). At the follower level, meta-analytic evidence showed that transformational leadership was positively related to motivation, satisfaction with the leader, and rated leader effectiveness (Judge & Piccolo, 2004). Transactional leadership, which includes contingent reinforcement and corrective regulation, remains an important mechanism for ensuring clearly defined expectations and stable functioning of organizational processes (Antonakis & House, 2014).

Leadership has been examined in relation to organizational culture (Schein, 2010); (Bass & Avolio, 1994), dyadic superior–member relationships (Dansereau, Graen, & Haga, 1975), follower motivation (Bass & Riggio, 2006), and trust within leader–follower relationships (Scandura & Pellegrini, 2008). According to Bass and Riggio (Bass & Riggio, 2006), the development of leadership competencies is shaped across different life and professional contexts, wherein family environment, educational systems, and work experience contribute to the development of transformational leadership. Professional development is additionally strengthened through mentoring, counseling, coaching, feedback, and formal training. Relational perspectives on leadership further emphasize the importance of the quality of leader-follower relationships. Dansereau and colleagues (Dansereau, Graen, & Haga, 1975) demonstrated that leaders form differentiated levels of exchange with team members, whereby relationships grounded in trust and mutual commitment contribute to higher organizational effectiveness. Graen and Uhl-Bien (Graen & Uhl-Bien, 1991) advanced this conceptualization through the leadership-making model and indicated that the long-term development of relationships and the promotion of employee autonomy represent key determinants of effective leadership.

Transformational leadership is recognized in the literature as a leadership style that enables organizations to effectively respond to the demands of contemporary operating environments. Transformational leadership has been examined in relation to organizational processes at different levels of analysis. In a service setting, work-unit-level transformational leadership was positively associated with service climate (Liao & Chuang, 2007). Organizational culture has also been conceptualized as reflecting varying combinations of transformational and transactional leadership qualities. Transformational organizational cultures are characterized by a shared sense of purpose, long-term commitment, mutual interests between leaders and followers, and an emphasis on adaptability, growth, and creativity (Bass & Avolio, 1994).

In contemporary business environments characterized by rapid change, uncertainty, and intensified competition, the importance of high-quality leadership is increasingly emphasized as a key determinant of organizational success (Yukl G. , 2013); (Northouse, 2021). Traditional conceptions of leadership grounded in formal authority, control, and rational decision-making are progressively giving way to leadership models that center on human resources, emotions, interpersonal relations, and employees' psychological well-being (Goleman , Boyatzis, & McKee, 2002). In line with these developments, leadership is increasingly conceptualized in the contemporary literature as a collective and socially embedded phenomenon. Rather than being viewed as an isolated activity of an individual in a managerial position, leadership is conceptualized as a process emerging through interaction and collaboration among organizational members in pursuing shared objectives. Hogan and Kaiser (Hogan & Kaiser, 2005) conceptualize leadership in terms of a leader's capacity to develop and sustain an effec-

tive group and argue that leadership effectiveness should be evaluated through group performance over time. Their perspective places the organization of collective effort and the performance of teams, groups, and organizations at the center of leadership, rather than defining it primarily through formal position or individual emergence.

The development of the relationship between leaders and their teams progresses through distinct phases, and achieving a mature and effective working relationship has limited potential for success without continuous guidance and support (Graen & Uhl-Bien, 1995); (Graen & Uhl-Bien, 1991). In this context, a deeper understanding of leadership styles that enable successful adaptation to changing organizational conditions and effective responses to contemporary workplace challenges becomes essential (Hogan & Kaiser, 2005). Leadership style is influenced by leaders' attitudes, personality, experience, emotional intelligence, and relationships, while the appropriateness of a particular style also depends on organizational and situational factors (Kochiyel, 2024). Ethical leadership provides an additional perspective on leader behavior, as both ethical and transformational leadership were positively associated with CSR practices toward employees, with a substantially stronger association for ethical leadership (Budur & Demir, 2019). High-quality relationships characterized by strong mutual trust and reciprocal investment between supervisors and team members are critical for building successful and stable organizational units (Dansereau, Graen, & Haga, 1975). The application of leadership-making processes in organizations (Graen & Uhl-Bien, 1991) contributes to the achievement of objectives set by supervisors while simultaneously fostering capability development and personal growth among team members.

In the context of Serbia, leadership has become the focus of a growing body of empirical research, with particular attention devoted to its effects on organizational processes and employee behavior. Studies conducted in the public sector highlight employees' perceptions of leader characteristics and leadership styles deemed effective in advancing professionalization and organizational reform (Janovac, Virijević Jovanović, & Zdravković, 2022). Moreover, the findings indicate that managers in the public sector often display a strong orientation toward tasks and structure, whereas a more balanced emphasis on both task accomplishment and interpersonal relations could enhance employee motivation (Janovac & Đoković, 2022).

Empirical research in Serbia demonstrates that leadership is examined across various organizational contexts and relational dynamics. In the banking sector, Berber and colleagues (Berber, Strugar Jelača, Bjekić, & Marić, 2022) analyze the influence of sociodemographic factors on leadership style and find that age and educational level are significantly related to specific leadership styles, whereas gender is not statistically significant. A notable contribution to understanding transformational leadership is provided by the study showing that a transformational style fosters employees' innovative work behavior, with the quality of leader-follower relations and employees' voice-related behaviors playing an important role (Strugar Jelača, Gašić, Bjekić, Alekić, & Marić, 2025). In the broader organizational context of Serbia, the research of Stojanović-Aleksić et al. (Stojanović-Aleksić, Stamenković, & Milanović, 2016) indicates that leadership styles differ according to leader gender. Another study (Stojanović Aleksić, Stanisavljević, & Bošković, 2016) examines the relationship between leadership styles and the quality of leader-follower relations and demonstrates that leadership styles characterized by greater involvement, support, and open communica-

tion are associated with higher-quality LMX relationships.

Research conducted by Nikolić and colleagues (Nikolić, Vukonjanski, & Terek, 2012) provides additional insight into the state of leadership in Serbian organizations. Findings showed that transactional leadership was slightly more pronounced than transformational leadership in Serbian companies, with High Performance Expectations and Contingent Punishment among the most pronounced leadership dimensions, while Supportive Leader Behavior and Contingent Reward were less pronounced. Subsequent findings showed statistically significant relationships between several leadership dimensions and financial performance under transition conditions in Serbia, with national origin and ownership structure moderating some of these relationships (Nikolić, Vukonjanski, Szabó, Nedeljković, & Terek, 2015). The 2011 study interpreted the observed pattern of weak supportive behavior and greater reliance on punishment within the broader context of transition conditions, economic crisis, and low employee living standards in Serbia. Leadership profiles also differed according to organizational origin and ownership: reward and supportive behaviors were most pronounced in foreign and private companies, where transactional leadership was strongest, whereas transformational leadership was most pronounced in domestic and state-owned companies, alongside weak leader support and elements of punishment-based transactional behavior (Nikolić, Vukonjanski, & Terek, 2012).

Emotional intelligence was positively associated with all examined leadership dimensions in organizations in Serbia, with a stronger association with aggregate transformational than transactional leadership (Vukonjanski Srdić, Miličić, & Pavlović, 2025). Most leadership dimensions were significantly associated with organizational commitment, while all examined leadership dimensions were positively associated with organizational innovation. ESG dimensions were positively associated with both outcomes, whereas external social capital was associated with organizational innovation but not with organizational commitment (Jovanović, Pavlović, & Vukonjanski Srdić, 2024). Together, these findings broaden the domestic empirical picture of leadership by linking leadership behaviors with emotional intelligence, organizational commitment, sustainability-related practices, and organizational innovation.

Overall, empirical research in Serbia highlights a broad range of leadership behaviors and their relationships with organizational and employee outcomes, as well as relational processes, across diverse organizational contexts.

METHODOLOGY

This study employed a repeated cross-sectional design comparing two independent samples of employees from organizations in Serbia surveyed in 2011 and 2025. The same leadership measurement instrument and response scale were used in both surveys, providing a consistent measurement basis for comparing perceived leadership behaviors across the two survey years. The two survey years correspond to the transition and post-transition periods examined in this study. The 2011 sample comprised 256 middle managers, whereas the 2025 sample comprised 455 employees, including both managers and non-managers. Both samples included respondents from domestic and foreign companies and from state-owned and private companies. In 2011, 67.6% of respondents were employed in domestic and 32.4% in foreign companies, while 46.1% were employed in state-owned and 53.9% in private companies. In 2025, the

corresponding proportions were 77.4% and 22.6% for domestic and foreign companies, and 27.7% and 72.3% for state-owned and private companies. The samples were drawn from the same national setting and included the same main categories of organizational origin and ownership, although their composition differed between the two survey years, particularly with respect to ownership structure. These compositional differences were considered when interpreting the between-sample results.

Measures

Transformational leadership was assessed using the Transformational Leadership Behavior Inventory (TLI), which was developed as a multidimensional measure of transformational leader behavior (Podsakoff P. , MacKenzie, Moorman, & Fetter, 1990). Initial and subsequent studies provided support for its factor structure, internal consistency reliability, and concurrent and discriminant validity (Podsakoff P. , MacKenzie, Moorman, & Fetter, 1990); (Podsakoff, MacKenzie, & Bommer, 1996); (MacKenzie, Podsakoff, & Rich, 2001). Articulating a vision, providing an appropriate model, and fostering the acceptance of group goals were found to be highly intercorrelated and were subsequently represented through the Core Transformational Leader Behavior construct (Podsakoff P. , MacKenzie, Moorman, & Fetter, 1990); (MacKenzie, Podsakoff, & Rich, 2001).

Transformational leadership was measured through four dimensions: Core Transformational Leader Behavior, High Performance Expectations, Supportive Leader Behavior, and Intellectual Stimulation. Core Transformational Leader Behavior reflects articulating a vision, providing an appropriate model, and fostering the acceptance of group goals. High Performance Expectations captures expectations for excellence and high performance, Supportive Leader Behavior reflects individualized support and attention to employees' feelings and needs, and Intellectual Stimulation captures behaviors that encourage employees to reconsider assumptions and approach their work in new ways. Transactional leadership was measured through two dimensions: Contingent Reward Behavior and Contingent Punishment Behavior. Contingent Reward Behavior reflects positive feedback and recognition contingent on performance, whereas Contingent Punishment Behavior reflects corrective responses contingent on inadequate performance (MacKenzie, Podsakoff, & Rich, 2001). Each dimension was assessed using a set of items referring to specific leader behaviors. Respondents indicated their level of agreement with these statements on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Aggregate transformational leadership (TF) and transactional leadership (TS) scores were calculated from the items comprising their respective dimensions. The dimensional scores were retained alongside the aggregate TF and TS measures, enabling comparisons of specific leadership behaviors as well as overall transformational and transactional leadership.

In Serbia, these leadership measures have been applied in previous studies examining leadership behaviors in different organizational settings (Nikolić, Vukonjanski, & Terek, 2012); (Nikolić, Vukonjanski, Szabó, Nedeljković, & Terek, 2015); (Vukonjanski Srdić, Miličić, & Pavlović, 2025); (Jovanović, Pavlović, & Vukonjanski Srdić, 2024). These applications provide prior evidence of their use in Serbian organizational research, with satisfactory internal consistency reported for the leadership dimensions in the available studies.

Data Analysis

Analyses were conducted using IBM SPSS 22. Descriptive statistics and Cronbach's alpha coefficients were calculated for all leadership measures in both samples. Correlation coefficients were examined separately for the 2011 and 2025 samples to describe the pattern of associations among the leadership dimensions. Between-sample differences in mean scores were tested using independent-samples t-tests. Cohen's *d*, calculated using the pooled within-group standard deviation, was used to assess the magnitude of the between-sample differences.

RESULTS

Table 1 presents the means, standard deviations, and Cronbach's alpha coefficients for all six leadership behavior dimensions and the aggregate transformational and transactional leadership measures in the 2011 and 2025 samples. Cronbach's alpha coefficients indicate satisfactory internal consistency across all measures in both samples.

Table 1. Descriptive statistics

Name	Abrv.	Mean		SD		α	
		2011	2025	2011	2025	2011	2025
Core transformational leader behavior	L1	4.53	4.12	1.78	1.51	.931	.890
High performance expectations	L2	5.47	4.50	1.49	1.40	.833	.818
Supportive leader behavior	L3	3.58	3.83	1.59	1.52	.871	.925
Intellectual stimulation	L4	4.14	3.95	1.80	1.40	.925	.905
Contingent reward behavior	L5	4.22	4.02	1.85	1.55	.878	.913
Contingent punishment behavior	L6	5.14	4.47	1.73	1.34	.883	.831
Transformational leadership	TF	4.35	4.07	1.26	1.16	.905	.922
Transactional leadership	TS	4.61	4.21	1.38	1.12	.794	.799

Source: Authors

Descriptive statistics showed that mean scores ranged from $M = 3.58$ for L3 to $M = 5.47$ for L2 in the 2011 sample and from $M = 3.83$ for L3 to $M = 4.50$ for L2 in the 2025 sample. L2 and L6 had the highest mean scores in both samples, whereas L3 had the lowest mean score in both samples. Compared with the 2011 sample, the 2025 sample showed lower mean scores for L1, L2, L4, L5, L6, TF, and TS, whereas L3 showed a higher mean. Among the individual leadership dimensions, the largest difference in mean scores was observed for L2 ($M = 5.47$ in 2011 and $M = 4.50$ in 2025), followed by L6 ($M = 5.14$ and $M = 4.47$, respectively). The aggregate TF and TS measures also showed lower mean scores in the 2025 sample. Standard deviations were lower across all leadership measures in the 2025 sample, indicating less dispersion in the observed scores than in the 2011 sample.

To examine the relationships among the leadership behavior dimensions, correlation analyses were conducted separately for the 2011 and 2025 samples. Table 2 presents the strength and direction of the associations among the transformational (L1–L4) and transactional (L5–L6) dimensions in each sample. Nearly all correlations were statistically significant in both samples, although their strength varied across the leadership dimensions.

Table 2. Correlation analysis

		L1	L2	L3	L4	L5	L6
2011	L1	1	.471**	.459**	.653**	.541**	.223**
	L2	.471**	1	.080	.334**	.240**	.388**
	L3	.459**	.080	1	.433**	.499**	-.003
	L4	.653**	.334**	.433**	1	.660**	.242**
	L5	.541**	.240**	.499**	.660**	1	.150*
	L6	.223**	.388**	-.003	.242**	.150*	1
2025	L1	1	.361**	.638**	.673**	.654**	.129**
	L2	.361**	1	.182**	.283**	.294**	.438**
	L3	.638**	.182**	1	.738**	.738**	.044
	L4	.673**	.283**	.738**	1	.756**	.160**
	L5	.654**	.294**	.738**	.756**	1	.136**
	L6	.129**	.438**	.044	.160**	.136**	1

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

Source: Authors

The strongest correlations in the 2025 sample were observed between L4 and L5 (r = .756), L3 and L4 (r = .738), and L3 and L5 (r = .738). In the 2011 sample, the strongest associations were observed between L4 and L5 (r = .660) and L1 and L4 (r = .653). Several correlation coefficients were higher in the 2025 sample, particularly L3–L4 (r = .433 in 2011 and r = .738 in 2025), L3–L5 (r = .499 and r = .738, respectively), L1–L3 (r = .459 and r = .638), and L1–L5 (r = .541 and r = .654). In contrast, several correlation coefficients were lower in the 2025 sample, including L1–L2 (r = .471 in 2011 and r = .361 in 2025), L1–L6 (r = .223 and r = .129), L2–L4 (r = .334 and r = .283), and L4–L6 (r = .242 and r = .160). With regard to the two transactional dimensions, the association between L5 and L6 was weak in both samples (r = .150 in 2011 and r = .136 in 2025). L6 showed comparatively weak associations with most transformational dimensions in both samples, while its strongest association among these dimensions was with L2 (r = .388 in 2011 and r = .438 in 2025). The association between L3 and L6 was not statistically significant in either sample.

Table 3. Between-Sample Differences in Leadership Measures

Mean		Group Statistics			Independent Samples Test						
		SD	SE	F	Sig.	t	df	p	MD	SE Diff.	
L1	2011	4.53	1.78	.12	18.48	.000	3.13	677	.002	.41	.13
	2025	4.12	1.51	.07			2.96	385.58	.003	.41	.14
L2	2011	5.47	1.49	.10	.30	.583	8.31	677	.000	.97	.12
	2025	4.50	1.40	.07			8.14	420.67	.000	.97	.12
L3	2011	3.58	1.59	.11	1.77	.184	–2.04	677	.042	–.26	.13
	2025	3.83	1.52	.07			–2.01	427.05	.045	–.26	.13

L4	2011	4.14	1.80	.12	34.77	.000	1.48	677	.140	.19	.13
	2025	3.95	1.40	.07			1.36	359.34	.175	.19	.14
L5	2011	4.22	1.85	.12	25.26	.000	1.42	677	.157	.19	.14
	2025	4.02	1.55	.07			1.34	380.84	.183	.19	.14
L6	2011	5.14	1.73	.12	29.25	.000	5.59	677	.000	.68	.12
	2025	4.47	1.34	.06			5.13	358.22	.000	.68	.13
TF	2011	4.35	1.26	.08	5.32	.021	2.84	677	.005	.28	.10
	2025	4.07	1.16	.05			2.76	412.20	.006	.28	.10
TS	2011	4.61	1.38	.09	16.21	.000	4.03	677	.000	.40	.10
	2025	4.21	1.12	.05			3.76	371.32	.000	.40	.11

Source: Authors

To assess the statistical significance of differences between the 2011 and 2025 samples, independent-samples t-tests were conducted for all leadership measures, with the results presented in Table 3. The analyses examined whether the observed differences in mean scores between the two samples were statistically significant.

The t-test results showed statistically significant between-sample differences for L1, L2, L3, L6, TF, and TS, whereas the differences for L4 and L5 were not statistically significant. L1 had a significantly higher mean in the 2011 sample than in the 2025 sample ($t(385.58) = 2.96$, $p = .003$). Among the individual leadership dimensions, the largest difference in mean scores was observed for L2 ($t(677) = 8.31$, $p < .001$), with a significantly lower mean in the 2025 sample. L3 had a significantly higher mean in the 2025 sample ($t(677) = -2.04$, $p = .042$). For L4, the difference between the two samples was not statistically significant ($t(359.34) = 1.36$, $p = .175$), despite the lower mean in the 2025 sample. Similarly, L5 did not show a statistically significant between-sample difference ($t(380.84) = 1.34$, $p = .183$), although its mean was also lower in the 2025 sample. L6 had a significantly higher mean in the 2011 sample ($t(358.22) = 5.13$, $p < .001$), with a mean difference of 0.68. At the aggregate level, transformational leadership was significantly higher in the 2011 sample ($t(412.20) = 2.76$, $p = .006$), with a mean difference of 0.28. Transactional leadership was also significantly higher in the 2011 sample ($t(371.32) = 3.76$, $p < .001$), with a mean difference of 0.40.

Table 4. Cohen's d Effect Sizes

Dimension	d
L1	0.25
L2	0.68
L3	–0.17
L4	0.12
L5	0.12
L6	0.45
TF	0.23
TS	0.33

Source: Authors

To assess the magnitude of the between-sample differences, Cohen's *d* was calculated for each leadership measure using the pooled within-group standard deviation. Values of .20, .50, and .80 were interpreted as small, medium, and large effects, respectively. The resulting effect sizes are presented in Table 4.

Among the statistically significant between-sample differences, L2 showed the largest effect and was the only individual dimension in the medium-effect range (d = .68). Small effects were observed for L1 (d = .25), L6 (d = .45), TF (d = .23), and TS (d = .33). Although the between-sample difference for L3 was statistically significant, its effect magnitude was below .20 (d = −.17). The effects for the non-significant differences in L4 and L5 were also below .20 (both d = .12).

DISCUSSION

The findings indicate selective differences in perceived leadership behaviors between the two independent samples surveyed in Serbia in 2011 and 2025. The largest difference among the individual leadership dimensions was observed for High Performance Expectations, which was significantly lower in the 2025 sample than in the 2011 sample. It was also the only individual leadership dimension with a medium effect size. This result indicates a lower perceived emphasis on high performance standards and expectations for employees in the 2025 sample. In the 2011 study, High Performance Expectations had the highest mean among the leadership dimensions, and managers were characterized as predominantly task- and result-oriented (Nikolić, Vukonjanski, & Terek, 2012). High Performance Expectations were positively associated with courtesy, but were also associated with greater role conflict and lower general satisfaction (Podsakoff, MacKenzie, & Bommer, 1996). Accordingly, the lower score observed in the 2025 sample should be interpreted as a lower perceived emphasis on High Performance Expectations, rather than as evidence that this difference was inherently positive or negative.

The significantly lower aggregate transformational leadership score in the 2025 sample indicates a lower perceived level of transformational leadership, although this pattern was not uniform across its individual dimensions. Core Transformational Leader Behavior was significantly lower in the 2025 sample than in the 2011 sample, whereas Intellectual Stimulation showed a lower mean in 2025 but no statistically significant between-sample difference. Treating Core Transformational Leader Behavior and Intellectual Stimulation separately is consistent with the behavioral operationalization in which they are modeled as distinct transformational leadership dimensions and have shown different relationships with follower outcomes (Podsakoff P. , MacKenzie, Moorman, & Fetter, 1990); (MacKenzie, Podsakoff, & Rich, 2001). Thus, the lower aggregate transformational leadership score should not be interpreted as evidence that all transformational leadership dimensions were lower in the 2025 sample.

At the aggregate level, perceived transactional leadership was significantly lower in the 2025 sample than in the 2011 sample, but this pattern was not uniform across its two dimensions. Contingent Punishment Behavior was significantly lower in the 2025 sample, whereas Contingent Reward Behavior showed a lower mean but no statistically significant between-sample difference. The 2011 study characterized transactional leadership in Serbian companies as slightly more pronounced than transformational leadership, with a relatively strong presence of contingent punishment and a lower level of contingent reward (Nikolić, Vukonjanski, & Terek, 2012). The

present comparison therefore provides evidence of a lower perceived level of punishment-based transactional behavior in the 2025 sample, but not of a statistically supported between-sample difference in contingent reward behavior.

Supportive Leader Behavior was the only individual leadership dimension with a significantly higher score in the 2025 sample than in the 2011 sample, indicating a higher perceived level of supportive leadership in the more recent sample. However, the between-sample difference was limited in magnitude and should therefore not be interpreted as substantial. In Serbian organizations, Supportive Leader Behavior has previously shown positive associations with organizational commitment and organizational innovation, although it did not emerge as a significant independent predictor in the regression models (Jovanović, Pavlović, & Vukonjanski Srdić, 2024).

Beyond these mean-level differences, the correlation matrices also show descriptive differences in the pattern of associations among leadership behaviors. Several associations involving Supportive Leader Behavior and Intellectual Stimulation were stronger in the 2025 sample, whereas other correlations were similar or lower than in 2011. Descriptive differences were also evident in several cross-style associations, particularly those linking Contingent Reward Behavior with transformational leadership dimensions, although this pattern was not uniform across all transformational–transactional relationships. Because differences between the correlation coefficients of the two independent samples were not formally tested, these patterns should not be interpreted as statistically confirmed changes in the interrelationships among leadership dimensions. They instead indicate descriptive variation in the configuration of associations across the two survey years.

The dimension-specific pattern does not support characterizing leadership in the 2025 sample as generally more support-oriented than in the 2011 sample. The distribution of effect magnitudes reinforces this interpretation: the most pronounced between-sample difference among the individual dimensions concerned High Performance Expectations, whereas the higher Supportive Leader Behavior score in 2025 represented a comparatively limited difference in magnitude. This pattern indicates that, in the present comparison, aggregate leadership measures may conceal heterogeneity among their constituent behaviors. Accordingly, the aggregate transformational and transactional leadership scores should be interpreted alongside their component dimensions rather than as evidence of uniform between-sample differences.

This study contributes to the literature on leadership by showing that statistically significant between-sample differences in aggregate transformational and transactional leadership do not imply uniform differences across their constituent behaviors. The joint examination of aggregate and dimensional results reveals a selective pattern that would not be captured by aggregate scores alone. The comparison also places these differences within the transition and post-transition periods of Serbia's socio-economic development, without attributing them directly to particular contextual changes. The organizational and societal factors underlying the observed between-sample differences were not measured in the present study and therefore cannot be identified from the repeated cross-sectional comparison. Because the two surveys involved independent samples, differences in sample composition may also have contributed to the observed between-sample differences and should therefore be considered when interpreting the comparison.

CONCLUSION

The findings indicate selective between-sample differences in perceived leadership behaviors rather than a uniform pattern across dimensions. The aggregate transformational leadership score was significantly lower in the 2025 sample than in the 2011 sample. The largest difference among the individual leadership dimensions was observed for High Performance Expectations, which was significantly lower in the 2025 sample than in the 2011 sample. It was also the only individual leadership dimension with a medium effect size, distinguishing it from the other statistically significant dimensional differences in terms of magnitude. This result indicates a lower perceived emphasis on high performance standards and expectations for employees in the 2025 sample. Core Transformational Leader Behavior was significantly lower in the 2025 sample than in the 2011 sample, whereas Intellectual Stimulation showed a lower mean but no statistically significant between-sample difference. Supportive Leader Behavior was the only individual transformational leadership dimension with a significantly higher score in the 2025 sample, although this difference was limited in magnitude. Accordingly, the lower aggregate transformational leadership score reflects dimension-specific differences rather than uniformly lower transformational leadership behaviors in the 2025 sample.

The aggregate transactional leadership score was significantly lower in the 2025 sample than in the 2011 sample. At the dimensional level, Contingent Punishment Behavior was also significantly lower, whereas Contingent Reward Behavior showed a lower mean but no statistically significant between-sample difference. Both statistically significant transactional leadership differences were small in magnitude. Beyond the mean-level differences, descriptive variation in the pattern of associations among leadership dimensions was observed across the two survey years. Because the correlation coefficients of the two independent samples were not formally compared, this variation should not be interpreted as evidence of statistically confirmed changes in the interrelationships among leadership dimensions. The combined pattern of results does not support characterizing leadership in the 2025 sample as generally more support-oriented than in the 2011 sample. Accordingly, the aggregate transformational and transactional leadership scores should be interpreted alongside their component dimensions rather than as evidence of uniform between-sample differences across leadership behaviors.

The contribution of this study lies in providing a repeated cross-sectional comparison of perceived leadership behaviors in two independent samples surveyed fourteen years apart, across Serbia's transition and post-transition periods, using the same measurement instrument. By examining aggregate and dimensional results jointly, the study provides a more differentiated account of between-sample differences than would be obtained from transformational and transactional leadership scores alone.

Future research should examine whether the observed between-sample differences remain when samples are more closely matched in terms of relevant employee and organizational characteristics. Such designs would reduce uncertainty about the extent to which sample composition contributes to the observed differences. Future studies could extend the present repeated cross-sectional comparison by directly measuring organizational and broader contextual conditions, enabling more explicit examination of factors associated with between-sample differences.

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https://doi.org/10.7251/EMC2603690T
UDK: 330.341.1:001.891/.892(100)
Datum prijema rada: 19. januar 2026.
Submission Date: January 19, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 690-701

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

VALUATION GIANTS: A MULTIVARIATE INVESTIGATION INTO THE RISE OF THE MAGNIFICENT SEVEN

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Abstract: *This study examines the factors determining market value in leading technology companies in terms of financial performance, capital structure, and investor sentiment. Using a fixed effects model, the relationships between market value and variables such as earnings per share (EPS), debt-to-equity ratio, return on equity (ROE), return on assets (ROA), price-to-book ratio, and return on investment (ROI) were analyzed. The findings indicate that EPS and ROI have a positive effect on market value, while the debt-to-equity ratio has a negative effect. This suggests that investors are sensitive to profitability increases and that perceptions of financial risk influence valuation. Interestingly, negative relationships were found between ROE, ROA, and market value, implying that high leverage or artificially inflated profits may be perceived as risk factors. R&D and SG&A expenditures were found to have no significant short-term impact. Overall, the results support that market valuation in large-cap technology companies is shaped not only by financial indicators but also by investor perceptions and growth expectations.*

Keywords: *Technology Companies, Investor Sentiment, Market Value, Financial Performance*

JEL Classification: *G12, G14, G17*

INTRODUCTION

In recent years, structural transformations in global financial markets have significantly increased the impact of large-scale companies operating in the technology sector on the economic and financial system. Technological developments such as dig-

italization, artificial intelligence, cloud computing, and automation directly shape not only business models but also company valuations, investment decisions, and capital flows. One of the most notable reflections of this transformation is the increasing influence of seven major technology companies listed on the US stock Exchange, known as the "Magnificent Seven" (Apple, Microsoft, Alphabet, Amazon, Nvidia, Meta Platforms, and Tesla), on financial markets.

As of 2023, these companies have reached a very high share of the total market capitalization of major indices such as the S&P 500 and Nasdaq 100. This situation increases concentration risk in capital markets and indicates that the performance of these companies has become critical enough to determine the direction of broad market indices (Holder & Almada, 2025: 83). At the same time, this structure necessitates a reassessment of issues such as market imbalances, the influence of major players, and systematic risk in financial analysis.

This study aims to explain the financial performance of the companies known as the "Magnificent Seven," their impact on the stock market, and their relationship with investor behavior. In addition, the study will analyze the key financial dynamics, macroeconomic conditions, and forward-looking risk factors underlying the rise of these companies in capital markets.

LITERATURE REVIEW

In today's global economy, a few giant corporations possess the potential to shape its overall direction. The influence of these technology-driven conglomerates extends beyond financial markets, manifesting also in the digital transformation of societies in line with their growing interest in technology. In this context, the group commonly referred to as the "Magnificent Seven", Apple, Microsoft, Amazon, Alphabet (Google), Meta, Tesla, and Nvidia, has become the focal point of attention for both investors and economists in recent years. These companies stand out not only for their substantial market capitalization but also for their capacity for innovation, investments in artificial intelligence, and strategic initiatives that drive the evolution of technology.

Table 1. Literature Review on Firm Value

Author(s)	Research Topic	Methodology	Key Findings
Bui vd. (2023).	The relationship between capital structure and firm value has been examined for companies listed on the Vietnam Stock Exchange.	Data from 769 companies listed on the Ho Chi Minh and Hanoi Stock Exchanges between 2012 and 2022 were analyzed, examining ROA, ROE, and Tobin's Q using OLS, FEM, REM, and GLS regression analyses.	The findings indicate that long-term debt does not significantly affect firm value, whereas short-term debt has a negative impact. Both short-term and long-term debt ratios adversely influence ROA, ROE, and Tobin's Q, with the most pronounced effect observed on the decline of Tobin's Q. Therefore, it is essential for firms to regularly review and assess their current investments, enabling managers to make informed decisions and optimize overall organizational performance.
Nenkov D. (2024)	The impact of the "Magnificent Seven" technology companies on the S&P 500 stock market performance has been examined.	A comparative analysis method was employed using key financial indicators, including EPS, ROE, PE, and PBV ratios.	High price-to-earnings (P/E) and price-to-book value (PBV) ratios indicate that these stocks are not supported by their fundamental indicators. This suggests that market sentiment may be driven by speculative behavior rather than actual financial performance.

Peprah et al. (2024).	The pre- and post-COVID-19 pandemic stock prices, managerial efficiency, and economic value added (EVA) of the "Magnificent Seven" companies have been examined.	Using data from 2016 to 2023, an intra-group ANOVA analysis was conducted, and EVA calculations were performed using the Stern-Stewart formula.	The pandemic period was observed to have a positive impact on the decision-making processes of the "Magnificent Seven" management teams. The use of artificial intelligence, operational agility, and innovation emerged as key factors for enhancing managerial efficiency. It was also suggested that EVA serves as a reliable measure for assessing a company's financial performance and managerial effectiveness during periods of uncertainty.
Eteman, (2024).	The speculative bubble effect of artificial intelligence on the stocks of the "Magnificent Seven" has been examined.	The GSADF test and volatility spillover analyses have been conducted on the stocks.	Among the "Magnificent Seven" stocks, Nvidia and Tesla have exhibited AI-driven speculative bubbles, which may contribute to increased volatility in other companies. It is suggested that policymakers could mitigate these speculative effects through the implementation of new regulations.
Adip et al. (2024).	The relationship between financial performance and firm value has been examined for the highest market capitalization technology companies listed on the IDX stock exchange.	Using stock market data from 2018 to 2022, the analysis was conducted employing SPSS and multiple regression methods.	It has been demonstrated that financial performance is positively related to firm value and has a significant impact on financial distress in technology companies. At the same time, the relationship between PD/DD and financial distress does not produce clear market reflections, confirming that the Indonesian stock market remains in a semi-efficient state.
Plagge and Rowley, (2024).	The dominant role of the "Magnificent Seven" in the U.S. (Russell 3000) stock market has been examined, along with performance comparisons and the strategic value of portfolio diversification.	The period from 2000 to 2023 was divided into twelve two-year subperiods, and alternative portfolio simulations were conducted excluding the top and bottom 10 performing stocks in each subperiod. The performance of large- and small-cap stocks was evaluated through correlation analysis using FactSet data.	During the 2000–2013 period, excluding the lowest-performing stocks increased returns by 1–2%, reflecting small-cap outperformance. However, from 2014 onward, particularly under the dominance of the Magnificent Seven, excluding the top contributors led to a 1–2% (and in some cases up to –5%) loss, while large-cap stocks achieved a 5% outperformance. This cyclical pattern indicates that the weighting of large-cap stocks amplifies returns, making active management and market timing more challenging.
Benham et al. (2024).	This study examines the increasing dominance of seven large-cap technology stocks in the U.S. market, assessing their contributions to recent market returns, their similarities to the Dot-Com Bubble period, and the potential risks associated with market concentration.	Using FactSet data from 1986 to 2023, it tracks the weight and return contributions of the "Magnificent Seven" and the top 10 stocks in the Russell 3000 index.	As of December 31, 2023, the "Magnificent Seven" accounted for 22% of the Russell 3000 index, contributing nearly all gains from January to October 2023, with their impact diminishing in November and December. This concentration has reached historical peaks—similar to the Dot-com Bubble—with the 1986 average at 17%, and technology weights surpassing those of the Dot-com era. Low debt-to-income ratios, long-term debt structures, and a low-interest-rate environment have mitigated cash flow issues. However, historically, market leadership shifts through "creative destruction," with the top 10 stocks' weights declining over a ten-year horizon. Although such changes have slowed in recent years, the Magnificent Seven may not be able to maintain their growth and dominance in the face of trends like artificial intelligence.

Jandhyala, (2025).	The stock market reactions following the earnings announcements of the seven major companies have been examined.	Earnings reports, trading volume, price reaction, and short-term volatility of the stocks were combined to construct the Composite Behavioral Curve (CBC).	The study demonstrates that stock trading exhibits specific and predictable patterns in response to significant announcements, with complex group dynamics shaping these reactions. Market movements are therefore far from random, unfolding within measurable and analyzable structures. For example, reaction patterns for stocks such as Apple and Amazon are relatively clear and repeatable, whereas responses for other companies, like Microsoft, are more variable, reflecting different aspects of crowd dynamics.
Krause, (2025).	The potential effects of the artificial intelligence system "DeepSeek," developed by China, on the "Magnificent Seven" have been examined.	The analysis was conducted using the Gordon Growth Model (GGM).	The decline in long-term growth expectations has been shown to significantly reduce the projected stock prices of these companies. Furthermore, their high sensitivity to changes in growth assumptions indicates that AI-driven competition can substantially shape market valuations and long-term investor expectations. Infrastructure providers such as Nvidia and Microsoft are highlighted as facing greater risks from cost-efficient AI models, whereas application leaders like Meta and Tesla may encounter longer-term challenges in maintaining high-quality AI services.
Bruneau, (2025).	This study analyzes the temporal dimension and market-implied correlations among the "Magnificent Seven" technology stocks, investigating their implications for portfolio optimization and risk management.	Correlations were calculated using the Pearson correlation coefficient with a two-year rolling window applied to daily return series. Market correlations were derived from S&P OTC derivative data using volatility indices and basket option prices, standardized with the "correlation shift" metric (α), and trends for the 2020–2024 period were analyzed.	Market-implied correlations contain an average premium of 12 points compared to historical values, with a contraction observed during the COVID-19 period (8.9 points) and a peak in 2022 (14.6 points). Tesla-focused pairs, however, are dominated by low-correlation patterns. The distribution of correlations has increased by 50%, and the implied values hold strategic significance for risk mitigation and derivatives trading, with the potential to create differences exceeding 10% in basket option premiums.
Umar et al., (2025).	It examines the return and volatility spillovers among the "Magnificent Seven" technology giants, focusing on asymmetric linkages under different market conditions.	Using the quantile connectedness approach (QVAR), daily stock returns and volatility spillovers between 2012 and 2024 were analyzed under different market conditions—bull, normal, and bear—through quantile-based modeling.	A high degree of connectedness among the companies has been observed, with large-cap firms (e.g., Alphabet and Microsoft) acting as net volatility transmitters, while smaller-cap firms (e.g., Tesla and Meta) serve as net receivers. Inter-quantile asymmetry becomes particularly pronounced during left-tail events, and idiosyncratic shocks amplify systemic risks. These findings provide critical insights for policymakers, investors, and regulators in developing risk management strategies.

Sahani, (2025).	It presents a comparative analysis of the major stocks in the S&P 500 index, examining macroeconomic impacts such as the COVID-19 pandemic, inflation, interest rate fluctuations, and the rise of artificial intelligence.	Based on annual firm-level data from Refinitive DataStream for 2014–2024, growth stocks were classified as those with an average P/E > 15, and value stocks as those with P/E ≤ 15. Analyses included the calculation of nominal and inflation-adjusted compound annual growth rates (CAGR), annual return comparisons, independent sample t-tests, and multiple linear regression models.	Although growth stocks significantly outperform value stocks in terms of long-term nominal CAGR (average 11.48% vs. 6.86%, p=0.0004) and real CAGR (average 8.36% vs. 3.87%, p=0.0004), annual return differences are not statistically significant. Regression results indicate that P/E and P/CF ratios are significant positive predictors of both nominal and real CAGR, though their explanatory power remains limited, while the P/B ratio is not significant. Growth stocks exhibit higher volatility and valuation ratios, suggesting that the technology-driven contribution of the "Magnificent Seven" necessitates a reevaluation of value investment strategies.

Source: Prepared by the authors based on the studies cited in the reference list

In recent years, the relationship between capital structure, firm value, and the market impact of technology companies has emerged as an important area of research in the financial literature. Bui et al. (2023) analyzed data from 769 firms listed on the Vietnam Stock Exchange between 2012 and 2022, revealing that short-term debt negatively affects firm value, whereas long-term debt has a limited impact. Similarly, Adip et al. (2024) identified a positive relationship between financial performance and firm value in Indonesia's information technology sector, while noting that the market remains semi-efficient. These studies indicate that, in emerging markets, the link between financial structure and performance is complex and highly dependent on country-specific dynamics.

Studies focusing on the technology sector particularly examine the dominant market influence of large-cap technology companies collectively known as the "Magnificent Seven." Nenkov (2024) highlights that the high P/E and P/B ratios of these stocks are not fully supported by fundamental indicators, drawing attention to speculative elements in market valuations. Benham et al. (2024) find that these companies account for 22% of the Russell 3000 index and contributed the majority of gains in 2023. Plagge and Rowley (2024) demonstrate that, between 2000 and 2023, the influence of large-cap stocks on returns has increased, complicating active portfolio management. Sahani (2025) compares growth and value stocks, showing that growth-oriented technology equities achieve higher long-term compound growth rates, albeit with increased volatility.

Research focusing on the impact of artificial intelligence has identified notable effects on technology stocks. Eteman (2024) detected AI-driven bubbles in Nvidia and Tesla shares, while Krause (2025) demonstrated that China's "DeepSeek" model could weaken the long-term growth expectations of these companies, thereby reducing their stock values. Both studies emphasize that AI-driven competition represents both an opportunity and a risk factor in market valuations.

Post-pandemic studies on managerial efficiency and investor reactions indicate significant patterns. Peprah et al. (2024) report that economic value added (EVA) increased in the "Magnificent Seven" companies, with artificial intelligence, operational agility, and innovation supporting managerial effectiveness. Jandhyala (2025) finds that stock movements following earnings announcements in these companies exhibit predictable behavioral patterns.

Findings on market correlation and volatility point to systemic risk implications. Bruneau (2025) reports that implied correlations among the "Magnificent Seven"

stocks increased by 50% between 2020 and 2024, while Umar et al. (2025) show that Alphabet and Microsoft act as volatility transmitters, whereas Tesla and Meta serve as volatility receivers. These results indicate that the interactions of large-cap technology stocks amplify systemic risks within the market.

Overall, the literature addresses financial performance, firm value, market concentration, the impact of artificial intelligence, and volatility dynamics in a multidimensional manner, demonstrating that market movements have become increasingly dependent on the strategic decisions of a small number of large technology companies and investor sentiment. This study aims to investigate the firm-specific financial values underlying the rapid attainment of high market capitalization by the companies collectively known as the "Magnificent Seven."

DATA SET AND METHODOLOGY

In recent years, a group of large-scale, technology-oriented companies known as the "Magnificent Seven" have gained a remarkable position in global financial markets, both in terms of investor interest and their influence on capital markets. These companies stand out not only for their high market valuations but also for their innovative product and service portfolios, investments in digital infrastructure, and expenditures on research and development (R&D). Moreover, due to their leading role in strategic areas such as digitalization, artificial intelligence, and e-commerce, these companies are frequently and prominently represented in growth-oriented portfolios. In this context, the scope of the study encompasses seven U.S.-based technology giants: Apple Inc., Microsoft Corporation, Alphabet Inc., Amazon Inc., NVIDIA Corporation, Meta Platforms Inc., and Tesla Inc. The data set for all seven companies has been prepared and made suitable for analysis. In this context, annual data for the variables specified in Table 1, covering an 11-year period from 2014 to 2024, have been included in the analysis. A balanced panel data model has been constructed, as each unit included in the analysis is observed throughout the entire time period.

Table 2. Descriptions of the Variables

Variable name	Abbreviation	Explanation	Source
Market Cap	MC	Calculated by multiplying the number of a company's publicly traded shares by the market price per share.	Oberlo.com
Research and Development Expenses	RD	Annual Research and Development Expenses (Millions of US $)	Macrotrends.net
Selling, General, and Administrative expenses	SG&A	Annual SG&A Expenses (Millions of US $)	Macrotrends.net
Earnings per Share	EPS	Annual EPS	Macrotrends.net
Current Ratio	CR	Company's ability to pay short-term obligations	Macrotrends.net
Dept to Equity Ratio	D/E	A measure of a company's financial leverage calculated by dividing its long-term debt by stockholders' equity.	Macrotrends.net
Return on Equity	ROE	The amount of net income returned as a percentage of shareholders equity.	Macrotrends.net
Return on Assets	ROA	As an indicator of how profitable a company is relative to its total assets	Macrotrends.net

Return on Investment	ROI	It is calculated by taking the difference between the return and the cost of the investment, and dividing that difference by the cost.	Macrotrends.net
Employee Count	EC	Annual worldwide employee count	Macrotrends.net
Price/Book Ratio	P/B	Latest closing price and dividing it by the most recent earnings per share	Macrotrends.net

Source: Prepared by the authors based on the relevant literatüre

Descriptive statistics for the variables used in the study are presented in Table 3. Accordingly, the company with the highest market value is Apple Inc., while the one with the lowest is NVIDIA Corporation. The company with the highest expenditures in Research & Innovation investments as well as Marketing and Sales expenses has been identified as Amazon Inc. While Apple Inc. holds the highest value in terms of EBITDA, the company with the highest earnings per share stands out as Meta Platforms Inc.

Table 3. Descriptive Statistics

Variable	Observation	Mean	Standard Deviation	Minimum Value	Maximum Value
MC	77	972.4204	879.349	10.89	3489
RD	77	18.51953	18.66462	.465	88.544
SG&A	77	24.15555	31.36819	.436	153.771
EPS	77	3.42961	4.191664	-.79	23.86
CR	77	3.13039	2.743375	.83	12.92
D/E	77	1.596104	1.521127	.1	6.45
ROE	77	.3017312	.3901676	-.901	1.6345
ROA	77	.1437688	.12247	-.125	.7786
ROI	77	.2519182	.234363	-.237	1.1365
EC	77	211519	368657.9	6384	1608000
PB	77	13.26974	11.50498	2.41	56.28

Source: Authors' calculations based on the study data

Since the study covers variables from seven companies over an 11-year data set, it constitutes a panel data structure in both the cross-sectional and time dimensions. Therefore, panel data analysis has been carried out in the study. The model constructed in this context is presented below.

$$MCit = \alpha it + \beta 1RDit + \beta 2SGAit + \beta 3EPSit + \beta 4CRit + \beta 5D/Eit + \beta 6ROEit + \beta 7ROAit + \beta 8ROIit + \beta 9ECit + \beta 10PBit + uit$$

ANALYSIS AND FINDINGS

The correlation matrix numerically illustrates the linear relationships between the dependent and independent variables. In cases where there is a high correlation between two or more independent variables, the problem of multicollinearity may arise, which can complicate the interpretation of regression coefficients and reduce the reliability of the model. Therefore, it is extremely important to examine the correlation matrix before beginning the analysis of the model in panel data.

Table 4. Correlation Matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) lnRD	1.000									
(2) lnSGA	0.9394	1.000								
(3) EPS	0.5310	0.4138	1.000							
(4) CR	-0.2838	-0.4162	-0.0710	1.000						
(5) D/E	-0.1377	0.0143	-0.2546	-0.5614	1.000					
(6) ROE	0.3839	0.2213	0.2829	-0.0743	0.0370	1.000				
(7) ROA	0.2390	-0.0016	0.3372	0.2287	-0.3905	0.7416	1.000			
(8) ROI	0.3323	0.1723	0.2635	-0.1078	-0.0933	0.8013	0.7558	1.000		
(9) EC	0.5391*	0.6066	-0.0256	-0.3373	0.1364	-0.0361	-0.2029	-0.0791	1.000	
(10) PB	-0.0882	-0.1375	-0.1056	-0.2402	0.5185	0.5390	0.3364	0.4436	-0.0326	1.000
Mean VIF: 3.26										

Source: Authors' calculations based on the study data

Upon examining the matrix, it is observed that the correlation between some variables is relatively high. However, the correlations between most pairs of variables are low to moderate, and the VIF value of 3.26 is relatively low, as it is generally expected to be below 10 (Neter et al., 2004; O'Brien, 2007), indicating that there is no multicollinearity problem. After this stage, it is possible to proceed with the analyses.

Before testing the fundamental assumptions, it is necessary in econometric analyses to choose between the fixed effects model and the random effects model. According to the results of the Hausman test conducted in this context ($Chi^2 = 37.5$; p-value = 0.000), in other words, since $p < 0.05$, it was concluded that the fixed effects model is the appropriate model for the analysis. The Pesaran test was conducted to examine whether there is cross-sectional dependence, that is, whether a variable in one unit affects another unit. According to the findings obtained ($Chi^2 = 0.299$; p-value = 0.7651) ($p > 0.05$), the null hypothesis (H_0) is accepted, indicating that there is no correlation between the units. In this case, when testing for stationarity, first-generation unit root tests should be employed (Yerdelen Tatoğlu, 2016: 230). The results of the Levin, Lin, and Chu panel unit root test conducted for this purpose are presented in Table 5.

Table 5. Levin, Lin, and Chu Panel Unit Root Tests

lnPD	lnRD	lnSGA	EPS	CR	D/E	ROE	ROA	ROI	EC	PB
0.0908	0,000	0,000	0,8895	0,0231	0,1385	0,0012	0,1221	0,2839	0,1235	0,1414

Source: Authors' calculations based on the study data

According to the LLC test results, the variables lnRD, lnSGA, CR, and ROE are stationary at level ($p < 0.05$). However, the variables EPS, D/E, ROA, ROI, EC, and PB are not stationary. Therefore, the first differences of these variables should be taken, or alternative stationarization methods should be applied before including them in the model. Accordingly, after differencing, stationarity was tested again, and the results presented in Table 6 were obtained.

Table 6. Levin, Lin, and Chu Panel Unit Root Tests (First Difference)

lnPD	lnRD	lnSGA	EPS	CR	D/E	ROE	ROA	ROI	EC	PB
0,0000	0,0000	0,0000	0,0000	0,0231	0,0000	0,0012	0,0000	0,0000	0,0000	0,0000

Source: Authors' calculations based on the study data

According to the repeated Levin, Lin, and Chu panel unit root test results, the variables that were non-stationary at level became stationary at the 1% significance level after taking the first difference. Therefore, at this stage, it is possible to test the fundamental assumptions. For this purpose, heteroskedasticity across units was examined using the Modified Wald Test, testing the null hypothesis (H_0: the variances are homoskedastic across units). If the p-value is less than 0.05, the null hypothesis (H_0) is rejected, indicating the presence of heteroskedasticity (Tatoğlu, 2016: 221). Subsequently, the presence of autocorrelation was tested using the Durbin-Watson Test developed by Bhargava, Franzini, and Narendranathan. Although critical values for this test are not provided in the literature, a value below 2 is interpreted as indicating significant autocorrelation (Yerdelen Tatoğlu, 2016: 226). The results of the tests described above are presented in Table 7.

Table 7. Fundamental Assumption Tests of the Fixed Effects Model

Heteroskedasticity (Modified Wald Test)	Autocorrelation (Durbin-Watson Test)
Prob>chi2 = 0.0000	Durbin-Watson = 2.5513469 Baltagi-Wu LBI = 2.7015317
H_0: No Heteroskedasticity	If the values are below 2, autocorrelation is present.

Source: Authors' calculations based on the study data

As a result of the assumption tests applied to the fixed effects model, a heteroskedasticity problem was detected in the model ($p < 0.01$). However, it is understood that there is no autocorrelation ($DW > 2$). In this context, the standard errors used in the analysis must be calculated robustly, and the model estimates should be interpreted accordingly.

The Huber, Eicker, and White estimator is used to obtain pooled ordinary least squares regression with heteroskedasticity-robust standard errors (Yerdelen Tatoğlu, 2016: 253). In this case, the Huber, Eicker, and White estimator was employed as a fixed effects model with robust standard errors, which prevents misleading t-tests and incorrect p-values that could result from the heteroskedasticity problem identified in this study. The final model results obtained in this context are presented in Table 8.

Table 8. Panel Regression Analysis Results Using the Huber, Eicker, and White Estimator

Market Cap (Ln)**	Coef Robust	Std. Hata	t	p>t
lnRD	-.0546887	.1823219	-0.30	0.774
lnSGA	-.0471879	.1653454	-0.29	0.785
dEPS***	.0885435	.0196669	4.50	0.004*
dD/E	-.2658457	.0264486	-10.05	0.000*
CR	.0023329	.0153806	0.15	0.884
ROE	-.2354256	.0318729	-7.39	0.000*

dROA	-.8086735	.307009	-2.63	0.039*
dROI	.1209419	.0613703	1.97	0.096
dEC	4.23e-07	2.46e-07	1.72	0.137
dPB	.0603773	.0046328	13.03	0.000*
Cons	1.847444	.6666391	2.77	0.032

*It refers to the variables that are significant at the 0.05 level
**(ln): It denotes the values that have been transformed using the natural logarithm function for analytical purposes
***d: It indicates that the first difference of the variable has been taken to achieve stationarity
Source: Authors' calculations based on the study data

According to the results of the fixed effects model, earnings per share, debt-to-equity ratio, ROE, ROA, and price-to-book ratio significantly explain the variation in the market value of the companies. In contrast, the effects of RD and SG&A expenditures were found to be insignificant; this suggests that such strategic expenditures may not have a short-term impact on market value. To summarize these findings briefly, a one-unit increase in earnings per share leads to an average increase of 8.85% in the logarithm of the company's market value. In other words, it can be stated that investors reward companies that increase their earnings per share with a higher market value. Indeed, this phenomenon corresponds to what is referred to in the literature as "market sensitivity". In particular, the negative effect of the debt ratio indicates that vulnerabilities in the financial structure influence investor perception. A one-unit increase in the debt-to-equity ratio results in an average decrease of 26.6% in the logarithm of the company's market value. This indicates that as the company's risk level increases, investors behave more cautiously, thereby lowering the valuation. The most striking finding is the significant and negative relationship between ROE and market value. According to classical finance theory, as return on equity increases, a company's performance and investor value are expected to rise. However, the findings show that a one-unit increase in ROE decreases the logarithm of market value by 0.23 units. Although this may initially appear contrary to theory, it would be appropriate to examine these companies' debts and equity in detail to clarify the situation. Indeed, in some cases, companies may artificially boost ROE by keeping equity low and increasing debt. This situation can be perceived as a risk by investors, thereby reducing the market value. Similarly, a significant and strongly negative relationship has been identified between ROA and market value. Since a very high ROA may have been perceived by investors as indicating that the company is deprioritizing growth, expectations for future market value could have decreased. ROI, which represents the return on investment, is statistically significant at the 10% significance level. This indicates that, holding other variables constant, a one-unit increase in ROI leads to an average increase of approximately 0.12 units in lnMV, the logarithm of the company's market value. In other words, it can be stated that companies with higher investment returns also experience positive responses in terms of market value.

CONCLUSION AND RECOMMENDATIONS

This study examines the financial factors determining the market value of large-cap technology companies and compares them with existing findings in the literature. As highlighted in previous research, financial performance, market concentration, the impact of artificial intelligence, and investor sentiment emerge as critical factors in

understanding the market valuation of leading technology firms, particularly those known as the "Magnificent Seven" (Nenkov, 2024; Sahani, 2025; Bruneau, 2025).

The research findings indicate that earnings per share (EPS), debt-to-equity ratio, ROE, ROA, and price-to-book ratio significantly influence the market value of companies. The positive impact of EPS on market value aligns with the well-documented concept of "investor sensitivity" and profit-oriented reward mechanisms in the literature. Conversely, the negative effect of the debt-to-equity ratio demonstrates that financial vulnerabilities reduce investor perception and, coupled with increased risk, lower company valuations. This finding parallels debt sensitivity observed in emerging markets, as reported by Bui et al. (2023) and Adip et al. (2024).

Another noteworthy finding is the negative relationship between ROE and ROA with market value. According to classical finance theory, increases in equity and asset profitability are expected to enhance valuation; however, the results obtained contradict this expectation. This can be explained by strategic decisions in which companies artificially elevate ROE by maintaining low equity and increasing leverage, which investors perceive as a risk factor. Similarly, a high ROA may be interpreted by investors as indicating limited growth and reinvestment potential. The positive and significant effect of ROI confirms that investment returns constitute an important factor supporting market valuation.

The insignificant results regarding strategic expenditures (R&D and SG&A) suggest that such spending may have a limited direct effect on market value in the short term. This finding aligns with the managerial effectiveness and long-term investment impacts highlighted by Peprah et al. (2024) and Jandhyala (2025), indicating that the market has not yet fully priced short-term strategic expenditures.

Overall, this study both confirms the relationships between market sensitivity and financial performance emphasized in the literature and reveals findings that deviate from certain classical finance theory expectations. In particular, the negative relationships observed for ROE and ROA indicate that investors assess financial structure and growth potential holistically, and that market valuation cannot be explained solely by profit indicators. Consequently, the rapid attainment of high market values by large-cap technology companies is determined not only by fundamental performance metrics such as earnings and ROI but also by investor perception, debt structure, and strategic risk management.

Despite providing valuable insights into the financial determinants of market value in large-cap technology companies, this study has several limitations. First, the analysis is based on a specific set of companies commonly referred to as the "Magnificent Seven," which may limit the generalizability of the findings to other sectors or smaller firms. Second, the study primarily relies on traditional financial metrics (EPS, ROE, ROA, ROI, debt ratios, price-to-book), while non-financial factors such as corporate governance, innovation culture, and environmental, social, and governance (ESG) considerations were not incorporated. Third, the data period may not fully capture long-term structural shifts in the technology sector, especially in light of rapidly evolving AI-driven business models.

Future research could expand on this study by including a broader range of technology companies across different market capitalizations and regions. Integrating non-financial indicators and sentiment analysis from investor communications or so-

cial media could provide a more holistic understanding of market valuation drivers. Additionally, longitudinal studies that track post-pandemic market dynamics and the long-term effects of strategic investments, such as R&D, would help clarify the temporal impact of these expenditures on market value.

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https://doi.org/10.7251/EMC2603702S
UDK: 613.86-057.16:[005.96:614.2
Datum prijema rada: 20. januar 2026.
Submission Date: January 20, 2026
Datum prihvatanja rada: 2. septembar 2026.
Acceptance Date: September 2, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 702-718

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

CONFLICT AND AMBIGUITY AS MEDIATORS BETWEEN JOB CREEP AND EMPLOYEE VOICE

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Abstract: *The aim of this study is to examine the effect of job creep on employee voice and the mediating roles of role conflict and role ambiguity. Using a quantitative relational survey design, data were collected through questionnaires from 393 healthcare employees at Karaman Hospital. Reliability, frequency, and correlation analyses were conducted using IBM SPSS; confirmatory factor analysis was performed with IBM SPSS AMOS; and mediation analyses were carried out using Hayes' Process Macro Model 4. The results indicate that job creep significantly increases both role conflict and role ambiguity. In addition, role conflict and role ambiguity have positive effects on employee voice. Together, job creep, role conflict, and role ambiguity explain a substantial proportion of the variance in employee voice. Mediation analyses further revealed a significant indirect effect of job creep on employee voice, indicating that role conflict and role ambiguity partially mediate this relationship at a low level.*

Keywords**:** *Job Creep, Employee Voice, Role Conflict, Role Ambiguity, Healthcare Workers.*

JEL classification: *D23, M10, M12*

INTRODUCTION

In contemporary work settings, the increasing flexibility, ambiguity, and incremental broadening of job descriptions often lead to misalignments between employees' actual responsibilities and organizational expectations. One prominent manifestation of this phenomenon is job creep, which describes the gradual normalization of additional tasks that employees initially undertake on a voluntary basis but that later become implicitly embedded in their formal roles (Van Dyne & Ellis, 2004). This dynamic can be meaningfully interpreted through Role Theory, which posits that unclear, inconsistent, or competing role expectations disrupt individuals' ability to perform effectively

within organizations (Kahn et al., 1964). Both classical and contemporary studies consistently demonstrate that role conflict and role ambiguity are strongly associated with adverse outcomes, including burnout, reduced job satisfaction, heightened turnover intentions, and diminished performance (Rizzo et al., 1970; Örtqvist & Wincent, 2006). These role-related stressors tend to be particularly pronounced in high-demand sectors such as healthcare, where emotionally charged tasks and time-sensitive decision-making are common, thereby intensifying employees' experiences of emotional exhaustion (Mwakyusa & Mcharo, 2024).

Role-related stressors also shape how employees communicate and engage within organizational settings. Employee Voice refers to employees' discretionary expression of constructive ideas, concerns, or suggestions intended to support organizational improvement (Morrison, 2014). However, voice behavior is likely to diminsin in contexts characterized by uncertainty and role conflict, as employees may fear that speaking up could overstep role boundaries, expose them to interpersonal or professional risks, or trigger negative reactions. Such concerns are especially salient when role expectations are ambiguous or when employees face competing demands (Tangirala & Ramanujam, 2008). Empirical evidence further indicates that role conflict undermines job satisfaction and work motivation, which in turn weakens employees' willingness to engage in voice behaviors (Jawahar et al., 2023; Rizzo et al., 1970; Örtqvist & Wincent, 2006). In contrast, supportive leadership practices and psychologically safe work environments can buffer these negative effects by fostering trust and encouraging employees to share their views openly (Qi & Liu, 2017; Soyalina & Karabey, 2020; Jabbar, Haider & Qureshi, 2023).

Within this framework, the literature reveals a notable gap in empirically testing an integrative model that explains how job creep influences employee voice through the mechanisms of role conflict and role ambiguity. Research on job creep has largely concentrated on outcomes such as increased workload, extra-role behaviors, and burnout (Van Dyne & Ellis, 2004), whereas studies on employee voice have predominantly examined antecedents including leadership practices, psychological safety, and organizational climate (Morrison, 2014). Despite this separation, prior work provides indirect evidence that the subtle expansion of job responsibilities and escalating job demands obscure role boundaries, thereby heightening role conflict and role ambiguity (Jackson & Schuler, 1985). Accordingly, examining the effects of job creep on employee voice via these role-related stressors offers a meaningful contribution by addressing an important theoretical and empirical gap in the literature. Moreover, analyses conducted within the healthcare context are expected to yield valuable practical insights for clarifying task allocation and reinforcing organizational communication channels.

Accordingly, this study seeks to investigate the mediating roles of role conflict and role ambiguity in the relationship between job creep and employee voice within the healthcare sector, a context characterized by its dynamic structure and continuously evolving conditions. The findings are expected to offer valuable insights into improving task allocation processes and strengthening organizational communication channels. In this respect, the first section of the study outlines the concepts of job creep, employee voice, role conflict, and role ambiguity within a theoretical framework and evaluates the relationships among these variables based on the existing literature. The second section details the research methodology, followed by the presentation of

empirical findings in the third section. Finally, the concluding section discusses the results, offers recommendations for practice, and emphasizes the study's theoretical contributions.

CONCEPTUAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

Job Creep

Job creep refers to the process through which additional tasks that employees initially undertake on a voluntary basis are gradually absorbed into their routine job responsibilities over time (Van Dyne & Ellis, 2004). This process often results in a misalignment between employees' assumed roles and organizational expectations, thereby contributing to increased workload and strain. Job creep typically emerges from the progressive blurring, flexibilization, and expansion of job descriptions, conditions that can generate stress related to both task execution and broader organizational roles (Kahn et al., 1964).

From the perspective of Role Theory, job creep can be interpreted as a salient indicator of role conflict and role ambiguity. When role expectations are unclear or contradictory, employees' functional behaviors are disrupted, leading to adverse outcomes such as heightened burnout, reduced job satisfaction, and stronger intentions to leave the organization (Rizzo et al., 1970; Örtqvist & Wincent, 2006). These effects are particularly pronounced in sectors such as healthcare, where rapid decision-making and emotionally demanding tasks are integral to daily work. In such contexts, excessive job demands intensify role-related stressors and substantially increase employees' levels of emotional exhaustion (Mwakyusa & Mcharo, 2024).

Job creep may also influence employees' internal communication and participation behaviors within organizations. As workload intensifies and uncertainty increases, employees may become more hesitant to express their views, which can ultimately suppress employee voice. Empirical studies indicate that job overload can affect employee voice both directly and indirectly by heightening role conflict and role ambiguity (Van Dyne & Ellis, 2004; Jawahar et al., 2023).

Although prior research on job creep has predominantly emphasized outcomes such as workload, burnout, and extra-role behaviors, studies on employee voice have largely focused on antecedents including leadership, psychological safety, and organizational climate (Morrison, 2014). Against this backdrop, examining the influence of job creep on employee voice through role-related stressors addresses an important theoretical and practical gap in the literature. Such an approach is particularly valuable in the healthcare context, where it can offer actionable insights for improving task allocation practices and strengthening organizational communication processes.

Employee Voice

Employee voice was initially conceptualized by Hirschman (1970) as engaging in constructive, solution-oriented actions aimed at improving an unsatisfactory situation rather than withdrawing from it. More broadly, employee voice refers to employees' expression of ideas, suggestions, concerns, or opinions with the intention of contributing to organizational improvement and development (Derin, 2017; Ekrot, Rank & Gemünden, 2016). By enabling employees to share their views on organizational practices and the work environment, employee voice supports continuous learn-

ing, adaptation, and organizational growth (Van Dyne & LePine, 1998). In practice, voice behaviors may take the form of problem-solving efforts, process improvements, proposals for organizational advancement, and the introduction of innovative ideas (Withey & Cooper, 1989).

From a managerial perspective, employee voice reflects an organizational climate in which employees' ideas are valued and human capital is recognized as a strategic resource. By drawing on diverse viewpoints and experiences, organizations can develop more comprehensive approaches to problem-solving and foster institutional development (Göktaş Kulualp, 2016). Furthermore, employee voice has an inherently political dimension, as employees tend to express their views strategically by selecting an appropriate time, manner, and communication channel while considering their personal interests and social relationships within the organization (Morrison & Milliken, 2000; Hung et al., 2012). In some cases, voice behavior is driven by the intention to preserve interpersonal harmony or strengthen social ties rather than to directly challenge organizational practices (Brinsfield, 2009). Accordingly, organizational voice initiatives are more likely to support change and development when they are framed in a constructive and cooperative manner instead of being perceived as confrontational or overtly critical (Dutton & Ashford, 1993; Brinsfield, 2009).

Employee voice can also be explained through motivational theories. From the perspective of Expectancy Theory (Vroom, 1964), employees are more likely to engage in voice behavior when they believe that expressing their opinions will lead to positive outcomes. In this respect, reward mechanisms such as recognition, feedback, and promotion opportunities play an important role in sustaining and reinforcing voice behavior over time (Premeaux, 2001).

H1: Job creep positively affects employee voice.

Role Conflict and Role Ambiguity

Role conflict arises when employees are confronted with role demands that are incompatible, inconsistent, or cannot be fulfilled simultaneously (Rizzo, House & Lirtzman, 1970; Örtqvist & Wincent, 2006). It may manifest when employees are required to prioritize one set of role expectations at the expense of another or when they face contradictory expectations originating from different sources within the organization (Rizzo, House & Lirtzman, 1970). Together with role ambiguity, role conflict constitutes a central source of role-related stress, as it heightens uncertainty regarding task expectations and undermines employees' ability to perform their roles effectively (Kahn et al., 1964).

Role ambiguity represents a core component of role stress and emerges when expectations regarding employees' duties and responsibilities are insufficiently defined within the framework of Role Theory. Kahn and colleagues (1964) describe role ambiguity as a condition in which employees lack clear criteria to guide their behavior because organizational expectations are unclear. Similarly, Rizzo, House, and Lirtzman (1970) conceptualize role ambiguity as the absence of reliable information regarding how, when, and according to which standards job tasks should be performed. A substantial body of research indicates that role ambiguity is associated with adverse outcomes, including reduced job satisfaction, diminished performance, elevated stress levels, and burnout (Jackson & Schuler, 1985; Fisher, 2001).

Role ambiguity also exerts a direct and negative influence on employees' voice behavior. When employees experience uncertainty, they often struggle to determine which behaviors are appropriate and tend to perceive speaking up as carrying greater personal and professional risk (Detert & Burris, 2007). As a result, role ambiguity weakens employees' willingness to offer constructive suggestions or to raise concerns about organizational issues (Morrison, 2014). In such uncertain environments, the inability to anticipate the potential consequences of voicing opinions leads employees to view voice behavior as a risky course of action.

A review of the existing literature indicates that studies directly addressing employee voice and role ambiguity in combination remain relatively scarce. Most prior research has examined voice behavior through constructs that are conceptually related to role ambiguity, such as role clarity, role stressors including role conflict and role overload, or broader forms of role uncertainty (Detert & Burris, 2007; Morrison, 2014; Tangirala & Ramanujam, 2008; Maynes & Podsakoff, 2014). Within this context, findings consistently suggest that role conflict and role ambiguity constrain employees' willingness to express their views on organizational processes, as unclear job expectations lead employees to perceive voice behavior as both risky and potentially costly (Li et al., 2010; Sias & Duncan, 2019). Accordingly, while the relationship between employee voice and role ambiguity is theoretically robust and indirectly supported by empirical evidence, it has seldom been examined explicitly in the literature.

Similarly, although studies that directly examine the concept of job creep within the role conflict and role ambiguity literature remain limited, a growing body of research demonstrates that related work demands such as work intensification, role expansion, workload creep, and job creep contribute to increased role ambiguity by obscuring role boundaries (Jackson & Schuler, 1985; Morrison, 2014). When the literature is considered as a whole, evidence suggests that job creep reinforces both role conflict and role ambiguity among employees (Ojha, 2025; Wang & Wang, 2025). These heightened role stressors, in turn, exert a constraining effect on employee voice by increasing perceived risks and reducing employees' willingness to express their views (Li et al., 2010; Maynes & Podsakoff, 2014; Morrison, 2014; Sias & Duncan, 2019; Tangirala & Ramanujam, 2008).

Drawing on these theoretical arguments and empirical findings, the present study formulates the following hypotheses to examine the potential interactions among the research variables:

H2: Job creep increases employees' perceptions of role conflict and role ambiguity.

H3: Role conflict and role ambiguity positively affect employee voice.

H4: Role conflict and role ambiguity mediate the relationship between job creep and employee voice.

Based on the existing literature, the present study develops the research model illustrated in Figure 1 to examine the relationships among job creep, employee voice, and perceptions of role conflict and role ambiguity among healthcare workers. The model incorporates four hypotheses designed to test the proposed relationships. Within this framework, job creep is specified as the independent variable, employee voice as the dependent variable, and role conflict and role ambiguity as mediating variables.

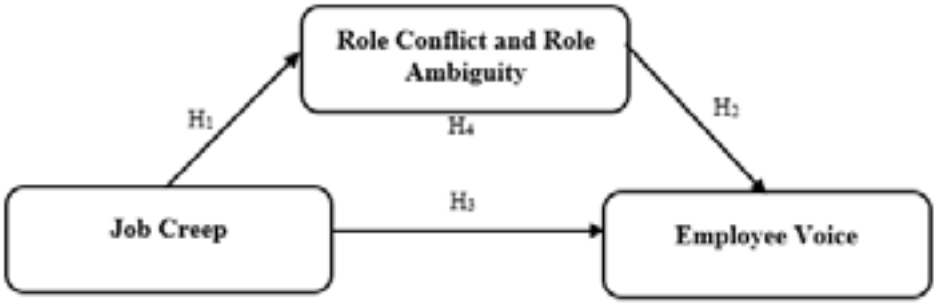

Figure 1. Conceptual Model of the Study
Source: Developed by the authors

METHOD

This study adopts a quantitative research design within the field of social sciences and focuses on examining relational associations and linear effects among the study variables. Data were collected through structured questionnaire forms administered to employees working in the healthcare sector using a convenience sampling approach. The central research question guiding the study is whether role conflict and role ambiguity mediate the effect of job creep on employee voice, and the research model was constructed accordingly. Face to face survey administration was employed during the data collection process.

Purpose and Significance of the Study

The primary aim of this study is to examine the effect of job creep on employee voice and to investigate the mediating roles of role conflict and role ambiguity in this relationship. Specifically, the study explores whether task demands that extend beyond formal job descriptions generate uncertainty among employees and how such uncertainty influences internal organizational expression behaviors. By focusing on healthcare workers, the study seeks to provide a deeper understanding of organizational communication processes and employee responses to uncertainty in high-demand work environments. Within this framework, role conflict and role ambiguity are conceptualized as critical mechanisms linking job creep to employee voice, with the assumption that the observed effects primarily operate through these role-related processes.

In increasingly uncertain and flexible work environments, emerging phenomena such as job creep necessitate a reconsideration of traditional job design approaches. By examining job creep through the lens of employee voice, this study offers a novel contribution to the literature, shifting the focus from predominantly negative outcomes toward behaviors that support organizational learning and development. Moreover, the study advances existing research by conceptualizing role conflict and role ambiguity not only as sources of strain but also as influential factors shaping employees' willingness to speak up. Findings derived from the healthcare context are expected to shed light on the structural dynamics that affect employee voice, particularly under conditions of crisis, workload pressure, and limited organizational resources.

Population and Sample

The population of the study comprises employees working at Karamanoğlu Mehmetbey University Karaman Education and Research Hospital between June 15 and June 30, 2025. The study sample consists of 393 healthcare workers who voluntarily participated in the research and were selected using a convenience sampling method. To ensure an adequate sample size for statistical analysis, methodological guidelines suggest that the number of participants should be at least five to ten times the number of measurement items included in the scales (Hair et al., 2006; Tabachnick & Fidell, 2007). As the collected data meet this criterion, the sample size was considered sufficient for the analyses conducted in the study.

Data Collection Tools

To assess levels of job creep in the study, the Job Creep Scale developed by Canbolat (2024) was employed. This scale consists of 13 items with 3 dimensions of additional workload, helpfulness, and withdrawal. Employee voice was measured using the 1 dimensional, 6 item Employee Voice Scale originally developed by Van Dyne and LePine (1998) and later adapted into Turkish and validated by Arslan and Yener (2016). Perceptions of role conflict and role ambiguity were measured with the Role Conflict and Role Ambiguity Scale developed by Rizzo, House, and Lirtzman (1970). This instrument includes 14 items, of which 8 measure the role conflict dimension and 6 measure the role ambiguity dimension. The Turkish adaptation and validation of the scale were conducted in prior studies by Yıldırım (1996), Çelik (2013), and Doğan et al. (2016). Accordingly, in the present study, role conflict and role ambiguity were treated as two distinct variables derived from the same measurement instrument. In the original scale structure, lower scores indicate higher levels of role ambiguity. To ensure clarity and consistency in interpretation, the role ambiguity items were reverse coded prior to analysis, following the approach suggested by Doğan, Demir, and Türkmen (2016).

All measurement instruments used in the study have demonstrated acceptable validity and reliability in previous research and are widely utilized in the social sciences literature. In the present study, all scales were administered using a five point Likert type format ranging from “1 = Strongly Disagree” to “5 = Strongly Agree”.

Ethical permissions for the study

In this study, all the rules specified in the “Directive on Scientific Research and Publication Ethics of Higher Education Institutions” were followed. None of the actions specified under the second section of the directive, “Actions Contrary to Scientific Research and Publication Ethics”, have been carried out.

Ethics committee permission information

Name of the ethics review board: Karamanoglu Mehmetbey University

Date of ethical assessment decision: 07.05.2025

Ethics assessment certificate number number: 05.24.2025-261036

ANALYSIS AND FINDINGS

In line with the study’s objective of examining the relationships among job creep, employee voice, role conflict, and role ambiguity, frequency analyses were first carried out to describe the demographic characteristics of the participants. The internal

consistency of the measurement instruments was assessed by calculating Cronbach's alpha reliability coefficients. Subsequently, correlation analyses were conducted to determine the direction and strength of the relationships among the variables and to provide a preliminary evaluation of potential multicollinearity issues.

To examine the construct validity of the scales, confirmatory factor analysis was performed using IBM SPSS AMOS. Finally, the proposed hypotheses were tested through mediation analysis employing Hayes' PROCESS Macro, Model 4. This analytical approach enabled the examination of both direct and indirect effects among the study variables within the proposed research model.

The results of the frequency analysis conducted to describe the demographic characteristics of the participants are presented in Table 1.

Table 1. Demographic Findings (n=393)

Variable	n	%	Variable	n	%
Gender			**Monthly Income**		
Female	178	45.3	50.000 and below	90	22.9
Male	215	54.7	50.001-65.000	110	28.0
Age			65.001-75.000	74	18.8
18-24	53	13.5	75.001-90.000	60	15.3
25-29	119	30.3	90.000 +	59	15.0
30-34	89	22.6	**Work Experience**		
35-40	66	16.8	1-5 years	157	39.9
41 +	66	16.8	6-11 years	62	15.8
Marital Status			12-19 years	120	30.5
Single	146	37.2	20-25 years	18	4.6
Married	209	53.2	25 +	36	9.2
Divorced	38	9.7	**Number of Children**		
Title			-	164	41.7
Midwife / Nurse	89	22.6	1	73	18.6
Auxiliary Services Personnel	257	65.4	2	110	28.0
Physician	47	12.0	3	28	7.1
			4	18	4.6

Source: Compiled by the authors based on the study data

According to the results presented in Table 1, most participants were male (54.7%), aged between 25 and 29 years (30.3%), married (53.2%), and employed in auxiliary services (65.4%). In addition, a considerable proportion of the sample reported a monthly income ranging from 50.001 to 65.000 TL (28.0%), had one to five years of work experience (39.9%), and did not have children. Following the frequency analyses, correlation analysis was conducted to examine the relationships among the study variables. The results of this analysis are reported in Table 2.

Table 2. Correlation Analysis Findings (n=393)

	Mean	SD	1	2	3	4	5	6	7	8
1- Job Creep	3.53	.8026	(.897)	.921*	.670**	.689**	.597**	.182**	**-0.092**	.466**
2-AddWorkload	3.52	1.0115		(.912)	.473**	.522**	.538**	.220**	**-0.019**	.405**
3-Helpfulness	3.83	.9049			(.859)	.143**	.572**	0.129*	**-0.072**	.341**
4- Withdrawal	3.14	1.1682				(.867)	.255**	**0.028**	-.167**	.333**
5- Employee Voice	3.66	.9576					(.932)	.241**	-.100*	.578**
6- Role Conflict and Role Ambiguity	3.22	.6625						(.811)	.827**	,272**
7- Role Conflict	2.91	1.1759							(.958)	-.316**
8- Role Ambiguity	3.63	.9153								(.922)

Source: Compiled by the authors based on the study data
**Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level
Note: Values in parentheses indicate the Cronbach's alpha coefficients of the scales and subdimensions

According to the results presented in Table 2, a statistically significant, positive, and moderate relationship was observed between job creep and employee voice. Job creep also exhibited statistically significant, positive, and low-level correlations with role conflict and role ambiguity. Similarly, employee voice was found to be positively and significantly associated with both role conflict and role ambiguity at a low level.

An examination of the subdimensions reported in Table 2 indicates that job creep was not significantly correlated with role conflict, whereas it demonstrated a statistically significant, positive, and moderate association with role ambiguity. The additional workload and helpfulness dimension showed a moderate correlation with employee voice and a low correlation with the overall role conflict and role ambiguity scale. This dimension was also moderately and positively related to the role ambiguity subdimension, while no significant relationship was identified between additional workload and helpfulness and role conflict. The withdrawal dimension displayed a low-level positive correlation with employee voice and role ambiguity, as well as a low-level negative correlation with role conflict and with the combined role conflict and role ambiguity scale, all of which were statistically significant.

Furthermore, employee voice exhibited a low-level positive correlation with the overall role conflict and role ambiguity scale, a low-level negative correlation with role conflict, and a moderate-level positive correlation with role ambiguity. A statistically significant, moderate, and negative correlation was also identified between role conflict and role ambiguity. The reliability of the data was supported by the high Cronbach's alpha coefficients obtained for all scales, indicating satisfactory internal consistency.

Following the correlation analysis, a Confirmatory Factor Analysis (CFA) was conducted to assess the construct validity of the measurement instruments. The results of the first-order multifactor CFA performed for the job creep scale are presented in Figure 2.

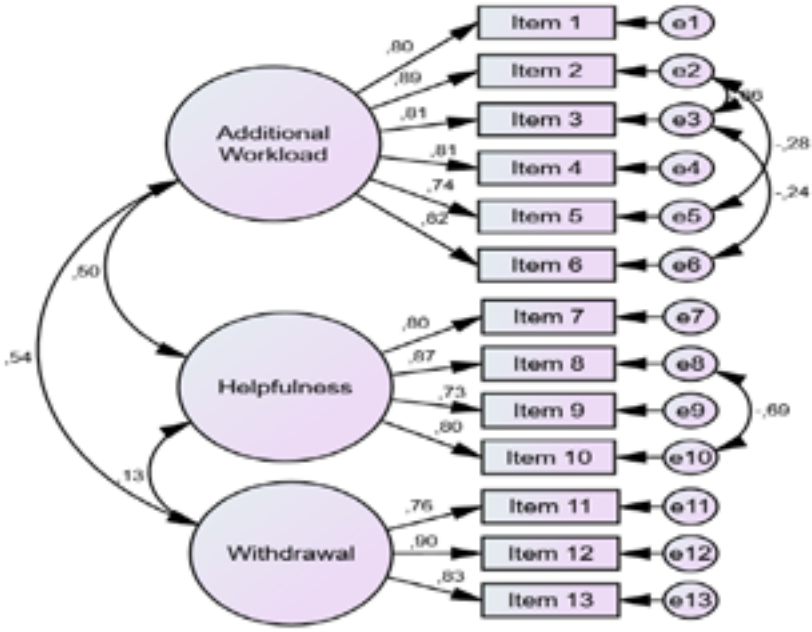

Figure 2. Confirmatory Factor Analysis Results of the Job Creep Scale
Source: Prepared by the authors based on the analysis results

According to Figure 2, the standardized factor loadings of the items included in the scale range from 0.73 to 0.90. Figure 3 presents the one-factor Confirmatory Factor Analysis (CFA) model conducted to assess the construct validity of the employee voice scale.

Figure 3. Confirmatory Factor Analysis Results of the Employee Voice Scale
Source: Prepared by the authors based on the analysis results

The results presented in Figure 3 indicate that the standardized factor loadings of the items in the employee voice scale range between 0.82 and 0.89, suggesting that

all items load strongly on the underlying construct. These values reflect a high level of convergence among the items and provide robust evidence for the construct validity of the employee voice scale within the study sample.

Figure 4 illustrates the first-order multifactor CFA model performed to examine the construct validity of the role conflict and role ambiguity scale.

Figure 4. Confirmatory Factor Analysis Results of the Role Conflict and Role Ambiguity Scale
Source: Prepared by the authors based on the analysis results

Accordingly, the standardized factor loadings of the items included in the scale range between 0.68 and 0.92, indicating that the items demonstrate acceptable to strong associations with their respective latent constructs and contribute meaningfully to the measurement structure of the scale. Across all three scales, the factor loadings of the items exceed the threshold value of 0.40. This finding suggests that each item shows a satisfactory level of alignment with the dimension to which it belongs (Başar, 2016). Table 3 presents the goodness of fit indices obtained from the Confirmatory Factor Analysis for all measurement scales used in the study.

Table 3. CFA Model Fit Indices of the Scales

Index	Job Creep Scale	Employee Voice Scale	Role Conflict and Role Ambiguity Scale	Good Fit Values	Acceptable Fit Values
X^2/df	3.461	**2.701**	3.240	<3	3< (X^2/df)<5
RMSEA	.079	.066	.076	<.05	<.08
SRMR	**.045**	**.015**	**.038**	<.05	<.08
CFI	**.956**	**.994**	**.968**	>.95	>.90
NFI	.939	**.990**	**.955**	>.95	>.90
GFI	.932	**.985**	.925	>.95	>.90

Note: χ^2/df = chi square to degrees of freedom ratio; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; CFI = comparative fit index; NFI = normed fit index; GFI = goodness of fit index. Source: Gürbüz (2021)

Source: Compiled by the authors based on the study data

According to the results presented in Table 3, the SRMR and CFI values of the job creep scale indicate a good model fit, whereas the remaining fit indices fall within the acceptable fit range. For the employee voice scale, the RMSEA value reflects an acceptable fit, while the other fit indices demonstrate a good fit. Similarly, the role conflict and role ambiguity scale exhibits acceptable fit levels for the χ^2/df, RMSEA, and GFI indices, and good fit levels for the remaining indices. Taken together, the results shown in Figures 2, 3, and 4 and those reported in Table 3 support the structural validity of all measurement scales based on the data obtained from the participants.

Following the establishment of construct validity, the research hypotheses were tested using PROCESS Macro Model 4 developed by Hayes (2018). Bootstrapping with 5.000 resamples was employed in the analyses. The results of these analyses are presented in Table 4.

Table 4. Regression Analysis Results for the Mediation Test (n=393)

	Outcome Variables									
	M (Role Conflict and Role Ambiguity)					**Y (Employee Voice)**				
Predictor Variables		β	*S.H.*	%95 *GA*			β	*S.H.*	%95 *GA*	
				LLCI	ULCI				LLCI	ULCI
X (Job Creep)	a	.151*	.041	.0698	.2312	c′	.682*	.049	.5868	.7779
M (Role Conflict and Role Ambiguity)	-	-	-	-	-	b	.197*	.058	.0815	.3131
Constant	i_M	2.691*	.148	2.398	2.983	i_Y	.616*	.235	.1550	1.078
						Total Effect (c)	.712*	.048	.6169	.8072
						Mediating Effect	.029*	.014	.0078	.0619
	R^2 = .033						R^2 = .374			
	$F_{(1; 391)}$ = 13.448; p < .001						$F_{(2; 390)}$ = 116.601; p < .001			

Note: *p < .001; S.E.: Standard Error; CI: Confidence Interval. Unstandardized beta coefficients (β) are reported

Source: Compiled by the authors based on the study data

According to the findings presented in Table 4, Job creep demonstrated a significant and positive effect on employee voice (β = .682, 95% CI [.5868, .7779], t = 14.038, p < .001). Together with role conflict and role ambiguity, job creep accounted for approximately 37% of the variance in employee voice (R^2 = .374). When role conflict and role ambiguity were excluded from the model, job creep continued to exert a significant and positive effect on employee voice (β = .712, 95% CI [.6169, .8072], t = 14.707, p < .001). Thus, Hypothesis H1 was supported. In addition, job creep was found to have a significant and positive effect on role conflict and role ambiguity (β = .151, 95% CI [.0698, .2312], t = 3.6671, p < .001), explaining approximately 3% of the variance in these variables (R^2 = .033). Accordingly, Hypothesis H2 was supported. Furthermore, role conflict and role ambiguity were found to significantly and positively affect employee voice (β = .197, 95% CI [.0815, .3131], t = 3.3510, p < .001), supporting Hypothesis H3. Finally, mediation analysis indicated that the indirect effect of job creep on employee voice through role conflict and role ambiguity was significant (β = .029, 95% CI [.0078, .0619], p < .001), providing support for Hypothesis H4. The fully standardized indirect effect size was .025, suggesting that the mediating effect in the proposed model is small in magnitude.

CONCLUSION

This study examined the effect of perceived job creep on employee voice among healthcare workers, as well as the mediating roles of role conflict and role ambiguity in this relationship. The results indicate that job creep has a significant and positive effect on employee voice, both directly and indirectly through role conflict and role ambiguity. Although the mediating effects of role conflict and role ambiguity are relatively small in magnitude, they are statistically significant. Accordingly, all hypotheses proposed in the study were supported.

The findings align with both classical and contemporary research emphasizing the role of role-related stressors in shaping organizational behavior. However, the result that job creep and role stressors are associated with increased employee voice partially diverges from the dominant perspective in the literature. Classical studies have predominantly suggested that role conflict and role ambiguity undermine motivation and job satisfaction, thereby inhibiting voice behavior (Örtqvist & Wincent, 2006; Detert & Burris, 2007; Maynes & Podsakoff, 2014; Li et al., 2010; Van Dyne & Ellis, 2004). In contrast, more recent studies propose that employees exposed to high job demands and role ambiguity may interpret these conditions as opportunities for improvement rather than as threats, leading to more proactive voice behaviors (Qi & Liu, 2017; Soyalina & Karabey, 2020; Jabbar et al., 2023; Jawahar et al., 2023; Ojha, 2025; Wang & Wang, 2025). From this perspective, the present findings suggest that in high-stakes contexts such as healthcare, employee voice may function as an adaptive mechanism for problem-solving and operational improvement. Therefore, the positive association between job creep and employee voice, mediated by role conflict and role ambiguity, supports the emerging view that role stressors can exert both inhibiting and activating effects on employee behavior, contingent upon contextual conditions.

The findings of this study can be explained within the framework of contemporary and contextual interpretations of Role Theory. According to Role Theory, an increase in workload complicates role expectations and leads to the emergence of role

stressors such as role conflict and role ambiguity (Rizzo et al., 1970). In this respect, the present study's finding that job creep increases both role conflict and role ambiguity is consistent with the theoretical assumptions of the model. Although classical approaches in the literature generally suggest that role stressors suppress employee motivation and adaptive behaviors, more recent studies, particularly those conducted in the healthcare sector, indicate that such stressors may also encourage employees to act in a more responsible, solution-oriented, and proactive manner. In line with this perspective, the present study demonstrates that job creep increases employee voice through elevated levels of role conflict and role ambiguity. This finding suggests that role stressors may serve not only as hindering factors but also as activating mechanisms depending on the contextual conditions. In this sense, the results support a more flexible and modern interpretation of Role Theory.

The findings make an important contribution to the literature by providing empirical evidence that role conflict and role ambiguity do not exclusively lead to negative outcomes, but can also foster proactive and constructive suggestion behaviors among employees. Moreover, while existing research on job creep has largely focused on unfavorable outcomes such as burnout, job satisfaction, or performance, this study addresses a notable gap by examining employee voice as an outcome variable. As employee voice directly contributes to organizational learning, engagement, and improvement processes, the results of this study extend the theoretical understanding of job creep and role stressors within organizational behavior research.

The findings of this study offer practical guidance for managers and human resources professionals, particularly in high-stress and decision-intensive environments such as the healthcare sector. Given that job creep increases employee voice through role conflict and role ambiguity, managers can benefit from carefully managing employees' additional responsibilities and task demands while simultaneously providing appropriate support and incentive mechanisms. In this context, strengthening psychological safety and adopting supportive leadership practices are critical for encouraging employees to express constructive suggestions and contribute meaningfully to organizational processes (Qi & Liu, 2017; Soyalina & Karabey, 2020; Jabbar, Haider, & Qureshi, 2023).

Despite its contributions, the study has several limitations. First, the data were collected from a single sector, namely healthcare, and within a specific geographic region, which limits the generalizability of the findings. Second, the use of cross-sectional and self-report survey data restricts the extent to which causal relationships can be inferred. Third, the analyses focused solely on role stressors such as role conflict and role ambiguity, while other potential psychological and organizational outcomes of job creep were not examined.

Future research may address these limitations by investigating the effects of job creep on employee voice across different sectors and cultural contexts. In addition, longitudinal and qualitative research designs could provide stronger evidence regarding causal relationships. Finally, future models may incorporate psychological variables beyond role stressors, such as burnout, motivation, and psychological safety, as well as organizational contextual factors including perceived organizational support and leadership style, in order to develop a more comprehensive understanding of the consequences of job creep.

CONFLICT OF INTEREST STATEMENT
There is no conflict of interest between the authors.
FINANCIAL SUPPORT
No funding or support was utilised in this study.
AUTHOR CONTRIBUTIONS
MS; FD: Idea.
MS: Design;
FD: Supervision;
MS, FD: Collection and/or processing of resources;
MS, FD: Analysis and/or interpretation;
MS, FD: Literature review;
MS, FD: Critical review
ETHICS COMMITTEE STATEMENT AND INTELLECTUAL PROPERTY COPYRIGHTS
The study adhered to the ethics committee's principles, and necessary permissions were obtained in accordance with intellectual property and copyright regulations.
USE OF ARTIFICIAL INTELLIGENCE (AI) TOOLS
This study utilized artificial intelligence tools limited solely to language editing purposes.
DATA AVAILABILITY
The dataset used in this study is available from the corresponding author upon reasonable request.

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https://doi.org/10.7251/EMC2603719D

UDK: 007.52:[316.77:81'42

Datum prijema rada: 8. mart 2026.
Submission Date: March 8, 2026
Datum prihvatanja rada: 7. septembar 2026.
Acceptance Date: September 7, 2026

Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review

Godina/Vol. **XVI** • Br./No. **III**
str./pp. 719-737

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

A SEMIOTIC ANALYSIS OF HUMAN AND MACHINE INTERACTION: THE BLACK MIRROR

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***Abstract**: This study examines the ethical implications of contemporary digital technologies for human existence, focusing on the semiotic construction of human–machine interaction in the anthology series Black Mirror. The research gap addressed in this article concerns the limited attention paid to the sign systems through which the series produces ethical meanings: while existing studies have discussed Black Mirror mainly as a thematic critique of technological dystopia, fewer have systematically examined how visual and verbal signs organise questions of consciousness, autonomy, surveillance, identity, and responsibility. To address this gap, the study uses a Saussurean and Peircean semiotic framework to analyse how selected episodes encode ethical problems at the intersection of organic and artificial life. The empirical corpus consists of fourteen purposively selected episodes from seasons 2–6, excluding the later seventh season released in 2025, and was examined through qualitative coding of visual and verbal signs related to consciousness transfer, artificial intelligence (AI), social media, virtual reality, surveillance, and digital vigilantism. The analysis identifies recurring oppositions between embodiment and disembodiment, autonomy and control, presence and mediation, and responsibility and outsourcing, which together articulate specific moral narratives about technological progress. The article's original contribution lies in linking semiotic form to technological ethics: it shows how popular techno-dystopian fiction not only represents ethical problems thematically but also constructs them through recurring signs, oppositions, motifs, and narrative patterns. The findings suggest that Black Mirror foregrounds the fragility of human agency in technologically mediated environments and problematises unregulated innovation as a threat to dignity, privacy, and social cohesion within the selected corpus. The study concludes that these findings are interpretive insights from a purposively selected corpus, while also indicating the need for further research on how AI and related technologies are represented, governed, and ethically implemented in ways that protect human agency, dignity, and the broader public interest.*

***Keywords:** Black Mirror series; artificial intelligence (AI); technological development; human–machine interaction; semiotic analysis.*

***JEL Classification**: O31, O33, Z13*

INTRODUCTION

People have an unstoppable drive to improve their cognitive abilities. To do so, they often try various techniques, such as philosophical martial arts, eastern mystical exercises, or mindfulness, a modern interpretation of these techniques (Bostrom & Sandberg, 2009). In contrast, some modern agents also use traditional techniques. These modern-day agents mostly use autonomous electronic devices (Alonso, 2014). These interactions between human activities, capabilities, and machines raise scepticism about their moral and ethical aspects. For example, many global and local authorities criticise the trustworthiness of constructed, machine, or artificial intelligence (AI), which differs from natural intelligence. Many people fear using AI in transport, patient care, and business. Ryan (2020) argues that trust in AI is not based on trust criteria because it lacks affective states and accountability for its actions. Although AI meets these criteria, it is reliance rather than trust. Trust should not be placed in sophisticated machines, such as AI, as it would diminish interpersonal confidence, anthropomorphise AI, and deflect accountability from its creators and employers. On the other hand, the nature of consciousness is still being debated, including whether machines represent it. Sloman & Chrisley (2003) debate whether virtual machines generate mental states and processes like humans and, if so, to what extent they will develop and support human mental phenomena. In addition, ethical issues remain, such as partners' responsibility in fatal events: Who will be judged for what happened? Undoubtedly, robots and machines operate in cooperation with humans. Therefore, both sides should share responsibility and be assigned supervision and execution (Nyholm, 2018).

In visual arts, science fiction cinema portrays both positive and negative attitudes toward technology, including AI. In a globalised world where individuals are increasingly isolated, AI is seen as a solution to loneliness. The brain supports learning and consciousness and is crucial to AI-human communication and relationships. The rapid development and widespread use of AI are inevitable (Yılmaz & Turan, 2018), and the movies provide insights into how humanity can prepare for this future. Dystopian stories and science fiction depict AI's potential to take over the planet. Popular culture suggests that sentient machines could populate Earth by the first half of the 22nd century, potentially becoming the dominant intelligent life form. However, if these concepts become reality, they could lead to dystopias that render the world untenable. Concerns (Arslan & Köseoğlu, 2023) include the potential destruction of humanity as AI becomes more human-like, causing a loss of human emotions.

This article's research gap arises from how existing scholarship has approached Black Mirror. Previous studies have productively discussed the series in relation to technological dystopia, artificial intelligence, surveillance, digital culture, and the social consequences of innovation. However, these discussions often foreground themes and plot content rather than the semiotic mechanisms that produce ethical meanings. Less attention has been given to how particular signs, images, interfaces, bodies, screens, avatars, and verbal cues generate moral interpretations of human–machine interaction, or to how recurring oppositions such as human/machine, autonomy/control, real/virtual, and private/public structure the series' ethical imagination.

This study therefore connects semiotic analysis with ethical debates on AI and digital technologies through a focused examination of selected Black Mirror episodes. Rather than treating the series as only a narrative warning about future technologies, the article shows how ethical dilemmas are encoded through signs and signifying structures. In doing so, it provides a structured account of how popular audiovisual culture organises concerns about consciousness transfer, algorithmic authority, surveillance, virtual embodiment, digital vigilantism, and technological responsibility. This contribution is original because it identifies the semiotic patterns that make these ethical tensions visible and interpretable within a purposively selected corpus.

By exploring dystopian narratives, we can better understand the potential consequences of unregulated technological advancement and the loss of human emotions in favour of artificial efficiency. This study investigates the ethical implications of technology for human existence, focusing on the intersections and commonalities between organic and artificial life. Centred on the problem statement, "Can humanity properly manage technological advances with wisdom and virtue?", this research aims to identify ethical dilemmas and the consequences of human-machine interaction. To achieve this, the study utilizes the British anthology series 'Black Mirror' (Brooker, 2011) as a primary case study. Through a qualitative inquiry utilizing semiotic analysis, the research seeks to answer three specific questions: whether transferring consciousness to machines creates ethical problems, how AI negatively affects social life, and the importance of ethics in the digital age. The remainder of this paper is organised to provide a comprehensive analysis of these themes. The initial sections review the development of AI, from Alan Turing's (1950) early work to the modern era of deep learning and industry 4.0, providing the necessary technological context. The paper then outlines the qualitative research method employed, detailing the selection of fourteen episodes from seasons 2–6, excluding season 1, *Bandersnatch*, and the later seventh season, through purposive sampling and the application of semiotic analysis (Peirce, 1998). It then presents detailed summaries and evaluations of the selected episodes, categorising them by themes such as grief, surveillance, social classes, and virtual reality. Finally, the study interprets these findings through a semiotic lens and discusses them in relation to existing literature on machine ethics, robot rights, and the psychological impact of technology, concluding with recommendations for interdisciplinary collaboration to ensure that AI is developed to serve humanity's best interests.

LITERATURE REVIEW

The Development of Artificial Intelligence (AI)

AI has fuelled the imagination of scientists, researchers and enthusiasts for decades. Its journey through history is not only a story of technological advancement but also a reflection of human endeavour and ingenuity. The roots of AI lie in ancient myths and philosophical enquiry into the nature of intelligence and consciousness. These early tales laid the groundwork for later philosophical debates about whether humans could create intelligent machines.

AI studies began in the 20th century with Alan Turing's work. In 1950, Turing proposed a test to determine whether a machine can exhibit human-like intelligent behaviour. This led to a surge of AI research in the 1950s, focusing on replicating human thought processes using symbolic representation and logical reasoning. McCarthy et

al. (1959) laid the groundwork for the first AI research, and programs like 'General problem solver' (Newell & Simon, 1961) showcased the power of symbolic reasoning in problem-solving. In the early 21st century, abundant data and computing power shifted AI research. Machine learning, particularly deep learning, gained prominence, enabling systems to learn from data without explicit programming. Deep learning's success in image recognition (Krizhevsky et al., 2012) and natural language processing (Devlin et al., 2019) has transformed many industries, from healthcare to finance.

As AI technologies have spread, concerns about their ethical and social implications have emerged. Issues such as algorithmic bias (Buolamwini & Gebru, 2018), job displacement (Frey & Osborne, 2017), and transparency (Bostrom & Yudkowsky, 2014) raise questions about the responsible development and use of AI systems. Fostering interdisciplinary collaboration is essential to ensure AI is developed and operated ethically and serves humanity's best interests.

A Milestone in AI: Deep Blue vs Kasparov

The chess matches between Ibm's supercomputer Deep Blue and Russian world chess grandmaster Garry Kasparov in the late 1990s marked a significant milestone in the history of human-computer interaction. Although Kasparov won the first match, Deep Blue defeated him in the rematch, demonstrating that computers can outperform humans even in complex strategic games (Weber, 1997). These encounters showcased rapid advances in computational power and algorithmic design for tasks requiring strategic thinking and decision-making (Campbell et al., 2002). They sparked debates (Ford, 2018) in the public and scientific communities about the future of AI and its social impacts, prompting scientists to explore AI applications beyond chess, such as banking and healthcare.

The 4th Industrial Revolution and Automation/Robotization

The fourth industrial revolution emerged, supported by developing communication and automation technologies. These include AI, the internet of things (IoT), big data analytics and advanced robots. Machine learning algorithms have enabled robots to gain insights from data and improve their effectiveness over time. IoT is a network that connects objects and systems, enabling data to be shared and integrated instantly across different platforms. A reliable, efficient connection is essential (Atzori et al., 2010) for automating complex industrial procedures and maximizing performance. It examines and extracts valuable insights from large, complex datasets using advanced techniques and tools. Efficient processing of large amounts of data is crucial for making optimal decisions and implementing predictive maintenance in automated systems. Robotics has advanced significantly, with increasingly autonomous robots capable of performing complex tasks. Collaborative robots, also known as *cobots* (Bogue, 2016), are specially designed to increase efficiency and ensure safety.

Industry 4.0 has significantly impacted productivity, labour markets and economic growth. Automation and robots have increased efficiency by executing activities more quickly, precisely and consistently than human workers. In addition, automation's impact on employment is complex and varied. Although AI is replacing certain professions (Autor, 2015), it has also created new opportunities in technology-focused sectors such as robotics, engineering, and data analytics. Additionally, automation and

robotization can boost economic growth by encouraging innovation and increasing productivity. The emergence of the fourth industrial revolution has brought numerous challenges and possibilities. AI and robot applications have increased ethical concerns regarding privacy, security, and the extent of human control. In this context, it is essential to create frameworks (Müller, 2020) for the ethical use of AI and determine responsibility. Researchers (Yıldırım & Şimşek, 2021) recommend a greater need for human-oriented studies.

As mentioned above, this process has fundamentally transformed industries and societies, initiating the fourth industrial revolution. Moreover, new organizational concepts have emerged (Durmuş & Akyüz, 2024), such as green technology. Although technology offers significant opportunities to increase productivity, economic growth and innovation, it has also created management-related problems and obstacles. Experts can overcome these obstacles and expand the benefits of industry 4.0 by leveraging the capabilities of emerging technologies.

AI as a Cinematic Subject

Movies have long reflected societal desires and anxieties about technological progress. Early depictions, such as the robot Maria in Fritz Lang's "Metropolis" (1927), portrayed AI as a triumph of human ingenuity while emphasizing its potential to cause social unrest. More recent films such as 'Her' (Jonze, 2013) and 'Ex Machina' (Garland, 2014) have instead foregrounded the moral and philosophical challenges AI poses (De Masi & Li, 2024). Directed by Spike Jonze, 'Her' offered a nuanced perspective on AI by revealing the complex relationships between humans and the AI operating system. The film explored loneliness, intimacy, and awareness (Gelly, 2019), encouraging viewers to reevaluate the distinctions between humans and machines. Similarly, 'Ex Machina' examines the ethical implications of creating AI and the consequences of machines possessing consciousness through the narrative of a sentient AI named Ava. The film addresses themes of autonomy, manipulation, and creators' moral obligations (Vallor, 2016). Another highly rated film, 'Archive' (Rothery, 2020), which has received numerous international awards, highlights the ethical and confidential handling of personal information. Films such as 'Ex Machina' suggest that synthetic intelligence can exhibit humanlike emotional intelligence.

Today, AI-powered robots are improving their ability to understand their environment, and artificial intelligence is becoming increasingly humanlike and sophisticated. However, this advancement prompts new inquiries, such as 'who holds the copyright for each trained AI'?

METHODOLOGY

After discussing the general role of AI and digital technologies, this study aims to demonstrate how ethical issues related to technology are constructed in popular audiovisual culture. The central problem statement guiding the analysis is: "Can humanity properly manage technological advances with wisdom and virtue?" In line with this objective, the study adopts a qualitative case study design and formulates the above research questions to determine the most appropriate analytical strategy.

1. How is the transfer of self and consciousness into machines represented in Black Mirror, and what ethical problems are associated with these representations?

2. In what ways are artificial intelligence and intelligent machines depicted as negatively affecting social life and social relations?

3. How is the importance of ethics in the age of digital technology articulated and problematised in the series?

Case Selection and Sampling

Following previous research that uses Black Mirror as an emblematic cultural text on digital futures (e.g. Yang, 2019; Klem, 2019; Wang, 2023; De Masi & Li, 2024), the British anthology series Black Mirror (created by Charlie Brooker, first aired in 2011) was selected as the case. The wider series has continued beyond the period covered by this study, with a seventh season released in 2025; however, this article's empirical corpus is limited to episodes available up to and including season 6. Within that scope, fourteen episodes from seasons 2–6 were selected through purposive sampling (Yin, 2003; Creswell, 2013) because they explicitly address one or more of the following thematic domains aligned with the research questions: (a) transfer of consciousness or self into a technological substrate; (b) AI and algorithmic systems affecting social life; (c) virtual reality and simulated environments; (d) surveillance and datafication; and (e) explicit ethical or moral dilemmas involving technology.

Table 1 lists the selected episodes, their seasons, and durations. The sample consists of fourteen episodes from seasons 2–6 only; it does not include season 1, the interactive film Bandersnatch, or the later seventh season. The total running time of the analysed corpus is 886 minutes, or approximately fifteen hours, providing a focused and explicitly delimited corpus for semiotic analysis.

Semiotic Framework and Unit of Analysis

The study employs a semiotic framework drawing on Saussurean and Peircean approaches (Saussure, 1915/1966; Peirce, 1998). To operationalize this framework, each selected scene was analysed through a set of observable semiotic categories. In Saussurean terms, the analysis first identified the signifier, understood as the concrete visual or verbal form appearing in the episode, such as a device, interface, body, screen, colour scheme, repeated phrase, rating score, avatar, or technological object. It then identified the signified, understood as the concept or ethical meaning attached to that form, such as grief, control, authenticity, surveillance, commodified consciousness, algorithmic authority, or loss of autonomy. Finally, the analysis examined binary oppositions and paradigmatic contrasts, such as human/machine, organic/artificial, autonomy/control, real/virtual, private/public, and embodiment/disembodiment, in order to determine how ethical meanings were structured within the scene.

In Peircean terms, each sign was coded according to its dominant sign relation. Icons were identified when a sign resembled the object it represented, for example, android bodies, avatars, robotic dogs, or visual simulations of memory. Indices were identified when a sign pointed to, resulted from, or materially indicated an underlying condition, such as surveillance feeds indicating control, rating scores indicating social status, neural implants indicating technological mediation of perception, or bodily reactions indicating fear and coercion. We identified symbols when meaning depended on cultural or narrative convention, such as hashtags, corporate platforms, legal consent forms, military terminology, or moral language about responsibility. For each

sign, the analysis also specified the object it referred to and the likely interpretant, understood as the ethical meaning generated within the narrative context.

Operationally, we coded a scene only when it contained at least one technologically mediated interaction and at least one ethically relevant sign. The coding sheet recorded: (1) episode and scene context; (2) signifier or representamen; (3) signified or object; (4) sign type, whether icon, index, or symbol; (5) relevant binary opposition; (6) ethical issue, such as autonomy, consent, privacy, personhood, accountability, dignity, or social control; and (7) interpretive memo explaining how the sign contributed to the narrative construction of human–machine interaction. This procedure allowed the analysis to move from individual signs to broader semiotic patterns across the corpus.

Analytic concept	Operational definition in this study	Example of observable evidence
Signifier / representamen	The concrete visual, verbal, or narrative form that carries meaning.	AI replica, rating score, hashtag, neural implant, avatar, surveillance screen.
Signified / object	The concept, condition, or ethical problem to which the sign refers.	Grief, social status, public punishment, manipulated perception, commodified identity.
Icon	A sign that resembles what it represents.	Android body resembling a deceased person; avatar resembling or replacing a self.
Index	A sign that points to an underlying condition or consequence.	Rating scores indicating social access; surveillance footage indicating control.
Symbol	A sign whose meaning depends on cultural, institutional, or narrative convention.	Hashtags, platform terms of service, military labels, corporate interfaces.
Binary opposition	A structured contrast through which ethical meaning is organised.	Human/machine, autonomy/control, real/virtual, private/public, body/data.
Interpretant	The ethical meaning produced by the sign in its narrative context.	The viewer is invited to read a technology as a threat to consent, agency, dignity, or accountability.

The unit of analysis is the scene, understood as a continuous segment of narrative action situated in a specific time-space configuration. Within each scene, specific signifying elements are examined, including: (a) technological devices and interfaces; (b) bodily states and gestures of human characters; (c) dialogue and voice-over that explicitly refer to ethical or moral questions; and (d) recurring visual motifs (e.g. screens, eyes, recording devices, avatars). These units are then related to broader narrative structures (e.g. oppositions such as human/machine, autonomy/control, real/virtual).

Coding Framework and Analytical Procedure

The empirical analysis proceeded in several stages. First, the author watched all fourteen episodes in full and produced detailed analytic notes focusing on human–machine interactions, explicit ethical dilemmas, and the consequences of technological use. Second, a preliminary coding framework was developed deductively from the research questions and the semiotic concepts (e.g. codes for types of human–machine

interaction, forms of surveillance, representations of consciousness transfer, instances of digital vigilantism, explicit references to ethics or responsibility) and inductively from salient patterns observed in the initial viewing.

Third, the episodes were re-watched scene by scene, and the pre-defined units of analysis were coded using this framework. For each coded segment, the relevant signs were identified (e.g., specific technological artefacts as icons or indices of control; symbolic use of colour or framing to connote isolation or dehumanisation), and short analytic memos captured the narrative's implied ethical stance. Fourth, codes were grouped into higher-order categories and themes corresponding to the three research questions (e.g. "commodification of consciousness", "algorithmic governance of social life", "erosion of consent and privacy", "contested ethics of technological progress").

Inter-Coder Reliability

To improve the reliability of the qualitative coding, a second independent researcher analysed a subset of the material. Both researchers applied the coding framework to the same set of scenes (covering all 14 episodes, with particular emphasis on key turning points in each narrative). We assessed agreement at the level of thematic codes assigned to each scene. Inter-rater agreement exceeded 80% for the percentage of scenes for which both coders assigned the same primary thematic code. Disagreements were discussed and resolved through consensual refinement of code definitions, and the coding framework was then applied to the remaining material.

The Black Mirror Case

Black Mirror is a British anthology series created by Charlie Brooker that explores the often dystopian consequences of contemporary and emerging technologies. Each stand-alone episode presents a self-contained narrative, typically set in a near future where digital technologies such as social media, AI, virtual reality, ubiquitous surveillance, and data-driven platforms shape everyday life. Across genres that range from science fiction to drama, horror, and satire, the series foregrounds morally fraught situations and invites viewers to reconsider their relationship with technology and its unintended effects.

The episodes frequently stage conflicts around autonomy, privacy, memory, intimacy, and responsibility, thereby offering rich material for examining how ethical concerns about technology are signified and narrated. Because of its critical acclaim and cultural impact, Black Mirror has become a key reference point in public and academic debates about digital futures, making it a particularly suitable case for a semiotic analysis of human–machine interaction and technological ethics.

EMPIRICAL DATA

The table below summarises the selected episodes.

Table 1. Selected Black Mirror Episodes Included in the Analysis

Season (S)	Episode (E)	Title	Duration
2	1	Be Right Back	48′
2	4	White Christmas	73′
3	1	Nosedive	63′
3	2	Playtest	57′
3	5	Men Against Fire	60′
3	6	Hated in The Nation	89′
4	1	Uss Callister	76′
4	2	Arkangel	52′
4	3	Crocodile	59′
4	5	Metalhead	41′
5	1	Striking Vipers	61′
5	2	Smithereens	70′
6	1	Joan is Awful	58′
6	3	Beyond The Sea	79′

Total: 14 episodes from seasons 2–6; total duration 886 minutes (≈15 hours). Season 1, Bandersnatch, and the later seventh season are outside the analysed corpus
Source: Author's compilation

After approximately fifteen hours of viewing, the author took detailed notes on each episode, focusing on scenes in which human–machine interactions, ethical dilemmas, and technological consequences were particularly salient. These notes formed the basis for the coding and semiotic analysis described above. Two independent researchers then cross-checked the coded material to enhance reliability, with inter-rater agreement exceeding 80% as explained in the methodology section.

S2 / E1 – "Be Right Back"

A grieving woman, Martha, uses an AI service that reconstructs her deceased partner Ash from his digital traces and eventually inhabits an artificial body. The episode contrasts intimate, embodied memories with the eerie persistence of a synthetic "Ash," foregrounding the limits of digitally mediated authenticity. It raises ethical questions about commodifying grief, the status of AI replicas as persons or tools, and whether extending a relationship through technology ultimately impedes acceptance of mortality.

S2 / E4 – "White Christmas"

"White Christmas" interweaves the stories of Matt and Joe, both implicated in a technology ("cookies") that creates sentient digital copies of human consciousness. Through the manipulation, torture, and indefinite confinement of these copies, the episode stages dilemmas around punishment, consent, personhood, and the commodification of subjectivity. It shows how surveillance and AI-driven control architectures can normalise extreme domination once consciousness is treated as data.

S3 / E1 – "Nosedive"

Set in a society where every interaction is rated on a ubiquitous social platform, "Nosedive" follows Lacie, whose life unravels when her carefully managed score collapses. Ratings interfaces, pastel corporate aesthetics, and choreographed politeness together symbolise a regime in which social value is reduced to quantifiable approval. The episode critiques social media addiction, conformity, and the erosion of authentic identity when algorithmic reputation governs access to rights and opportunities.

S3 / E2 – "Playtest"

In "Playtest," Cooper tests an experimental augmented-reality horror game via a neural implant that blurs the line between perception and simulation. As the game increasingly draws on his personal fears, he loses any stable reference point for what is real. The narrative interrogates the psychological and ethical risks of immersive technologies that directly interface with the brain, highlighting how entertainment can become a site of uncontrolled experimentation on consciousness.

S3 / E5 – "Men Against Fire"

"Men Against Fire" depicts soldiers equipped with a brain implant ("MASS") that enhances combat performance by visually transforming targeted humans into monstrous "roaches." When the system malfunctions, Stripe realises he has been killing ordinary people who have been dehumanised through technological filtering. The episode critiques propaganda, perception management, and algorithmic dehumanisation in warfare, raising questions about responsibility when lethal decisions are mediated by neuro technologies.

S3 / E6 – "Hated in the Nation"

This episode links a viral hashtag (#DeathTo) to a series of killings carried out by autonomous drone bees originally designed for pollination. As public shaming escalates into real-world executions, the story exposes how online outrage, anonymity, and state surveillance can converge in technologically facilitated vigilantism. It warns of the ethical and political consequences when networked platforms and autonomous systems amplify collective aggression without adequate safeguards.

S4 / E1 – "USS Callister"

"USS Callister" portrays Robert Daly, a game designer who secretly clones his co-workers' DNA to create sentient digital versions of them inside his private space opera simulation. He exercises absolute power over these copies of consciousness, subjecting them to humiliation and control. The episode explores abuse, authoritarianism, and the ethics of virtual environments in which ostensibly "fictional" beings may experience real suffering, questioning where moral responsibility lies when godlike control is technologically enabled.

S4 / E2 – "Arkangel"

"Arkangel" follows Marie, who implants her daughter Sara with a surveillance device that allows real-time tracking, visual filtering of distressing stimuli, and playback of Sara's experiences. What begins as protective care gradually becomes invasive

control, damaging trust and autonomy. The episode interrogates parental overreach, the erosion of privacy, and the unforeseen relational consequences of normalising technological oversight as love.

S4 / E3 – "Crocodile"

In a future where memories can be externally accessed and viewed via a device called the "recaller," architect Mia commits a series of escalating crimes to hide an old accident. An insurance investigator's routine use of memory extraction inadvertently uncovers her past, illustrating how a supposedly neutral truth technology can entangle bystanders and intensify harm. The episode examines guilt, moral responsibility, and the dangers of treating subjective memory as an authoritative, surveillable resource.

S4 / E5 – "Metalhead"

Set in a stark post-apocalyptic landscape, "Metalhead" follows Bella as she is hunted by a highly efficient robotic "dog." The machine's implacable pursuit and minimal design symbolise a pure, context blind instrumentality detached from human judgement or mercy. The episode foregrounds themes of survival and the loss of human control, suggesting how autonomous weapons and security systems might outlive and dominate the fragile humans who created them.

S5 / E1 – "Striking Vipers"

Two old friends, Danny and Karl, rekindle their relationship through a VR fighting game whose hyper-realistic avatars enable an unexpected sexual and emotional connection. Their in-game intimacy destabilises Danny's marriage and their own sense of identity, revealing tensions between embodied life and virtual desires. The episode probes the ethics of digital infidelity, the fluidity of gender and sexuality in virtual spaces, and how VR complicates boundaries between fantasy and real-world commitments.

S5 / E2 – "Smithereens"

"Smithereens" centres on Chris, a rideshare driver who takes a tech employee hostage to force a conversation with the CEO of a major social media firm. Haunted by his fiancée's death in a distracted driving accident linked to the platform's design, Chris confronts the corporation's responsibility for addictive interfaces and their social effects. The episode explores grief, corporate accountability, and the systemic harm of attention-economy business models.

S6 / E1 – "Joan Is Awful"

Joan discovers that a global streaming platform is broadcasting a dramatized show of her life, generated in real time through a powerful "quamputer" that processes her personal data and environment. Without meaningful consent, her everyday choices are transformed into entertainment content starring celebrity actors. The episode critiques data exploitation, AI-generated media, and the collapse of boundaries between private life and commercial spectacle in the platform economy.

S6 / E3 – "Beyond the Sea"

Two astronauts, Cliff and David, pilot a deep-space mission while teleoperating lifelike replicas of their bodies on Earth to maintain family life. After David's family is murdered, he temporarily uses Cliff's replica to cope, but emotional entanglements with Cliff's wife lead to devastating consequences. The story dramatizes how remote embodiment technologies complicate identity, fidelity, and grief, foregrounding the ethical risks in separating consciousness from a single, accountable physical body.

The table below reveals the narrative patterns in the data. The discussion section highlights the connotations, paradigms, and myths in the analysis.

Table 2. Interpretation of Episodes with The Semiotic Analysis

Episodes	The Signifier	The Signified
S2, E1	Digital Replica	Cope with Sorrow
S2, E4	A Device Called 'Cookie'	Conscious-Sense of One's Guilt
S3, E1	A Social Media Site	Digital Approvement
S3, E2	A Novel Augmented Reality Horror Game	Blurring of Digital and Physical Boundaries
S3, E5	A Brain Implant Called 'Mass'	Politic Manipulation and Illusion
S3, E6	A Hashtag on Social Media	Herd Mentality and Propaganda
S4, E1	A Virtual Reality Game	Manipulation and Cyberbullying
S4, E2	A Parental Control System called Arkangel	Extreme Authority
S4, E3	A Technology Known as A 'Recaller'	Past Deeds' Consequences
S4, E5	Robotic Creatures Known as 'Dogs'	The Pressure of The Authority
S5, E1	A Virtual Reality Game	Suppressed Feelings of Humans
S5, E2	The Social Network Firm 'Smithereen'	Social Media Addiction
S6, E1	A Global Streaming Platform	Privacy and Personal Data Protection
S6, E3	Robotic Duplicates	Goodwill and Moral Values

Source: Author's compilation

All episodes mention at least one effect of modern technological advancements. Moreover, they show the rigidity of human nature, which was the same in ancient times, so humanity still seems unchangeable.

RESULTS AND DISCUSSION

The semiotic analysis of the fourteen Black Mirror episodes shows that human–machine interaction is consistently framed through ethical tensions around consciousness, social order, and responsibility. Across the corpus, technologies operate not merely as narrative devices but as signs that condense broader anxieties about the limits of human agency, the stability of identity, and the erosion of moral judgement in digitally mediated environments. In what follows, the findings are organised in line with the three research questions.

RQ1. Representations of Transferring Self and Consciousness into Machines

Several episodes construct the transfer of self or consciousness into technological systems as a profound ethical disturbance. In Be Right Back, grief is semiotically

encoded through the repeated juxtaposition of intimate, embodied memories with the AI replica's artificial presence. The android body functions as an uncanny icon and index of the deceased partner, while its inability to reproduce spontaneity and emotional depth exposes the limits of machine-mediated authenticity. The episode thus visualises a key ethical question: whether technologically extended life undermines the dignity and finitude that give human existence its meaning.

White Christmas and Beyond the Sea further elaborate this theme by representing consciousness as something that can be copied, stored, and re-embedded in different substrates. In these narratives, consciousness transfer is symbolised by interfaces, control panels, and miniature "copies" of the self that are subjected to temporal manipulation and coercion. These signs foreground power asymmetries between those who control the technology and those whose subjectivity is technologically captured, raising questions about consent, personhood, and punishment. The notion of a "self" that can be paused, accelerated, or indefinitely confined illustrates the ethical vacuum that can emerge when legal and moral frameworks lag behind technological capabilities, echoing calls for AI laws designed to prevent abuse and reinforce human ethics (Ashrafian, 2015).

Episodes such as Playtest and Crocodile extend this problem to memory and perception. In Playtest, virtual reality headsets and neural implants function as indices of a porous boundary between reality and simulation; the collapsing distinction between the two dramatizes the human mind's vulnerability when used as a testing ground for immersive technologies. In Crocodile, the memory-extracting device operates as a symbol of absolute epistemic authority, transforming subjective recollections into evidentiary "truth". The device's ability to penetrate private mental spaces semiotically encodes a world in which internal experiences are no longer protected, thereby raising ethical concerns that resonate with debates on brain–computer interface (BCI) policy and the need for more sustained reflection on BCI ethics (Coin et al., 2020).

Taken together, these episodes depict consciousness and memory as manipulable data, thereby foregrounding the ethical risks of treating the self as information that can be archived, duplicated, or weaponised. They also visualise a world in which irrational responses to loss, isolation, and grief, such as clinging to artificial surrogates, are understandable yet ethically problematic survival strategies in technologically saturated environments.

RQ2. Negative Social Impacts of AI and Intelligent Machines

A second cluster of episodes addresses how AI systems, platforms, and autonomous machines reshape social relations and collective life. Nosedive constructs a world in which a ubiquitous rating system fully mediates social evaluation. The constant presence of smartphones, rating interfaces, and pastel coloured suburban spaces operates as a symbolic code for enforced civility and aspirational conformity. Here, the algorithm becomes a quasi-invisible authority, governing access to housing, transport, and status. The episode thus visualises the erosion of authentic sociality and the reduction of identity to quantifiable metrics of popularity and likeability.

In Men Against Fire, military implants and augmented reality overlays function as indices of a systematic dehumanisation of the enemy. The technological "filter" that transforms human targets into monstrous figures semiotically encodes how perception itself can be programmed, supporting analyses that link autonomous systems to con-

cerns about human dignity in warfare (Sharkey, 2019). At the same time, the suggestion that such systems might be designed to be more "ethical" than human combatants (Sullins, 2010) is complicated by the show's emphasis on how technological mediation facilitates, rather than constrains, violence when embedded in hierarchical command structures.

Hated in the Nation and Smithereens foreground the collective dimensions of digital harm. In Hated in the Nation, hashtags, drone bees, and live feeds together form a sign system that links online harassment to material lethality. The swarm's movement from digital command to physical attack renders visible the otherwise abstract consequences of social media mobs and digital vigilantism. This aligns with contemporary discussions of hate speech and content moderation that seek to balance freedom of expression with the need to mitigate harm, such as treating malicious content analogously to quarantined software (Ullmann & Tomalin, 2020). Smithereens, by contrast, centres on the addictive design and opaque governance of social media platforms; the corporate control room, algorithmic dashboards, and distracted users symbolise a socio-technical order in which platform logics subordinate attention and mental health.

Episodes featuring autonomous or semi-autonomous machines, Metalhead in particular, depict technology as a relentless, impersonal force. The robotic dogs are constructed as icons of pure instrumentality: efficient, affectless, and devoid of context-sensitive judgement. Their pursuit of human characters in desolate landscapes shows how, once deployed, such systems can exceed human control and generate environments in which survival, rather than ethical deliberation, becomes the dominant concern.

Finally, USS Callister, Arkangel, Striking Vipers, and Joan Is Awful explore how virtual environments and surveillance technologies reshape intimacy, authority, and identity. In USS Callister, the virtual game world becomes a stage where power fantasies are enacted without external constraint; avatars and code function as symbols of a regime in which others can be reduced to programmable objects. Arkangel presents parental surveillance technology as a sign of care that gradually becomes an instrument of control and intrusion, visually underscoring the thin line between protection and violation of privacy. Striking Vipers and Joan Is Awful highlight how immersive gaming and streaming architectures destabilise fixed identities: digital avatars and algorithmically generated "versions" of the self dramatise the multiplication of subject positions and the difficulty of maintaining coherent boundaries between public, private, and commercial uses of personal data.

Across these episodes, AI and related technologies are thus represented as reconfiguring social life by altering how individuals see one another, how they are evaluated, and how they relate to institutions. The series suggests that when such systems are introduced without robust ethical safeguards, they amplify existing inequalities, intensify social pressures, and normalise forms of coercion and surveillance.

RQ3. The Importance of Ethics in the Age of Digital Technology

The third research question concerns how Black Mirror articulates the need for ethical reflection in technologically mediated societies. Rather than offering explicit moral prescriptions, the series uses narrative and visual strategies to stage ethical dilemmas and to expose the consequences of their neglect. Recurrent motifs, such as screens that mediate relationships, interfaces that override consent, and devices that

outlive their creators, operate as symbolic reminders that technical capabilities routinely outpace ethical and legal frameworks.

Episodes such as White Christmas, Men Against Fire, Hated in the Nation, and Smithereens collectively foreground the absence or inadequacy of regulatory mechanisms. The ease with which consciousness can be punished indefinitely, perceptions manipulated, or crowds mobilised for punitive ends highlights the gap between technological sophistication and normative guidance. This resonates with broader debates on AI law, governance, and the integration of artificial entities into society, where empirical research on moral and social attitudes toward robots and AI remains limited but increasingly recognised as crucial (Harris & Anthis, 2021).

The series also anticipates concerns about BCI ethics and the emergence of "homo technologicus" (Warwick, 2016). By depicting characters whose cognitive and bodily boundaries are permeated or extended by implants, interfaces, and networked devices, Black Mirror visualises a transitional condition between homo sapiens and technologically augmented humans. The ethical stakes are signified through the costs borne by individuals, loss of privacy, autonomy, or even ontological security, whenever new capabilities are adopted without corresponding reflection on responsibility, rights, and dignity.

Overall, the semiotic patterns identified across the episodes suggest that Black Mirror consistently frames ethics not as an optional add-on to technological progress but as a constitutive dimension of human–machine interaction. Technologies in the series function as mirrors that reflect back human desires, fears, and failures. When characters confront situations of loss, isolation, and grief, the technologically available options, whether resurrecting the dead via AI, escaping into virtual realities, or outsourcing decisions to algorithms, are portrayed as understandable yet fraught responses that can ultimately exacerbate suffering. In this sense, the series invites viewers to question whether societies can manage technological advances with wisdom and virtue, underscoring the urgency of developing ethical frameworks that keep pace with innovation.

CONCLUSION

This study examined how selected episodes of Black Mirror semiotically construct ethical tensions in human–machine interaction. On the basis of the fourteen episodes analysed, the findings indicate that the series repeatedly represents technologies such as AI replicas, consciousness copies, rating systems, neural interfaces, surveillance devices, autonomous machines, virtual worlds, and data-driven platforms as signs through which concerns about autonomy, consent, privacy, identity, accountability, and social control are articulated. The analysis supports the conclusion that, within this corpus, technological innovation is commonly narrated as ethically ambivalent: it may respond to recognisable human needs such as grief, security, social connection, or entertainment, but it also becomes problematic when it commodifies subjectivity, weakens human agency, intensifies surveillance, or allows responsibility to be displaced onto systems and institutions.

These conclusions should therefore be understood as interpretive findings about a purposively selected set of audiovisual texts rather than as generalisable claims about all science fiction, all digital technologies, or actual user behaviour. The study demon-

strates that a semiotic approach can clarify how ethical meanings are produced through recurring oppositions such as human/machine, autonomy/control, real/virtual, and private/public. However, it does not establish causal effects on audiences, measure public attitudes toward AI, or evaluate the technical feasibility of the technologies depicted in the series. Its contribution lies in showing how popular techno-dystopian fiction can stage and organise ethical questions that are relevant to broader debates on AI, surveillance, virtual reality, and human–technology relations.

Future Recommendations and Limitations

Exploring the ethical implications of interactions between human consciousness and machines would raise essential questions about identity, authenticity, and the moral obligations involved in such technological advancements, and could inform further research. Moreover, investigating the negative impacts of AI and advanced technologies on social life in greater depth could help examine how social media, surveillance, and technological control affect human behaviour, relationships, and societal structures. It is also crucial to expand the discussion of ethics in the digital age, drawing on narratives that explore privacy, data exploitation, and the blurred boundaries between reality and virtual worlds. This could inform the development of ethical frameworks and policies to guide the responsible use of emerging technologies. The author strongly recommends encouraging interdisciplinary collaboration among fields such as philosophy, psychology, sociology, and computer science to better understand the complex interplay between humans and machines and the moral and social implications of technological progress. There is also a need to promote further research on developing ethical AI systems that align with human values and moral principles, highlighting the dangers of unchecked technological power and the need for accountability. Exploring the potential of science fiction narratives, such as those in Black Mirror, as a tool for anticipating and addressing the ethical challenges posed by technological advancements could yield new social science perspectives. By addressing these recommendations, researchers and policymakers can work together to ensure that ethical considerations guide technological progress and serve humanity's best interests.

Several limitations should be noted. First, the sample consists of fourteen episodes selected through purposive sampling, so the analysis cannot represent the entire Black Mirror series or other media texts dealing with technology. Second, the study relies on qualitative semiotic interpretation; although inter-coder checking strengthened reliability, the analysis remains shaped by the selected theoretical framework and the researchers' interpretive judgements. Third, the study focuses on textual and visual signs within the episodes and does not include audience reception data, interviews, surveys, production materials, or comparative analysis with other series or films. Fourth, because the objects of analysis are fictional narratives, the findings should not be read as empirical evidence about the real-world effects of AI, virtual reality, surveillance systems, or other emerging technologies.

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https://doi.org/10.7251/EMC2603738A
UDK: 657.05:330.322(4-672EU)
Datum prijema rada: 30. januar 2026.
Submission Date: January 30, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 738-748

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

THE IMPACT OF CAPITAL STRUCTURE ON COMPANY VALUE AND THE MODERATING ROLE OF THE BOARD

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***Abstract**: This study examines the effect of leverage, board size, firm size, growth, asset structure, profitability, and firm age on firm value, using Tobin's Q as a proxy. Furthermore, this study explores the role of board size as a moderating variable in the relationship between leverage and firm value. Control variables such as company size, growth, fixed asset ratio, Return on Total Assets, and company age are added in this study. Based on 128 financial report data of public companies listed on the Indonesia Stock Exchange from 2021 to 2024, and using panel data regression with a Fixed Effects Model, the results show that leverage has a significant negative impact on firm value. Although board size does not directly affect firm value, board size serves as a key moderating variable that reduces the negative impact of leverage on firm value. These findings highlight the important role of corporate governance in mitigating financial risks associated with capital structure.*

***Keywords**: Capital Structure, Leverage, Tobin's Q, Board Size*

***JEL Classification**: G32, G32, L25*

INTRODUCTION

Investors rely on a company's value as a key factor when evaluating investment opportunities. This shows greater investor confidence in the company, which is reflected in its rising valuation. When allocating resources, investors generally prefer companies with higher values.

This variation in company value is caused by several factors, including the amount of debt a company holds. Increasing corporate debt levels generate significant sentiment among investors (Mclean & Zhao, 2014) . Increasing debt levels can also benefit company value (Bui et al., 2023) Consequently, it indicates that the company is performing very well, making it easier for the organization to obtain financing from

external sources. Karaca et al. (2025) state that increasing liabilities is detrimental to company value. Companies with greater liabilities are more likely to experience financial distress than those with fewer commitments. The risk of default is considered a potential risk. This condition raises concerns among investors, leading to a decline in company value.

Within the corporate governance function, the volatility of a company's debt is closely related. Company management can increase or decrease the amount of debt. There is a correlation between the number of directors and the level of oversight exercised within the organization. Whenever a debt policy poses a risk to the organization, the board of directors has the authority to take action. Furthermore, Lv et al. (2025) and Khaoula & Moez (2019) found that good governance increases firm value. It can be concluded that rising debt, if managed well, can boost investor confidence. However, a large number of directors can create coordination problems and agency costs. Therefore, their interaction needs to be examined.

Many researchers have examined the relationship between capital structure and firm value. However, previous research has been limited to factors that directly influence firm value. Therefore, the purpose of this study is to investigate the role of corporate governance to fill this gap. Furthermore, this study uses the most recent data from 2021 to 2024, with a particular focus on the manufacturing sector of public companies in Indonesia.

LITERATURE OVERVIEW

Conceptually, capital structure, as measured by leverage, is expected to decrease firm value due to increased financial risk. In contrast, board size is considered a governance mechanism that can mitigate this risk. The interaction between leverage and board size is expected to moderate the relationship. Control variables are included to isolate the impact of a firm's operational characteristics on firm value. The following is an overview of the conceptual framework:

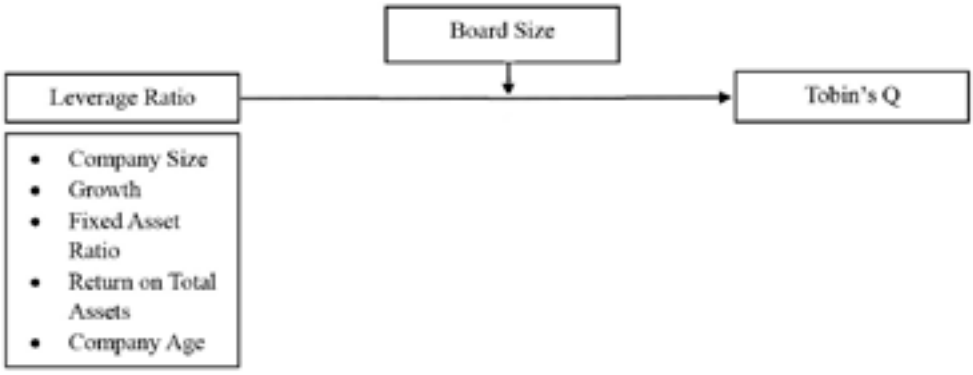

Figure 1. Conceptual Framework

Trade-off Theory
Source: Processed by the author

This theory states that increasing debt can decrease a company's value when the tax benefits of debt are no longer enough to outweigh the costs of bankruptcy

(Modigliani & Miller, 1958) . Conversely, when debt levels are optimal, they can provide tax benefits for the company.

Agency Theory

This theory suggests that effective governance can minimize conflicts of interest and boost company value. High levels of debt can lead to conflicts between shareholders and creditors. Management acting on behalf of shareholders often engages in overly risky projects (risk-shifting) or avoids beneficial investments if most of the profits will go to creditors (underinvestment). These risks are viewed negatively by the market (Jensen & Meckling, 1976).

Capital Structure and Firm Value

Karaca et al. (2025) and Bui et al. (2023) found an influence between capital structure and firm value. The research findings specifically indicate that lower borrowing levels can increase firm value, whereas excessive borrowing above a threshold decreases firm value. In line with these findings, Uddin et al. (2022) also found an influence between leverage and firm value. These results also support the trade-off theory, which states that tax savings achieved by firms through interest expense deductions result in a lower total cost of capital and ultimately increase firm value. More specifically, leverage hurts firm value (Alabdulkarim et al., 2024; Chandro Sarkar, 2022; Demiraj et al., 2023; Misrah & Arifin, 2024) . The higher a firm's debt level, the higher the risk of default or bankruptcy, thus lowering future cash flow expectations and market valuation. Therefore, firm value can decline due to increased debt. Based on this explanation, the hypothesis proposed is as follows:

H1: Leverage has a negative and significant effect on firm value.

Capital Structure, Board Size and Firm Value

Rodríguez Valencia (2025) found a moderating effect of board size on the influence of leverage on firm value. An optimal or large board size acts as a governance mechanism that reduces the agency costs of debt and the market's perceived risk. Board effectiveness becomes particularly important when financial risk or leverage is high. Under these conditions, the board of directors can increase oversight of the use of debt-sourced funds. This, in turn, prevents management from taking actions that harm creditors and signals to the market that the risk of financial distress can be well managed. These actions by the board of directors have been shown to increase firm value (Bayyurt & Basti, 2019; Omenihu & Nwafor, 2025) . Based on this explanation, the following hypothesis is proposed:

H2: Board size positively moderates the negative relationship between leverage and firm value.

METHODOLOGY

This study aims to examine the effect of capital structure and the moderating influence of board size on firm value. Control variables included in the analysis are firm size, growth, fixed asset ratio, profitability, and firm age. The definitions for each variable are as follows:

Table 1. Variable Definition

Variable Types	Variable Name	Variable Symbols	Definition	Source
Dependent Variable	Company Values	Tobin's Q	The ratio between a company's market value and the replacement value of its assets. Measures management's effectiveness in creating value.	Lv et al. (2025)
Independent Variables	Leverage Ratio	LEV	Debt to equity or asset ratio. Measures a company's level of financial risk.	Lv et al. (2025)
Moderating Variables	Board of Directors Size	BOARD SIZE	Number of members on the board of commissioners or directors. Measures the capacity of corporate governance oversight.	(Wang & Liang, 2025)
Control Variables	Company Size	SIZE	Company size is measured by the logarithm of total assets.	Lv et al. (2025)
	Growth	GROWTH	Company revenue growth	(Karaca et al., 2025)
	Fixed Asset Ratio	FAR	Net fixed assets at the end of the year/ total assets at the end of the period	Lv et al. (2025)
	Return on Total Assets	ROA	Net profit after tax/total assets at the end of the period	(Bui et al., 2023)
	Company Age	AGE	Age of the company since its founding up to the research period.	Lv et al. (2025)

Source: Processed by the author

This study uses data from the annual reports of manufacturing holding companies listed on the Indonesia Stock Exchange (IDX). The yearly reports used in this study were from 2021 to 2024, sourced from the IDX website and the company websites. A total of 128 annual reports from 32 manufacturing companies were used in this study. The analysis uses panel data regression with a fixed-effects model (FEM).

EMPIRICAL EVIDENCE

Table 2. Statistics Descriptive

Variable	Obs	Mean	Std. Dev.	Min	Max
Tobin's Q	128	1.4095	1.5953	0.0875	8.7492
LEV	128	0.8144	1.0856	0.0672	6.4659
BOARD SIZE	128	10.6797	3.3271	5.0000	19.0000
SIZE	128	29.9835	1.3611	27.6288	32.9379
GROWTH	128	0.3405	1.6445	-11.8444	7.0693
FAR	128	0.4922	0.2611	-0.1957	0.9935
ROA	128	0.0919	0.0676	-0.0341	0.3319
AGE	128	19.3672	12.9139	1.0000	43.0000

Source: Processed by the author using the STATA application

Table 2 summarizes the characteristics of the research data, which comprises 128 observations of publicly traded manufacturing companies listed on the Indonesia

Stock Exchange. The dependent variable in this study is Tobin's Q, a proxy for firm value. In contrast, the independent and control variables include leverage, board size, firm size, firm growth, fixed-asset ratio, profitability, and firm age. The average Tobin's Q value is 1.4095, with a minimum value of 0.0875 and a maximum value of 8.7492. This indicates that, in general, the companies in the study sample have a higher market value than their book value, suggesting a positive market perception of their prospects. However, the relatively large standard deviation of 1.5953 indicates significant variation across companies in market valuation, with some exhibiting very high market performance while others have low firm value.

The leverage variable has an average of 0.8144 and a maximum of 6.4659. High leverage values in some companies indicate a significant dependence on debt-based funding. The relatively high standard deviation of leverage, at 1.0856, indicates substantial differences in funding structures between companies, thus varying the potential for financial risk in this study's sample. The average board size was 10.67, with a range of 5 to 19 members. This finding suggests that most companies have relatively large governance structures, which may be associated with the complexity of their operations. Variation in board size also indicates differences in oversight mechanisms and strategic decision-making within each company.

Company size, measured using the natural logarithm of total assets, had an average value of 29.98 with a relatively small standard deviation of 1.3611. This indicates that the companies in the study sample have relatively homogeneous asset sizes, so differences in operational scale are not extreme. The company growth variable showed an average value of 0.3405, with a wide range of values from -11.84 to 7.0,6 and a standard deviation of 1.6445. This indicates that although companies generally experienced positive growth, some experienced a sharp decline, while others showed very high growth rates. Thus, the growth dynamics of companies in the sample are heterogeneous.

The fixed asset ratio (FAR) averaged 0.4922, indicating that almost half of the company's total assets are fixed assets. This shows that companies in the sample tend to be capital-intensive. However, the minimum negative FAR value indicates possible data anomalies or specific accounting adjustments, requiring further examination for outliers before further analysis. Profitability, measured by Return on Assets (ROA), averaged 0.0919, indicating that companies generated, on average, 9.19 percent of profit from their total assets. Although some companies had negative ROA values, indicating losses, the overall level of profitability in the sample can be categorized as relatively good. The average company age was 19.37 years, with a minimum value of 1 year and a maximum of 43 years. This indicates that the research sample spans companies from relatively new to long-established, enabling a more comprehensive analysis of the influence of corporate maturity on firm value.

Overall, the descriptive statistics show significant variation in some key variables, particularly Tobin's Q, leverage, and firm growth. This variation suggests that the relationship between financial structure, corporate governance, and market performance merits further analysis using the regression model used in this study.

Table 3. Baseline Regression

Variable	(1)	(2)
	Tobin's Q	Tobin's Q
LEV	0.081*	0.040**
	(-.6367728)	(-.544971)
SIZE		0.017** (1.922362)
GROWTH		0.601 (0.0150229)
FAR		0.349 (0.8989684)
ROA		0.174 (3.160947)
AGE		0.005*** (-.1399541)
Obs.	128	128
Adj. R^2	0.0931	0.1235
Cons	1.928084	-53.81348

Note(s): ***p < 0.01, **p < 0.05, *p < 0.1
Source: Processed by the author using the STATA application

Table 3 above presents the results of a panel data regression using a fixed effects model that examines the influence of leverage and firm characteristics on firm value, represented by Tobin's Q. Column 1 shows a direct relationship between leverage and firm value. At the same time, column 2 includes control variables to obtain a more robust estimate. In column 1, leverage (LEV) produces a negative coefficient of 0.6367, significant at the 10% level (0.081). This result indicates that increasing leverage decreases firm value. Furthermore, when control variables are included, as seen in column 2, the effect of leverage remains negative and statistically significant at the 5% level, with a coefficient of -0.5449. This indicates that the relationship between leverage and firm value is consistent and not distorted by other internal company factors. These results support Hypothesis 1.

Furthermore, firm size (SIZE) exhibits a positive coefficient of 1.9223, significant at the 5% level, indicating that larger firms tend to have higher market valuations, likely due to economies of scale, greater access to funding, and stronger market credibility. Meanwhile, the variables for growth (GROWTH), fixed asset structure (FAR), and profitability (ROA) exhibit positive but insignificant coefficients. This insignificance implies that these variables do not contribute significantly to the variation in firm value in this model. In contrast, firm age (AGE) exerts a substantial and significant effect at the 1% level with a coefficient of -0.1399. From a model fit perspective, the adjusted R-squared value increases from 0.0931 in Column 1 to 0.1235 in Column 2, indicating that the addition of control variables improves the model's ability to explain variation in Tobin's Q.

Overall, the empirical results indicate that leverage, firm size, and firm age consistently contribute to changes in firm value. In contrast, firm growth, fixed asset intensity, and profitability did not show significant effects in this baseline model. These

findings provide empirical evidence that a firm's capital structure and fundamental characteristics play a more dominant role in shaping market perceptions of its value.

Table 4. Moderating Testing

Variable	(3)
	Tobin's Q
LEV	0.000***
	(-2.018304)
BOARDSIZE	0.147 (-.0698576)
LEVERAGE X BOARDSIZE	0.000*** (0.1972078)
SIZE	0.023** (1,891,758)
GROWTH	0.884 (0.0031743)
FAR	0.059* (1.550522)
ROA	0.212 (2.642608)
AGE	0.009*** (-0.1314328)
Obs.	128
Adj. R^2	0.0084
Cons	-53.07134

Note(s): ***p < 0.01, **p < 0.05, *p < 0.1
Source: Processed by the author using the STATA application

The regression results in Table 4 above demonstrate the testing of the moderating role of board size in the relationship between leverage and firm value (Tobin's Q). Specifically, the LEV variable has a negative and significant coefficient at the 1% level, indicating that leverage influences firm value. The BOARDSIZE variable shows a positive but insignificant coefficient, indicating that board size does not directly affect firm value. The main finding in this model is the significant interaction variable LEVERAGE × BOARDSIZE, which is essential at the 1% level. These results confirm that board size acts as a moderating variable, strengthening the effect of leverage on firm value. This means that companies with larger boards tend to manage leverage-related financial risks more effectively, so that leverage can contribute more positively to firm value. Based on these test results, Hypothesis 2 is supported.

Table 5. Robustness Test

Variable	(4)	(5)
	Tobin's Q	Tobin's Q
DER	0.059*	0.041**
	(-0.0005429)	(-0.0005201)

SIZE		0.040** (1.763833)
GROWTH		0.870 (0.0041278)
FAR		0.965 (-0.0576391)
ROA		0.151 (3.463341)
AGE		0.004*** (-0.1420403)
Obs.	128	128
Adj. R^2	0.0940	0.1122
Cons	2.020982	-48.43107

Note(s): ***p < 0.01, **p < 0.05, *p < 0.1
Source: Processed by the author using the STATA application

Robustness testing was conducted to confirm previous results. Robustness testing was performed by replacing the dependent variable with an alternative proxy. In this study, the chosen proxy is the debt-to-equity ratio (DER). DER has the same characteristics as the previous variable. The test results in columns 4 (without control variables) and 5 (with control variables) illustrate the effects of DER and control variables on firm value, proxied by Tobin's Q. In both models, the DER variable shows a significant negative coefficient at the 10% level in column 4 and at the 5% level in column 5. These results indicate that an increase in equity-based DER can reduce firm value. This result is consistent with the results of previous tests. Therefore, the robustness test is valid.

RESULT AND DISCUSSION

The results of panel data regression testing using the Fixed Effects Model approach indicate that capital structure hurts firm value. These results are shown both with and without control variables, indicating that the effect remains negative and significant. The test results have also been confirmed in robustness testing. These findings suggest that a company's increase in debt tends to reduce firm value, especially after accounting for firm characteristics. Previous studies also support these findings. Karaca et al. (2025) and Bui et al. (2023) also found similar results, finding an effect of capital structure on firm value. A capital structure dominated by debt negatively impacts firm value (Alabdulkarim et al., 2024; Chandro Sarkar, 2022; Demiraj et al., 2023; Misrah & Arifin, 2024). Furthermore, these findings theoretically support the trade-off theory of Modigliani & Miller (1958), which posits that although debt provides tax benefits, excessive use of debt increases bankruptcy and agency costs, thereby reducing firm value.

The findings of this study are also consistent with the agency theory of Jensen & Meckling (1976), which states that a highly debt-based capital structure can increase conflict between shareholders and creditors. This conflict increases monitoring costs and risk-shifting behavior, leading to a negative market response. Several previous studies support a negative relationship between leverage and firm value. For example,

Alabdulkarim et al. (2024) found that companies with high debt levels tend to have lower market valuations, particularly in countries with developing financial systems. Misrah & Arifin (2024) also showed that leverage is negatively related to firm value when the firm is above its optimal debt level. In developing countries, capital structures are more sensitive to bankruptcy risk and economic uncertainty, so increasing leverage is often associated with a decrease in firm value.

The adverse effect of leverage on firm value can be reduced by incorporating the role of the board. The board has been shown to moderate the relationship between leverage and firm value in a positive way. This indicates that although leverage directly reduces firm value, the presence of a larger board of directors can mitigate this negative impact. In other words, stronger monitoring and governance mechanisms, enabled by a larger board size, can reduce the risks and agency costs arising from high debt usage. This moderation finding is consistent with agency theory, which emphasizes the board of directors' role as an internal monitoring mechanism to limit managers' opportunistic behavior, particularly in high-risk financing decisions. A larger board allows for a diversity of expertise, experience, and perspectives in strategic decision-making, thereby improving the quality of oversight of capital structure policies. This finding is also consistent with research by Rodríguez Valencia (2025), which found a moderating effect of corporate governance, as measured by board size, on the relationship between leverage and firm value. The board can also prevent management from taking actions that are detrimental to creditors and signal to the market that the risk of financial distress is well managed. Board actions have been shown to increase firm value (Bayyurt & Basti, 2019; Omenihu & Nwafor, 2025). Overall, these moderating results indicate that board size acts as a governance mechanism that weakens the negative relationship between leverage and firm value. These findings confirm that the impact of capital structure on firm value is not universal but is highly dependent on the quality of corporate governance. Therefore, highly leveraged companies need to strengthen their board structure to effectively manage agency and financial risks, thereby maintaining firm value in the eyes of investors.

Based on the finding that leverage has a negative and significant impact on firm value, management is advised to adopt a more conservative capital structure policy and avoid excessive debt use. Companies need to actively evaluate optimal debt levels by considering cash flow capacity, bankruptcy risk, and capital market conditions. Increasing leverage should focus on financing projects with clear, measurable returns, so that increased risk and agency costs do not outweigh the benefits of debt. Furthermore, moderation results indicate that board size can mitigate the negative impact of leverage on firm value. Therefore, companies with relatively high leverage are advised to strengthen their board structure, both in terms of the number of members and the quality of those members. The addition of board members should consider diverse expertise, particularly in finance, risk management, and corporate governance, to ensure more effective oversight of financing policies.

CONSCLUSION

Companies are advised to consider board size as part of their financial risk management mechanism. A larger and more competent board of directors can improve monitoring, reduce opportunistic behavior by managers, and ensure that debt decisions

align with shareholder interests. In this context, supporting board committees, such as the audit committee and risk committee, need to be optimally empowered to oversee capital structure policies and debt risk exposure. Capital market regulators and supervisory authorities are also advised to encourage stronger governance practices, particularly for highly leveraged companies. Guidelines on board composition and size can be strengthened by emphasizing the importance of financial expertise and independence, so that the board can effectively manage capital structure risk.

For investors, the results of this study imply that a company's leverage level needs to be analyzed in conjunction with the quality of corporate governance, particularly the size of the board of directors. Investors are advised to assess debt risk not only through financial ratios but also to consider whether the company has adequate oversight mechanisms to manage such risks. Companies with high leverage but supported by strong and effective boards of directors tend to have a lower risk of impairment than companies with weak governance. Future researchers are advised to develop models that incorporate additional governance dimensions, such as board independence, CEO duality, or audit committee effectiveness, to gain a more comprehensive understanding of the role of corporate governance in the relationship between capital structure and firm value. In addition, future research may consider non-linear approaches or threshold effects to identify optimal leverage levels more accurately.

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https://doi.org/10.7251/EMC2603749K

UDK: 004.738.5:351.824.11(4/9)

Datum prijema rada: 3. mart 2026.
Submission Date: March 3, 2026
Datum prihvatanja rada: 27. avgust 2026.
Acceptance Date: August 27, 2026

Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review

Godina/Vol. **XVI** • Br./No. **III**
str./pp. 749-770

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

THE IMPACT OF BANKING SECTOR DEVELOPMENT ON SUSTAINABLE ENVIRONMENTAL QUALITY: APPLICATION OF OECD COUNTRIES

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Abstract: *This study examines the impact of banking sector development, economic growth, energy consumption, and renewable energy consumption on environmental quality (CO2 emissions) and sustainability-oriented policy design in 26 OECD countries over the period 2001-2021. Utilizing robust econometric techniques for panel data, including LLC/IPS unit root tests, Pedroni/Kao cointegration, FMOLS/DOLS estimations, and Dumitrescu-Hurlin (2012) causality tests, this study aims to clarify the environmental role of the financial system. The empirical findings demonstrate that banking sector development and renewable energy consumption significantly reduce CO2 emissions, while economic growth leads to an increase in emissions. Furthermore, the causality analysis reveals a bidirectional relationship between banking sector development, renewable energy, and CO2 emissions. The study's 20-year scope and robust methodology enhance its credibility. Its main contribution lies in revealing the environmental benefits of financial development—an underexplored topic offering valuable insights for green growth and sustainability-oriented policy design. These findings suggest that policymakers should promote green credit allocation and integrate ESG frameworks into banking regulations to accelerate the transition to sustainable energy.*

Keywords*: Banking Sector, CO2, Sustainable Environment, OECD Countries*

JEL Classification: *A100, F18, G21, Q56, Q58*

Table 1. List of abbreviations

BoC	Bank of Canada	**ESG**	Environmental, Social, and Governance
BoJ	Bank of Japan	**FMOLS**	Fully Modified Ordinary Least Square
CO2	carbon dioxide	**GND**	Green New Deal
DOLS	Dynamic Ordinary Least Squares	**GSS**	Green, Social and Sustainability
EBA	European Banking Authority	**IEA**	International Energy Agency
ECB	European Central Bank	**OECD**	The Organization for Economic Cooperation and Development
EGD	European Green Deal	**SLB**	Sustainability Linked Bond

Source: authors

INTRODUCTION

The OECD is an international organization comprised of countries with high economic development and democratic principles. It consists of 38 member states, including the EU, the US, Canada, Japan, South Korea, Sweden, and Turkey (OECD, 2025). These countries, possessing vast energy resources, play a dominant role in global energy dynamics, with the power to regulate global market stability and influence energy security (Umar and Safi, 2023). However, this critical role also necessitates the diversification of economies and the fight against environmental challenges such as climate change. Financial development plays a significant role in this pursuit of sustainability (OECD, 2020; Shahbaz et al., 2023; Ganda, 2019).

Although green environmental policies have become a rising trend in the last decade, global carbon emissions continue to increase (Shahbaz et al., 2018; Haug and Ucal, 2019). In OECD countries, the average per capita CO2 emissions for 2023 are reported to be approximately 6.43 metric tons (Umar and Safi, 2023; Ganda, 2019). IEA reports also confirm that this upward trend continues (IEA, 2025). Environmental economists attribute this negative trend to policy failures and the exploitation of resources by industrial sectors while disregarding green sustainability (Ren et al., 2022). Environmental degradation is more pronounced in developing economies due to low technological advancement and lack of legislation (Adams and Klobodu, 2018). In this process, the banking sector, one of the most important actors in the financial system, can promote environmental sustainability by directing capital flows (Ahad et al., 2019). Environmentally sen-

sitive green financing practices contribute to protecting environmental quality, while policies that do not take these dynamics into account can finance activities that harm the environment. Therefore, systematically examining the relationship between banking development and environmental quality is critical for aligning the financial system with the Sustainable Development Goals (Acheampong, 2019; Yang et al., 2021).

Operating with this perspective, OECD countries are using the banking sector as a tool to develop environmental policies (Samour et al., 2022; Umar and Safi, 2023). Many strategic practices have been implemented in member states to this end. For instance, under the European Green Deal, climate risks have become a key criterion in credit allocation. The EBA has developed sustainability standards, and the German KfW Bank offers low-interest loans to low-carbon projects (KfW Bank, 2025). In France and Canada, the Banque de France is conducting stress tests for climate risks (OECD, 2018), while the Bank of Canada is conducting a "Climate Scenario Analysis" to measure financial stability (BoC, 2025). Similarly, in the US and Japan, JPMorgan Chase has committed $2.5 trillion in financing for climate initiatives, and the Bank of Japan (BoJ) has launched a low-interest loan program for green investments (World Bank, 2016, 2018; BoJ, 2025). Furthermore, South Korea restructured its banking sector with the "Korean Green New Deal" (Korea's GND, 2020), while the Swedish Central Bank removed carbon-intensive sector bonds from its reserves (WCED, 1987; Riksbank, 2020). The OECD's "Green Finance and Investment Centre" also promotes information sharing and the development of environmentally friendly financial products among member countries (OECD, 2020). For clarity, these practices across the OECD are visualized in Table 2.

Table 2. Banking sector practices towards sustainable environmental quality in OECD countries

Country	Policy	Parameter
EU (OECD Countries)	ECB climate stress tests EBA ESG disclosure standards KfW, Banque de France green loans	Global GSS+ (Green, Social and Sustainability) + SLB (Sustainability Linked Bond) bond volume: ~$4.2 trillion Q3 2023 2023 green bonds: $575 billion
USA and Canada	JPMorgan: $2.5 trillion financing under "net zero" target BoC climate scenarios and stress tests	Total US and Canadian SLB/Bond issuance on the rise in 2023; global GSS+ bonds account for 5% (~$618 billion)

Japan	BOJ green loan programs (since 2021)	Japan leads in sustainable bond issuance in 2023 (based on country)
South Korea	Green New Deal Low cost green financing through government bank partnerships	US, France, China, and South Korea ranked among the top 15 in GSSI issuance
Sweden	Riksbank removes carbon intensive bonds from portfolio (2020)	–
OECD General	OECD General Green Finance & Investment Centre Green Recovery Database Reports on the green/growth potential of bond markets	Green bond issuance in developing countries increased by 34% in 2023 ($135 billion) OECD forecast: The market could reach $4.7–5.6 trillion in 2035

Source: oecd.org; unepfi.org; finance.ec.europa.eu/sustainable; equator principles.com; ngfs.net; fsb tcfd.org; www.worldbank.org; climatebonds.net; bis.org

This study examines the impact of the banking sector on environmental sustainability (CO2) using data from 26 OECD countries for the period 2001–2021 (OECD, 2020). Stationarity of the series was investigated using LLC and PP tests, long-term relationships using Pedroni and Kao cointegration tests; coefficients were estimated using FMOLS and DOLS methods. Causality between variables was analyzed using the Dumitrescu–Hurlin test. According to the FMOLS and DOLS results, the development of the banking sector and renewable energy consumption significantly reduce CO2 emissions, while economic growth leads to an increase in emissions. Causality analysis reveals a bidirectional relationship between banking sector development, renewable energy, and CO2 emissions. In conclusion, the study empirically demonstrates that a mature banking structure is a critical driving force in carbon reduction in OECD countries.

LITERATURE BACKGROUND

The Impact of the Banking Sector on Environmental Quality and Sustainable Financial Development

In academic literature, the role of the banking sector on environmental quality is a complex area explained by two fundamental opposing mechanisms. First, the "scale effect" argues that financial development stimulates economic

activity, increasing energy consumption and exacerbating environmental degradation. Sadorsky (2010) supported this view by confirming, in a panel data analysis of 22 developing countries, that financial development, as measured by banking and equity indicators, significantly increased energy consumption. Similarly, a quantile regression analysis by Rădulescu et al. (2022) revealed that a 1% expansion in the banking sector in OECD countries increased the ecological footprint due to the flow of resources to carbon-intensive sectors. Second, the "technical and structural effect" argues that the financial system improves environmental quality by directing capital to efficient projects, financing technological innovations, and promoting green investments.

Proponents of this view include Tamazian et al. (2009), who empirically demonstrated in their study of BRIC countries that a well-functioning banking sector reduces CO2 emissions by facilitating technology transfer and financing energy-efficient projects. This study aims to determine whether economies of scale or technical effects are more dominant in the context of OECD countries. Current literature emphasizes the critical role of the banking sector in structuring sustainable development and environmental quality in OECD countries, where economic development and regulatory policies converge to shape green activities (Halkos and Polemis, 2017; Li and Ayub, 2025).

The Relationship Between Banking Sector Development and Sustainable Environmental Quality in OECD Countries

Effective banking practices can both accelerate and hinder environmental progress depending on their strategic orientations. Consequently, banking institutions in OECD countries are increasingly recognized as critical structures capable of mobilizing resources for sustainable infrastructure, driven by a complex interplay of risk management and technological innovation (Halkos and Polemis, 2017; Wang et al., 2023; Li and Ayub, 2025).

The expansion of the banking sector affects environmental outcomes by creating resources for both traditional and green investments. For example, using quantile regression, Rădulescu et al. (2022) provide empirical evidence that 1% growth in the banking sector is associated with an increase in ecological footprint in OECD countries. This finding shows that misguided banking sector development can worsen environmental degradation. On the other hand, a strong banking system can direct funds to renewable energy projects and clean technology investments. Beka and Abazi-Alili (2024) showed that the increase in banking performance, measured by financial stability and return on assets, in OECD countries

is positively correlated with renewable energy consumption. Furthermore, as discussed by Aras and Kazak (2022) and Shabir et al. (2024), banks integrating environmental, social, and governance (ESG) practices into their lending decisions are more likely to support sustainable projects. Including ESG criteria in lending processes mitigates the negative effects of uncontrolled credit expansion. Banks' interest in ESG criteria stems from a sense of corporate social responsibility, as well as the need to manage physical risks related to climate change and transition risks to the devaluation of fossil fuel assets (Bolton et al., 2020).

The effects of the banking sector are also evident in the real economy. In OECD countries, there is a long-term interdependence between the banking sector and the real sector, and financed activities can cause positive or negative environmental externalities (Sendeniz-Yuncu et al., 2008). Increased credit flows to carbon-intensive industries lead to high emissions (Rădulescu et al., 2022), while a transition to sustainable development may be possible when banks prioritize green technology and are supported by effective ESG frameworks (Aras and Kazak, 2022; Shabir et al., 2024). The effects of the banking sector cannot be considered independently from the economic growth dynamics explained by the Environmental Kuznets Curve (EKC) hypothesis. Formulated by Grossman and Krueger (1995), this hypothesis suggests that growth initially increases environmental degradation, but after a certain income level, structural change and environmental awareness lead to improvements in environmental quality. However, the validity of the EKC hypothesis is debatable; many studies, even in OECD countries, have shown that a monotonically increasing relationship has been found between economic growth and emissions (Apergis and Payne, 2010; Apergis and Ozturk, 2015; Acheampong, 2019).

At this point, financial development can "flatten" the EKC curve by financing technological innovations and initiating environmental improvements at lower income levels (Tamazian et al., 2009; Zhang, 2011). Shahbaz et al. (2013) showed that in the case of Malaysia, financial development can alter the EKC model with investments that increase energy efficiency. Dang and Dang (2019) emphasize that improving environmental quality requires coordinated policy measures that target resource efficiency while reducing pollution. This shows that the impact of banking sector development depends on institutional frameworks. Therefore, policymakers in OECD countries should consider regulatory reforms aimed at aligning banking practices with goals such as tax incentives that encourage green loans.

At the heart of environmental quality discussion lies the structure of energy

consumption. Dogan and Seker (2016), in their panel analysis of EU countries, showed that a 1% increase in non-renewable energy consumption increased CO2 emissions by 0.32%, while a 1% increase in renewable energy consumption reduced emissions by 0.16%. Renewable energy projects are dependent on external financing due to high initial investment costs. Empirical studies by Ren et al. (2022) and Mehmood (2023) demonstrate that banking sector development directly encourages investment in renewable energy projects by providing low-cost, long-term loans and facilitates the achievement of emission reduction targets.

The literature shows that the banking sector plays a key role in achieving the Sustainable Development Goals in OECD countries, and that this effect depends on credit quality. Creating regulatory frameworks that encourage green investments in banking (e.g., climate stress tests) can be a significant catalyst in reducing the environmental costs of growth and accelerating the transition to renewable energy. Therefore, the relationship between banking development and environmental quality, along with economic growth, total energy consumption, and renewable energy dynamics, should be evaluated within a multidimensional framework. This study aims to fill precisely this gap.

METHODOLOGY

Data and Research Model

This section examines the relationship between banking sector development, economic growth, energy use, renewable energy consumption, and CO2 emissions across 26 OECD member countries over the period 2001–2021. To form a balanced panel dataset and empirically analyze the impacts of financial development and economic growth on carbon emissions, the baseline econometric model is formulated in logarithmic form, following the frameworks of Samour et al. (2022) and Mehmood (2023). The mathematical formulation of the baseline model is presented in Equation (1), and its conceptual framework is illustrated in Figure 1.

$$lnCO2_{it} = \beta_0 + \beta_1 lnBANK_{it} + \beta_2 lnGDPPC_{it} + \beta_3 lnENU_{it} + \beta_4 lnRENE_{it} + \vartheta_t \quad (1)$$

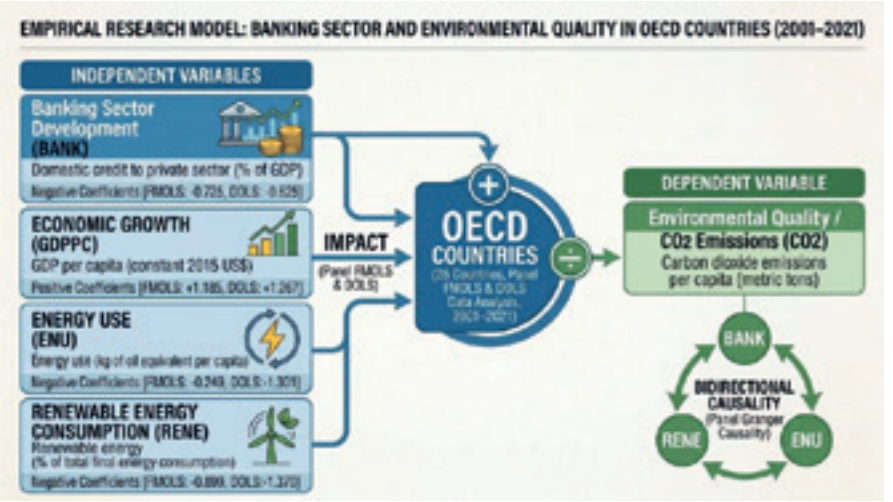

Figure 1. Research Model

Source: authors

The natural logarithm of all variables in the model has been taken. *lnCO2,* representing environmental quality, is carbon dioxide emissions per capita; *lnBANK,* representing banking sector development, is the domestic credit to the private sector by banks; *lnGDPPC,* representing economic growth, is *GDP* per capita. As control variables, *lnENU* represents total energy use, *lnRENE* represents renewable energy consumption, and ϑ_t represents the error term. Detailed information about the variables is presented in Table 3.

Table 3. Variable definitions

Variables	Symbol	Definition	Unit	Source
CO2 emissions	CO2	Carbon dioxide emissions (total) excluding LULUCF	Metrics tons per capita	World Development Indicators
Banking Sector Development	BANK	Domestic credit to private sector by banks	% of GDP	World Development Indicators
GDP Per Capita	GDPPC	GDP per capita	constant 2015 US$	World Development Indicators
Energy Use	ENU	Energy Use	Kg of oil equivalent per capita	World Development Indicators

Renewable Energy	RENE	Renewable Energy Consumption	% of total final energy consumption	World Development Indicators

Source: authors

Methodologically, the study first examines the stationarity of the variables using the Levin et al. (2002) and Im et al. (2003) panel unit root tests. Following the stationarity analysis, the cointegration relationship among the series is tested using the Pedroni and Kao cointegration methods. Furthermore, the cointegration coefficients and their direction are analyzed using the FMOLS (Fully Modified Ordinary Least Squares) method developed by Pedroni (2000) and the DOLS (Dynamic Ordinary Least Squares) method developed by Stock and Watson (1993). Finally, the causal relationship between the variables is investigated with the Dumitrescu-Hurlin (2012) panel causality test.

Initially, the Levin et al. (2002) and Im et al. (2003) panel unit root tests are used to determine the stationarity of the series. The *LLC* test is one of the significant tests that examines the common unit root process in panel data sets. The assumption of a common autoregressive coefficient *(β)* for all cross-sectional units increases the power of the test, but it can be restrictive due to its homogeneity assumption. It has been reported that the test can be applied in models with a constant, a constant and trend, or with a constant and lagged differences (Baltagi, 2005). The equation for the *LLC* panel unit root test is expressed as follows:

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{it-L} + \propto_{mi} d_{mt} + \varepsilon_{it}, \qquad m = 1,2.3 \qquad (2)$$

The H0 hypothesis of the *LLC* test is "there is a unit root in the panel," while the alternative hypothesis H1 is "there is no unit root in the panel." The IPS test, the second unit root test applied to the model, allows for different autoregressive coefficients in individual cross-sections. In this test, where the *ADF* test is applied separately for each cross-section, the test statistic is generated by taking the average of these results. The equation for the *IPS* panel unit root test is as follows:

$$\Delta y_{i,t} = \alpha_i + p_i y_{i,t-1} + \delta_{i,t} \qquad (3)$$

The H0 hypothesis of the more flexible *IPS* panel unit root test is "all series have a unit root," whereas the H1 hypothesis posits the assumption that "some series are stationary." The Pedroni cointegration test, applied to perform cointegration analysis in panel data, presents seven different test statistics (Pedroni,

2004). These tests include both group and panel statistics. Allowing for heterogeneous cointegration vectors is considered a strength of the method. The formulas for the test are presented in Table 4. The Kao cointegration test is a test with the same approach as the Pedroni test (Pedroni, 1999). Proposing *DF* and *ADF*-type tests to examine the cointegration relationship, the Kao test is frequently used due to its simple structure.

Table 4. Pedroni cointegration test statistics

(Within-dimension)			
First Section	1	Panel v-statistics	$T^2N^{3/2}Zv_{N,T} \equiv T^2N^{3/2}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}L_{11i}^{-2}e_{i,t-1}^{2}\right)^{-1}$
	2	Panel p- statistics	$T\sqrt{N}\,Z_{P_{N,T}^{-1}} \equiv T\sqrt{N}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}L_{11i}^{-2}e_{i,t-1}^{2}\right)^{-1}$
	3	Panel t- statistics	$Z_{tN,T} \equiv \left(\sigma_{N,T}^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T}L_{11i}^{-2}e_{i,t-1}^{2}\right)^{-1/2}$ $\sum_{i=1}^{N}\sum_{t=1}^{T}L_{11i}^{-2}\left(e_{i,t-1}^{*}\Delta e_{it}-\lambda_i\right)$
		(non-Parametric)	
	4	Panel t- statistics Parametric	$Z_{tN,T}^{*} \equiv \left(S_{N,T}^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T}L_{11i}^{-2}e_{i,t-1}^{2}\right)^{-1/2}$ $\sum_{i=1}^{N}\sum_{t=1}^{T}L_{11i}^{-2}e_{i,t-1}^{*}\Delta e_{it}^{*}$
(Between-dimension)			
Second Section	5	Grup-p statistics	$TN^{-1/2}Z_{P_{N,T}^{-1}} \equiv TN^{-1/2}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}e_{i,t-1}^{2}\right)^{-1}$ $\sum_{t=1}^{T}\left(e_{i,t-1}\Delta\, e_{it}-\lambda_i\right)$
	6	Grup-t statistics (non -parametric)	$N^{-1/2}Z_{P_{N,T}^{-1}} \equiv N^{-1/2}\sum_{i=1}^{N}\left(\sigma_i^2\sum_{t=1}^{T}e_{i,t-1}^{2}\right)^{-1/2}$ $\sum_{t=1}^{T}\left(e_{i,t-1}\Delta e_{it}-\lambda_i\right)$
	7	Grup-t statistics (Parametric)	$N^{-1/2}Z_{P_{N,T}^{-1}} \equiv N^{-1/2}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}s_i^{*2}e_{i,t-1}^{2*}\right)^{-1/2}\sum_{t=1}^{T}e_{i,t-1}^{*}\Delta e_{it}^{*}$

Source: authors

To analyze the cointegration coefficients of the dependent and independent variables in the model, the *FMOLS* (Fully Modified Ordinary Least Squares) method developed by Pedroni (2000) is used. This method offers the ability to

estimate coefficients accurately and without bias when a cointegration relationship exists in panel data. Its strengths are particularly noted in its ability to correct for serial correlation and endogeneity problems between the error terms and explanatory variables. The panel regression model on which the *FMOLS* method is based is as follows:

$$y_{it} = \alpha_i + \beta x_{it} + \mu_{it} \quad X_{it} = X_{it-1} + e_{it} \qquad (4)$$

In the equations, *y_it* represents the dependent variable, *x_it* the independent variable, *α_i* the constant term, and *μ_it* the error term. In this model, both *x_it* and *y_it* are *I(1)* processes and are cointegrated. Pedroni (2001) applied the *FMOLS* method to panel data. The extended equation for the panel is as follows:

$$\hat{\beta}^*_{GFM} = N^{-1} \sum_{i=1}^{N} \beta^*_{FM,i} \qquad (5)$$

In Equation 5, *β_(FM,i)^** represents the cointegration coefficients obtained from the *FMOLS* estimation for each cross-section. Additionally, the t-statistics for the group-mean panel *FMOLS* method are derived from the statistics of the cointegration coefficient obtained from the *FMOLS* estimation for each individual cross-section. The calculation of these t-statistics is performed as follows:

$$t_{\hat{\beta}^*_{GFM}} = N^{-1/2} \sum_{i=1}^{N} t_{\hat{\beta}^*_{FM,i}} \qquad (6)$$

In the equation, *t_(β^_(FM,i)^*)* represents the t-statistic for the cointegration coefficient obtained for each cross-section included in the panel (Nazlıoglu, 2010).

The Dumitrescu-Hurlin (2012) Panel Granger causality test, frequently used to investigate causality in panel data studies, calculates average statistics by performing individual Granger tests for each unit. The advantages of this method include its applicability in cases where the time dimension is larger than the cross-sectional dimension (T > N) as well as when the cross-sectional dimension is larger than the time dimension (N > T). The model, which analyzes the causality relationship between stationary series, is as follows (Dumitrescu and Hurlin, 2012):

$$y_{it} = \alpha_i + \sum_{k=1}^{\rho} \gamma_i^{(k)} y_{it-k} + \sum_{k=1}^{p} \beta_i^{(k)} x_{it-k} + \epsilon_{it} \qquad (7)$$

The H0 hypothesis of the test is "there is no Granger causality from x to y," while the alternative hypothesis H1 is "there is Granger causality from x to y." In this model, which has a heterogeneous structure, the null hypothesis assumes ho-

mogeneity of the results, whereas the alternative hypothesis allows for heterogeneity. It is also noted that the stationarity of the series is important for the application of the test (Celik and Unsur, 2020).

RESULTS

This section of the study presents the results from the analysis methods applied to the model constructed to explain the relationship between CO2 emissions, banking sector development, economic growth, energy use, and renewable energy consumption in OECD member countries. Before presenting the findings, descriptive statistics for the dependent and independent variables that constitute the model are presented in Table 5. Upon examining the descriptive statistics in Table 5, it is seen that the maximum logarithmic value of 8.680 for the *lnCO2* emissions variable occurred in the USA in 2004 with 5,888.17 *MT CO2e.* The minimum logarithmic value of 1.084 was observed in Iceland in 2001 with 2.959 *MT CO2e.* For the *lnBANK* variable, which indicates banking sector development, the highest logarithmic value of 5.718 was in Iceland in 2006 with 304.575 *(% of GDP*), while the minimum value of 2.401 was recorded in Mexico in 2001 with 11.087 *(% of GDP).* For the *lnGDPPC* variable, the maximum logarithmic value of 11.453 was in Ireland in 2021 with $94,184, and the minimum logarithmic value of 8.299 was in Colombia in 2001 with $4,020. The maximum logarithmic value of 9.809 for the *lnENU* variable was observed in Iceland in 2013 with 18,212 kg of oil equivalent per capita.

Table 5. Descriptive statistics for the variables

Variables	lnCO2	lnBANK	lnGDPPC	lnENU	lnRENE
Mean	4.864	4.349	10.211	8.086	2.624
Median	4.603	4.494	10.463	8.175	2.653
Maximum	8.680	5.718	11.453	9.809	4.417
Minimum	1.084	2.401	8.299	6.448	0.356
Std.Dev.	1.545	0.573	0.693	0.631	0.988
Skewness	0.044	0.901	0.726	0.191	0.520
Kurtosis	3.387	3.698	2.538	3.673	3.044
Observations	546	546	546	546	546

Source: authors

In panel data analyses, stationarity of the series is necessary to obtain reliable results. Accordingly, the stationarity of the series must be tested to establish a significant relationship and achieve accurate results. The results of the Levin et al.,

(2002) and Im et al., (2003) panel unit root tests, which are frequently used methods in panel data analysis, are shown in Table 6.

Table 6. Panel unit root test results

Level	LLC		IPS	
	With constant and trend			
	t- statistic	Prob.	t- statistic	Prob.
lnCO2	1.648**	0.049	1.145	0.126
lnBANK	2.227**	0.013	0.288	0.386
lnGDPPC	2.120**	0.017	3.112***	0.009
lnENU	5.5811***	0.000	5.012***	0.000
lnRENE	1.865**	0.031	0.048	0.519
First Difference				
ΔlnCO2	5.439***	0.000	8.840***	0.000
ΔlnBANK	13.348***	0.000	9.643***	0.000
ΔlnGDPPC	13.781***	0.000	12.026***	0.000
ΔlnENU	16.034***	0.000	16.065***	0.000
ΔRENE	18.066***	0.000	16.113***	0.000

Note: Δ indicates the first difference of the series. *** and ** denote significance at the 1% and 5% levels, respectively

Source: authors

When the results of the unit root tests are examined, it is observed that in both test results, the *lnGDPPC* and *lnENU* variables are stationary at the level, while the other variables have a unit root at the level. However, after applying the first difference, it is determined that all variables become stationary according to both the *LLC* and *IPS* unit root test results.

Table 7. Panel cointegration test results

Pedroni Panel Cointegration Test	With Constant (No Trend)		Weighted	
	t- statistic	Prob.	t-statistic	Prob.
Panel v statistic	1.078	0.140	0.248	0.598
Panel rho statistic	0.975	0.835	0.782	0.782
Panel PP statistic	3.547***	0.000	5.336***	0.000
Panel ADF statistic	4.121***	0.000	4.913***	0.000

Group rho statistic	2.757	0.997
Group PP statistic	7.461***	0.000
Group ADF statistic	5.202***	0.000
Kao Panel Cointegration Test	**t- statistic**	**Prob.**
ADF	2.522***	0.005

Note: *** denotes significance at the 1% level

Source: authors

After determining the stationarity of the series, the cointegration relationship among them was examined using the Pedroni and Kao cointegration tests. In the results of the Pedroni cointegration test shown in Table 7, the null hypothesis is rejected at the 1% significance level in two of the four panel tests, indicating the existence of a cointegration relationship. The Group *PP* and Group *ADF* statistics from the Pedroni method's Group tests are also statistically significant at the 1% level. The results of the Kao cointegration test, the second cointegration test applied to verify the analysis, also confirm the presence of a cointegration relationship.

The coefficient and direction of the cointegration relationship obtained from the Pedroni and Kao tests were analyzed using *FMOLS* and *DOLS* estimators, and the results are presented in Table 8.

Table 8. Coefficient estimation test results

Model	$lnCO2_{it} = \beta_0 + \beta_1 lnBANK_{it} + \beta_2 lnGDPPC_{it} + \beta_3\ lnENU_{it} + \beta_4 lnRENE_{it} + \vartheta_t$							
FMOLS								
Variable	**lnBANK**		**lnGDPPC**		**lnENU**		**lnRENE**	
Panel	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**
	-0.725***	0.000	1.185***	0.000	-0.249***	0.000	-0.899***	0.000
DOLS								
Variable	**lnBANK**		**lnGDPPC**		**lnENU**		**lnRENE**	
Panel	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**
	-0.625***	0.000	1.267***	0.000	-1.301***	0.000	-1.370***	0.000

Note: *** denotes significance at the 1% level

Source: authors

The results of the coefficient estimation tests applied to the model are shown in Table 8. According to these results, it is understood that the outcomes from the *FMOLS* and *DOLS* methods are consistent. When the results are examined, both tests show that banking sector development *(lnBANK)* has a statistically significant and negative effect on *CO2* emissions. This result indicates that banking sector development contributes positively to the reduction of environmental pollution. Furthermore, the results reveal that energy use *(lnENU)* and renewable energy consumption *(lnRENE)* also have a reducing effect on CO2 emissions. Finally, the results suggest that for the 26 OECD member countries, economic growth *(lnGDPPC)* has a positive impact on environmental pollution.

After examining the cointegration relationship between the variables, the causal relationship was analyzed using the Dumitrescu-Hurlin (2012) causality test.

Table 9. Dumitrescu-Hurlin panel causality test results

Null (H_0) Hipotez	Wald Statistic	Z-bar Statistic	Prob.
lnBANK ↛ lnCO2	4.988***	4.904	0.000
lnCO2 ↛ lnBANK	5.835***	6.468	0.000
lnGDPPC ↛ lnCO2	7.555***	9.644	0.000
lnCO2 ↛ lnGDPPC	2.585	0.466	0.642
lnENU ↛ lnCO2	3.475**	2.108	0.035
lnCO2 ↛ lnENU	4.439***	3.889	0.000
lnRENE ↛ lnCO2	7.940***	10.355	0.000
lnCO2 ↛ lnRENE	4.480***	3.964	0.000

*Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively*

Source: authors

Examining Table 9, which contains the results of the Dumitrescu-Hurlin (2012) panel causality method, a bidirectional causality is found between banking sector development and *CO2* emissions. Other results in the table show a bidirectional relationship between energy use, renewable energy consumption, and CO2 emissions, and the null hypothesis is rejected. Another finding reveals a unidirectional causality relationship from economic growth to CO2 emissions.

DISCUSSION

This study examines the impact of banking sector development on CO2 emissions in OECD countries for the 2001–2021 period, using modern panel data techniques. The findings provide significant contributions to the core debates in the literature regarding the environmental role of the banking sector. The most important result of the study is that the development of the banking sector significantly reduces CO2 emissions. This indicates that banks in OECD countries are undertaking a role that improves environmental quality by directing their resources toward green technologies and sustainable projects rather than carbon-intensive sectors. This finding confirms the real-economy impact of sustainability-focused practices, such as Environmental, Social, and Governance (ESG) criteria.

Other findings show that economic growth increases emissions, while renewable energy consumption decreases them. The causality analysis revealed a bidirectional feedback mechanism between banking development and CO2 emissions, and a unidirectional relationship from economic growth to emissions. A significant consistency in the findings can be observed when comparing the results with studies in the literature. The most striking finding of this study is that banking sector development (lnBANK) has a negative and significant effect on CO2 emissions. This finding suggests that the banking sector in OECD countries plays a role in enhancing environmental quality by directing funds towards green technology and sustainable projects rather than carbon-intensive industries. These findings are supported by the works of Aras and Kazak (2022) and Shabir et al. (2024), who suggest that banks that adopt ESG criteria in their lending practices successfully reduce the ecological footprint. This suggests that the "green banking" mechanism may be more dominant in the OECD, which is contrary to the finding by Rădulescu et al. (2022) that banking expansion increases the ecological footprint. Subsequently, the fact that economic growth (lnGDPPC) increases CO2 emissions is consistent with arguments within the framework of the Environmental Kuznets Curve (EKC) hypothesis.

This result suggests that OECD countries as a panel have not yet fully transitioned to a growth path that reduces emissions and are in the increasing segment of the EKC during the period under review. This finding is consistent with studies by Acheampong (2019) and Apergis and Ozturk (2015) questioning the validity of the EKC hypothesis for CO2 or finding that the turning point occurs at high income levels. Finally, consistent with expectations, the fact that renewable energy consumption (lnRENE) reduces emissions confirms a broad consensus in the literature (Samour et al., 2022; Mehmood, 2023). This result is consistent with studies

showing a reciprocal causal relationship between banking growth, energy consumption, and CO2 emissions like Shahbaz et al., 2013; Al-Mulali et al., 2015, who find a mutual feedback mechanism between financial development, energy consumption, and environmental degradation. On the other hand, our results are inconsistent with studies (e.g., Sadorsky, 2010) that only find a unidirectional effect between financial development and emissions. In particular, the reciprocal causal relationship between banking development and CO2 emissions suggests that these two variables influence each other. While the banking industry influences environmental quality through financial decisions (lnBANK → lnCO2), increasing environmental concerns and regulations also influence banking practices (e.g., adoption of ESG standards) (lnCO2 → lnBANK). The unidirectional causal relationship between economic growth and emissions (lnGDPPC → lnCO2) supports the "growth-related emissions" hypothesis proposed in the literature and confirms that economic activity is the primary driver of environmental degradation. The lack of a causal relationship between CO2 emissions and economic growth can be explained by the fact that environmental policies implemented in OECD countries during the study period did not statistically significantly hinder economic growth.

CONCLUSION

This study examines the impact of banking sector development, economic growth, energy use, and renewable energy consumption on CO2 emissions in 26 OECD countries over the period 2001–2021. Utilizing panel data econometric techniques, including Pedroni and Kao cointegration tests, FMOLS and DOLS estimators, and Dumitrescu-Hurlin causality tests, the results reveal that banking sector development and renewable energy consumption significantly reduce CO2 emissions, whereas economic growth increases them. Furthermore, the causality analysis confirms bidirectional relationships between banking development, renewable energy consumption, and CO2 emissions.

These findings indicate that the banking sector in OECD countries contributes to environmental quality through a “technical and structural effect,” suggesting that financial development can support the transition toward sustainable investment rather than carbon-intensive activities. This finding also highlights the potential real-economy effects of sustainability-oriented practices, including ESG integration. For policymakers, the results emphasize the importance of leveraging the financial system as a catalyst for the green transition. Strengthening regulatory tools such as climate stress testing, providing tax incentives for green investments, and integrating ESG criteria into banking regulations may help align financial

development with environmental objectives and reduce the environmental costs of economic growth.

While this study provides empirical evidence on the banking-environment nexus, its focus on OECD countries represents a limitation. Future research should include developing and emerging economies to enable comparative analysis and incorporate micro-level banking data to examine how specific financial instruments influence environmental sustainability. Overall, the findings suggest that a well-regulated and sustainability-oriented banking sector can play an important role in supporting the transition toward a low-carbon economy.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

1. Author: Incorporation of intellectual content, study concept, reviewing the manuscript.

2. Author: Data collection, data interpretation, methodology, original draft preparation.

3. Author: Theoretical background, proofreading, critical revision.

4. Author: Proofreading, critical revision.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

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https://doi.org/10.7251/EMC2603771J
UDK: 658.86/.87:338.486.1.02(497.5)
Datum prijema rada: 4. mart 2026.
Submission Date: March 4, 2026
Datum prihvatanja rada: 7. septembat 2026.
Acceptance Date: September 7, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 771-797

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

SUSTAINABILITY-ORIENTED PREFERENCES FOR ADRIATIC ISLAND DESTINATIONS: AN EXPLORATORY PCA APPROACH

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Abstract: *This study examines sustainability-oriented tourist preferences for Adriatic island destinations and explores the underlying dimensions that structure destination choice. Particular attention is given to natural and environmental values, tourism and development pressures, cultural authenticity, local identity, and the experiential qualities associated with island tourism. The empirical research was conducted between June and September 2025 on a stratified random sample of 529 tourists visiting selected Adriatic islands. Data were collected using a structured questionnaire covering socio-demographic characteristics, travel behaviour, destination values, and sustainability-related attitudes and perceptions. Descriptive and bivariate analyses examined individual preference patterns, while principal component analysis (PCA) was used as an exploratory technique to identify the underlying structure of sustainability-oriented destination preferences. The measurement instrument demonstrated high internal consistency, while the Kaiser–Meyer–Olkin measure and Bartlett's test confirmed the suitability of the data for component analysis. The findings indicate that tourists attach particular importance to natural and environmental qualities, contact with nature, lower tourism intensity, and the preservation of cultural and local identity. The exploratory PCA revealed three distinct dimensions of sustainability-oriented island destination preferences: avoidance of mass tourism and development pressures, natural values and the psychological experience of vacation, and cultural authenticity and local identity. Together, these dimensions accounted for 67.80% of the total variance. The findings contribute to a more differentiated understanding of sustainability-oriented destination choice by demonstrating that tourists perceive island sustainability as a multidimensional combination of environmental, experiential, developmental, and cultural attributes. The study also provides practical implications for destination managers seeking to balance tourism development with environmental preservation, authentic visitor experiences, and the protection of local identity.*

Keywords: *Adriatic islands; island destinations; sustainability-oriented preferences; tourist preferences; sustainable tourism; principal component analysis*

JEL Classification:*L83, Q01, Q56, Z32*

INTRODUCTION

Tourism is one of the most important economic activities in the Republic of Croatia, with island destinations occupying a special place due to their natural, spatial-geographical and socio-cultural characteristics. The Adriatic islands are at the same time carriers of exceptional tourism potential and extremely sensitive spatial systems, whose limited carrying capacity, isolation and dependence on natural resources require careful planning and development management. In this context, the issue of sustainability is no longer a normative ideal, but a necessary prerequisite for the long-term competitiveness and preservation of island destinations. The modern tourist shows an increasingly pronounced preference for destinations that offer authentic experiences, preserved nature, lower levels of crowds and more direct contact with the local community. Such patterns of behaviour are particularly evident in the context of island destinations, which, in the perception of tourists, often contrast with coastal and urban areas marked by mass tourism. However, at the same time, the strengthening of tourist demand for islands creates strong development pressures which, if not aligned with the principles of sustainable development, can lead to spatial degradation, disruption of the quality of life of the local population and the loss of fundamental destination values. In the scientific literature of recent decades, increasing attention has been paid to the study of the relationship between tourist preferences, destination characteristics and the concept of sustainable development. Research on tourist destination choice has traditionally developed along several related but conceptually distinct streams. Motivation research explains the internal forces that stimulate travel, most notably through the push–pull framework (Dann, 1977; Crompton, 1979), whereas destination image research focuses on tourists' cognitive and affective representations of destinations and their role in destination evaluation and behavioural intentions (Pike, 2002; Pike, 2007). A further stream examines sustainability-related destination attributes, including environmental quality, resource preservation, carrying capacity, tourism intensity, and the social and economic consequences of tourism development (Gössling et al., 2017; Rodríguez et al., 2008). More recent research has additionally highlighted ecological destination image, environmental beliefs, overtourism, and the vulnerability of tourism-dependent island destinations (Luong, 2023; García-Buades et al., 2022; Krajíčková et al., 2022; Slijepčević & Kordej-De Villa, 2025). Although these research streams provide important insights into destination choice, they address different stages and components of tourists' decision-making processes. Motivation explains why individuals travel; destination image reflects what they believe and feel about a destination; attitudes represent favourable or unfavourable evaluations; perceived sustainability concerns tourists' assessments of sustainability-related destination characteristics; and satisfaction is predominantly a post-consumption evaluation of the tourism experience. Destination preference, as conceptualised in this study, refers instead to the relative desirability tourists assign to destination characteristics when evaluating

an island as a potential or actual holiday destination. Preference therefore represents an evaluative orientation toward destination attributes rather than being synonymous with motivation, image, attitude, perceived sustainability, or satisfaction. Within this conceptualisation, sustainability is not treated as a single preference construct in itself. Rather, sustainability-related characteristics constitute a set of destination attributes that may become preference-relevant when tourists evaluate alternative island experiences. Environmental preservation, limited tourism and development pressure, contact with nature, cultural authenticity, and preservation of local identity may therefore contribute to destination preference insofar as tourists perceive these characteristics as desirable features of the island tourism experience.

This distinction is particularly relevant for island destinations. Their spatial limitations, ecological sensitivity, dependence on natural resources, exposure to tourism pressure, and strong place-based cultural identities create conditions in which environmental, experiential, developmental, and cultural attributes are closely intertwined. Existing studies provide substantial evidence on individual elements of this relationship, but the literature reviewed here provides less insight into whether these sustainability-related attributes form a coherent multidimensional structure of tourist preferences in the specific context of Adriatic islands. Accordingly, the research gap addressed in this study is not the absence of research on sustainable tourism or destination choice, but the limited empirical integration of these attributes into an exploratory structure of sustainability-oriented island destination preferences. The purpose of this study is therefore to examine how sustainability-related attributes are reflected in tourists' preferences for Adriatic island destinations and to explore whether these attributes can be organised into a smaller number of conceptually meaningful preference dimensions. Principal component analysis (PCA) is employed for this exploratory purpose rather than to confirm a predetermined theoretical measurement model. A special research challenge is the identification of latent dimensions that structure tourist preferences and their perception of sustainability, which go beyond individual, isolated variables.

Based on the above, the purpose of this paper is to develop and empirically test a model of island destination preferences with an emphasis on sustainability, based on tourist perceptions and attitudes. The research relies on a combination of descriptive, bivariate and multivariate statistical procedures, where principal component analysis (PCA) allows the reduction of a large number of manifest variables and the identification of key latent factors that shape the choice of an island destination. Such a methodological approach allows for a deeper understanding of the complex relationships between destination values, travel motives and attitudes towards island development.

In the present study, sustainability is therefore conceptualised primarily at the attribute level rather than as a synonym for destination preference. Environmental preservation, responsible development, lower tourism intensity, protection of natural resources, and preservation of cultural and local identity represent characteristics of a destination that tourists may evaluate with different degrees of desirability. When such attributes systematically influence tourists' evaluations of island destinations, they become components of sustainability-oriented destination preference. The term "sustainability-oriented preference" consequently refers to a pattern of tourist evaluations in which sustainability-related destination attributes receive particular importance in the assessment of island attractiveness.

OVERVIEW OF PREVIOUS RESEARCH

Research into the selection of a tourist destination traditionally starts from travel motivation and the decision-making process. Classic works emphasise that destination choice is shaped by a combination of internal incentives (e.g., escape, relaxation, self-discovery) and external destination attributes (e.g., facilities, natural resources, safety), later conceptualised through the push–pull framework. Within this approach, *push* factors explain why a tourist travels, while *pull* factors explain why a specific destination is chosen (Dann, 1977; Crompton, 1979). More recent studies confirm the enduring relevance of the push–pull logic, while also highlighting the need for more precise measurement and hierarchical modelling, particularly when motivations are linked to sustainability perceptions and quality of experience (Joseph, 2025).

Alongside motivation, destination image consistently emerges as a key predictor of tourist preferences, satisfaction, and behavioural intentions. Review studies indicate that destination image is predominantly conceptualised as a multidimensional construct, although significant methodological heterogeneity remains in its operationalisation (Pike, 2002; Pike, 2007). Sustainability is increasingly framed as an integrated concept encompassing economic, social, and environmental impacts of tourism, balancing the needs of visitors, industry, and local communities (UN Tourism, n.d.; UN DESA, n.d.). Consequently, destination research increasingly examines how sustainability-related attributes influence perceived quality, competitiveness, and attractiveness. Empirical studies demonstrate that sustainability variables can exert a strong and direct effect on destination competitiveness, frequently tested using multivariate techniques such as PCA and regression analysis (Rodríguez, 2008).In the field of tourist behaviour, recent research further confirms the importance of ecological destination image, environmental beliefs, and attitudes toward ecotourism in shaping destination evaluation and behavioural intentions (Luong et al., 2023; Huo et al., 2023). Island destinations are typically characterised as spatially limited and ecologically sensitive systems, exposed to seasonality, infrastructural constraints, and strong dependence on natural resources. Because of this limited carrying capacity, the literature increasingly emphasises the need for careful development management and a balance between economic benefits and resource conservation (Gössling et al., 2017).

A similar distinction is necessary between destination preference and destination image. Destination image concerns the set of cognitive beliefs and affective impressions tourists hold about a destination, whereas preference concerns the relative desirability assigned to destination characteristics during evaluation and choice. A destination may therefore be perceived as highly developed, accessible, culturally rich, or environmentally preserved without all of these characteristics being equally preferred by a particular tourist. Attitude represents a broader favourable or unfavourable evaluation of the destination, while satisfaction generally refers to a post-visit assessment of whether the experience met or exceeded expectations. Perceived sustainability, in turn, reflects tourists' assessment of how environmentally, socially, or economically sustainable a destination appears to be. These constructs may influence one another, but they should not be treated as interchangeable with destination preference.

The push–pull framework provides a useful starting point for understanding the distinction between travel motivation and destination preference. Push motives refer to internal psychological forces that generate the desire to travel, such as escape, relax-

ation, novelty, or self-discovery, whereas pull factors represent destination characteristics perceived as capable of satisfying those motives (Dann, 1977; Crompton, 1979). From this perspective, preference emerges at the evaluative stage at which tourists assign different levels of desirability to destination attributes. A tourist may, for example, be motivated by escape and relaxation, while preferring an island destination because it is perceived as less crowded, environmentally preserved, authentic, and conducive to contact with nature. Motivation and preference are therefore theoretically related but conceptually distinct: motivation provides the internal reason for travelling, whereas preference reflects the relative attractiveness of destination characteristics capable of satisfying that motivation.

In the Croatian context, studies on tourism development in offshore islands (e.g., Dugi otok, Vis, Lastovo, Mljet) highlight the importance of aligning tourism growth with local resources and the preferences of both tourists and residents, favouring selective and sustainable forms of tourism (Razović, 2015). Further research shows that high dependence on tourism can generate structural vulnerability, often analysed through residents' attitudes and the sustainability of tourism-led transformation (Slijepčević, 2025). The concept of overtourism has gained increasing attention, particularly in island and coastal destinations, where excessive demand may undermine residents' quality of life and visitor experience. Empirical evidence suggests that perceptions of overtourism significantly influence stakeholder attitudes and destination evaluations, underscoring the role of management strategies and tourist behaviour in mitigating negative impacts (García-Buades et al., 2022; Krajíčková & Králiková, 2022). Recent European practice further confirms a shift from growth-oriented strategies toward carrying capacity management and "quality over quantity" approach**es** (Le Monde, 2024). In destination preference research, the combined use of descriptive indicators, bivariate tests, and multivariate techniques is common, with PCA/factor analysis frequently employed to reduce large sets of indicators and identify latent dimensions of destination values. This approach is particularly suitable when preferences are measured using extensive batteries of statements and when the objective is to construct parsimonious and interpretable preference models (Rodríguez, 2008; Bui, 2024). In the context of island destinations, such techniques enable the identification of core dimensions—such as natural values, avoidance of mass tourism, authenticity, and cultural heritage—which are central to sustainability-oriented preference models.

The conceptual framework proposed in this study integrates the previously discussed research streams through an attribute–experience–preference mechanism. The underlying assumption is that tourists do not evaluate sustainability-related destination characteristics in isolation. Instead, destination attributes acquire preference value through the type of experience they are expected to facilitate. Environmental preservation and limited development pressure contribute to the perception of an island as relatively intact and differentiated from highly urbanised tourism environments. Lower levels of mass tourism and crowding may enhance perceptions of tranquillity, privacy, escape, and psychological restoration. Preserved cultural heritage, local traditions, and community identity contribute to perceptions of authenticity and place distinctiveness. These environmental, developmental, experiential, and cultural characteristics therefore represent different but potentially interconnected routes through which an island destination may acquire preference value.

The proposed mechanism can be expressed conceptually as:

Destination attributes → perceived experiential value → sustainability-oriented destination preference.

Within this framework, environmental preservation, controlled tourism development, and cultural authenticity are primarily destination attributes; contact with nature, peace, escape, relaxation, and perceived authenticity represent experiential or evaluative consequences of those attributes; and destination preference represents the relative desirability attached to this configuration of characteristics. The framework therefore does not assume that all sustainability attributes constitute a single latent construct. Rather, it proposes that they may form several interconnected preference dimensions whose empirical structure should be explored. This approach is particularly appropriate for island destinations because the tourism experience is strongly dependent on the relationship between environmental quality, development intensity, spatial characteristics, cultural identity, and opportunities for psychological and experiential escape. The exploratory question is therefore whether tourists evaluate these characteristics independently or whether they cluster into broader and conceptually interpretable dimensions of sustainability-oriented preference.

RESEARCH METHODOLOGY AND RESEARCH RESULTS

The development of island tourism increasingly takes place under conditions of growing pressure on limited spatial resources, natural ecosystems, infrastructure, and local communities. In this context, sustainability represents not only a destination management objective but also an increasingly relevant element of tourists' perceptions and destination preferences. Island destinations are particularly sensitive to these pressures because their attractiveness is closely associated with preserved natural environments, landscape quality, cultural authenticity, local identity, and the possibility of experiencing tourism outside highly urbanised and congested settings. Despite growing academic interest in sustainable tourism, there remains a need for a more integrated understanding of how sustainability-related destination attributes are reflected in tourists' preferences for island destinations. The research problem therefore concerns the structure of sustainability-oriented tourist preferences and, more specifically, whether individual perceptions related to natural values, tourism intensity, development pressures, cultural authenticity, local identity, and the experiential qualities of island tourism form broader and interpretable preference dimensions. Accordingly, the subject of the research is tourists' sustainability-oriented preferences for Adriatic island destinations, examined through their attitudes, travel motives, perceptions of destination attributes, and evaluations of sustainability-related characteristics.

The general objective of the study is to examine the structure of sustainability-oriented tourist preferences for Adriatic island destinations and to identify the key dimensions underlying destination choice.

More specifically, the study aims to:

- examine the importance tourists attach to natural and environmental attributes when choosing an island destination;
- assess tourists' perceptions of different dimensions of island sustainability;
- examine attitudes towards mass tourism, overcrowding, and development pressures;

- investigate the perceived importance of cultural authenticity, heritage, and local identity;
- examine the role of experiential attributes, particularly contact with nature, peace, relaxation, and escape from everyday life; and
- explore whether individual sustainability-related destination attributes can be reduced to a smaller number of meaningful underlying dimensions that provide a more parsimonious representation of tourists' island destination preferences.

Based on the theoretical framework and the exploratory nature of the empirical analysis, the following hypotheses were formulated:

H1. Tourists attach greater importance to natural and environmental destination attributes than to infrastructural and transport-related attributes when choosing Adriatic island destinations.

H2. Sustainability-related attributes, particularly natural and environmental qualities, represent important determinants of tourists' preferences for Adriatic island destinations.

H3. Tourists perceive mass tourism, overcrowding, and excessive development pressures as factors that reduce the attractiveness and perceived sustainability of Adriatic island destinations.

H4. Sustainability-oriented tourist preferences for Adriatic island destinations are structured around a smaller number of distinct underlying dimensions integrating natural and experiential values, avoidance of tourism and development pressures, and cultural authenticity and local identity.

The empirical research was conducted using a quantitative cross-sectional research design. Data were collected through a structured questionnaire administered to tourists visiting selected Adriatic islands between 1 June and 30 September 2025. The study included a stratified random sample of 529 tourists visiting Dugi otok, Krk, Lošinj, Vis, and Mljet. The empirical research was conducted using a quantitative cross-sectional research design. Data were collected through a structured questionnaire administered to tourists visiting selected Adriatic islands between 1 June and 30 September 2025. The study included a stratified random sample of 529 tourists visiting Dugi otok, Krk, Lošinj, Vis, and Mljet. The empirical research was conducted using a quantitative cross-sectional research design. Data were collected between 1 June and 30 September 2025 among tourists visiting five selected Adriatic islands: Krk, Lošinj, Vis, Dugi otok, and Mljet. The final sample consisted of 529 respondents.The sampling procedure was organised by island destination, with each island representing a separate sampling stratum. The stratification was introduced to ensure the representation of tourists visiting island destinations characterised by different levels of tourism development, accessibility, tourism intensity, and environmental and cultural characteristics. The final sample was distributed across the five strata as follows: Krk (n = 150; 28.36%), Lošinj (n = 125; 23.63%), Vis (n = 115; 21.74%), Dugi otok (n = 111; 20.98%), and Mljet (n = 28; 5.29%). Krk therefore represented the largest stratum, followed by Lošinj, Vis, and Dugi otok, while Mljet accounted for the smallest proportion of respondents. The sampling frame consisted of tourists present on the selected islands during the data-collection period and accessible at predefined survey locations. The inclusion criteria required respondents to be tourists visiting one of the selected

islands during the research period, to voluntarily agree to participate, and to provide a sufficiently completed questionnaire. Only one questionnaire per respondent was included in the final dataset. Within each island stratum, respondents were approached during different days and time periods at selected tourist locations in order to achieve broader coverage of the tourist population and reduce location- and time-related selection bias. All 529 respondents were included in analyses performed on the total sample, including the exploratory principal component analysis. However, due to the substantially smaller number of respondents surveyed on Mljet (n = 28), this stratum was excluded from selected island-specific descriptive comparisons in Tables 5–7 in order to avoid overinterpretation of results based on a comparatively small subsample.

The questionnaire covered respondents' socio-demographic characteristics, travel behaviour, perceptions of island destination attributes, attitudes towards sustainability, tourism and development pressures, natural and cultural values, and experiential characteristics associated with island tourism. Sustainability-related perceptions and destination preferences were primarily measured using five-point Likert-type scales. The analytical procedure was conducted in several stages. First, descriptive statistics were used to examine the characteristics of the sample and the distribution and intensity of tourists' evaluations of individual destination attributes. Second, bivariate statistical procedures were applied to examine selected differences and relationships between variables. Finally, principal component analysis (PCA) was employed as an exploratory multivariate technique to identify the underlying structure of sustainability-oriented destination preferences and to reduce a larger set of interrelated observed variables into a smaller number of interpretable components. The final analytical sample consisted of 529 tourists surveyed across five Adriatic island destinations: Dugi otok, Krk, Lošinj, Vis, and Mljet. Mljet was included in the original study sample, with 28 respondents surveyed on the island. However, because the Mljet subsample was substantially smaller than the subsamples available for the other island destinations, it was retained in analyses based on the total sample but excluded from selected island-specific comparisons presented in Tables 5–7. This decision was made to avoid overinterpreting descriptive differences based on a relatively small island-specific subsample.

Accordingly, analyses referring to the overall sample (N = 529), including the exploratory principal component analysis, include respondents surveyed on Mljet. By contrast, Tables 5–7 present descriptive comparisons only for Dugi otok, Krk, Lošinj, and Vis. The distinction between pooled analyses and island-specific comparisons is explicitly stated in the revised manuscript.

The empirical part of the study was conducted using a **quantitative cross-sectional research design**. The study does not employ a mixed-methods design. Data were collected through a structured questionnaire administered to tourists visiting selected Adriatic islands between 1 June and 30 September 2025. The final sample consisted of 529 tourists visiting Dugi otok, Krk, Lošinj, Vis, and Mljet. The questionnaire was designed to capture respondents' socio-demographic characteristics, travel behaviour, perceptions of island destination attributes, attitudes towards sustainability, tourism and development pressures, natural and cultural values, and experiential characteristics associated with island tourism. Sustainability-related perceptions and destination preferences were primarily measured using five-point Likert-type scales.

Table 1. Respondents according to sociodemographic characteristics (N=529)

Variable and variable form	Number of respondents	Percentage of respondents
Sex		
Male	218	41,21%
Female	311	58,78%
Total	529	100,00%
Age		
15 - 24	61	11,53%
25 - 34	207	39,13%
35 - 44	134	25,33%
45 - 54	72	13,61%
55 - 64	36	6,81%
65+	19	3,59%
Total	529	100,00%
School preparation		
Elementary School	17	3,21%
High School	78	14,74%
College	249	47,06%
Faculty	85	16,09%
Master's Degree	81	15,31%
Doctorate	19	3,59%
Total	529	100,00%
Personal monthly income		
To 800 eur	82	15,50%
801 – 1200 eur	228	43,10%
12001 – 1700 eur	119	22,50%
1701 – 2200 eur	31	5,86%
More than 2200 euros	69	13,04%
	529	100%
Place of employment		
Public authority	47	8,9%
Non-governmental organizations	65	12,27%
Craft	42	7,94%
Company	336	63,52%
Institution	39	7,37%
Type of employment		
Agency mediation	33	6,23%
Banking and insurance	73	13,80%
State or local government	41	7,75%
Industry	167	31,57%
Utilities	16	3,02%

Culture	25	4,73%
Education	26	4,91%
Personal services	32	6,05%
Traffic	39	7,37%
Sports and recreation	9	1,71%
Hospitality	51	9,64%
Fun	9	1,71%
The rest	8	1,51%

Source: author's work

Respondents could answer the questionnaire questions with only one of several possible answers. The sample of respondents consisted of 41.21% men and 58.78% women. Of the more significant age groups, we singled out three groups. 39.13% of respondents were aged 25-35, while 25.33% were respondents between 35-44 years of age, and 13.61% represented the 45-54 age group. Regarding education, almost 2/3 (63.15%) of the respondents have a higher education, 14.74% have a secondary school, and 15.31% of the respondents 81 have completed a master's degree, and 3.59% have a doctorate. Looking at the criterion of type of employment, the majority of people are employed in industry at 31.5%, followed by banks and institutions with 13.5%. By place of employment, 63.52% of respondents work in companies, while 12.27% of respondents are employed in non-governmental organisations. 13.80% earn their monthly income in banking and insurance, 9.64% work in the hospitality industry, 7.37% in transport, 7.75% in state or local administration, 6.23% in agency work, and 6.05% in personal services.

Table 2. Frequency of travel to one of the Adriatic islands for more than three days in the last 12 months

Frequency of travel to one of the Adriatic islands for more than three days in the last 12 months	Number of responses	Percentage of respondents
0 – 1 travel	156	29,49%
2 – 3 travels	228	43,10%
4 – 5 travels	103	19,47%
6 – 10 travels	42	7,94%
11 – 15 travels	0	0%
More than 16 travels	0	0%
Total	529	100,00%

Source: author's work

Accordingly, (Table 2.) 43.0% of respondents who have traveled to the Adriatic islands for more than three days in the last 12 months travel 2 to 3 times a year, 19.47% of respondents who have traveled to the Adriatic islands for more than three days in the last twelve months travel 19.47%, 7.94% of respondents travel between 6 and 10 times, and 29.49% of respondents travel 0-1 time more than three days in the last twelve months. In addition to the stated frequency of travel to the Adriatic islands, some dependent variables will be compared in later analyses, with the frequency of

travel being expressed in only three groups (less frequent, medium and more frequent). Less frequent travel, expressed in further analyses, is travel from 0-1 time, medium travel to the Adriatic islands is 2-3 times during the year, and more frequent travel is travel from four or more times.

Table 3. Daily non-passionate spending per family member on vacation (N=529)

Daily non-passionate spending per family member on vacation (N=529)	Number of responses	Percentage of respondents
to 50,00 eur	17	3,21%
of 51,00 to 100,00 eur	40	7,56%
of 101,00 to 200,00 eur	45	8,50%
of 201,00 to 350,00 eur	66	12,48%
of 351,00 to 500,00 eur	184	34,78%
of 501,00 to 750,00 eur	105	19,86%
More than 751,00 eur	72	13,61%
Total	529	100,00%

Source: author's work

Tourist destinations are spatial units of tourist offer consisting of direct tourist receptive capacities such as accommodation, food and supplies, entertainment, sports and recreation and indirect capacities such as shops, crafts, cultural institutions, and various sights. All of the above capacities, facilities and activities are objective pre-requisites for the development of tourism in a tourist destination and more or less participate in satisfying the needs of consumers in tourism and make up the structure of non-passive consumption.

Table 4. Descriptive indicators of the intensity of influence of destination values, i.e. destination characteristics, on choosing an island as a vacation destination

Descriptive indicators of the intensity of influence of destination values, i.e. destination characteristics, on choosing an island as a vacation destination	Arithmetic mean	Standard deviation	Coefficient of variation
Peace and less crowding	2,87	1,188	41
Less tourist development (mass development)	2,82	1,450	51
A wider range of indigenous products	2,33	1,402	**60**
Greater preservation and protection of the environment	3,13	1,055	34
Greater diversity of landscapes and natural beauty (e.g. beaches)	3,16	1,125	36
Better preservation of flora and fauna	3,19	1,195	38
Better hotel offers and hotel facilities	2,21	1,083	49
Diversity of the indigenous gastronomic offer.	2,33	1,402	**60**
Better destination marketing	2,61	1,122	43
A multitude and diversity of sports and recreational facilities	2,81	1,270	45
Greater kindness and hospitality of the local population	3,12	1,314	42
Richer and greater diversity of vegetation	4,12	0,943	23

Greater presence of historical and cultural landmarks	3,46	1,226	35
Better supply of domestic food products	2,95	1,259	43
Better transport connections	2,12	1,395	**66**
Better entertainment and event facilities	2,86	1,327	46
Better revitalisation of the landscape	3,37	1,194	35
Total	2,91	1,221	44

Source: author's work

The results presented in Table 4 indicate that natural and environmental attributes have the strongest influence on the choice of an island destination. The highest mean was recorded for richer and greater diversity of vegetation (M = 4.12), followed by the presence of historical and cultural landmarks (M = 3.46), landscape revitalisation (M = 3.37), preservation of flora and fauna (M = 3.19), and landscape diversity and natural beauty (M = 3.16). In contrast, transport connections (M = 2.12) and hotel offers and facilities (M = 2.21) were rated as the least influential destination characteristics. The coefficient of variation indicates the greatest agreement among respondents regarding vegetation diversity (CV = 23%), while opinions were most heterogeneous regarding transport connections (CV = 66%). Overall, the findings suggest that natural, environmental, and cultural values are more important in island destination choice than infrastructure and conventional tourism facilities.

Although only 28 valid questionnaires were collected on Mljet, the island was deliberately retained in the study because of its particular relevance to the research context of sustainable island tourism. Mljet represents an especially valuable case from a sustainability perspective due to its highly preserved natural environment, relatively limited level of tourism development and urbanisation, strong dependence on natural resources, and the importance of maintaining a balance between tourism development and environmental protection. These characteristics make Mljet particularly relevant for examining sustainability-oriented tourist preferences, especially those related to environmental preservation, contact with nature, lower tourism intensity, limited development pressures, and the preservation of authentic island identity.The relatively small number of respondents from Mljet (n = 28) resulted from fieldwork conditions and the lower number of eligible and accessible respondents encountered at the predefined survey locations during the data-collection period. Therefore, the smaller Mljet subsample should be interpreted as a fieldwork limitation rather than as an indication of the lower analytical or conceptual importance of the destination. Given the specific sustainability characteristics of Mljet, excluding the island entirely from the study would have reduced the diversity of island contexts represented in the sample. For this reason, the 28 respondents from Mljet were retained in all analyses conducted at the level of the total sample (N = 529), including the exploratory principal component analysis. However, because the Mljet subsample was substantially smaller than those of Krk, Lošinj, Vis, and Dugi otok, it was excluded from selected island-specific comparisons in Tables 5–7. This methodological decision was made to avoid overinterpreting potentially unstable differences based on a small destination-specific subsample while simultaneously preserving Mljet's contribution to the overall analysis of sustainability-oriented preferences.

Table 5. Descriptive indicators of acceptance of individual statements regarding the preservation of the landscape and the beauty of nature

Averment	Island	Arithmetic mean	Standard deviation	Coefficient of variation
I visit islands because of the A greater diversity of landscapes and natural beauty, e.g. beaches	Dugi Otok	3,44	1,129	33
	Krk	3,23	1,271	39
	Lošinj	3,62	1,111	31
	Vis	3,36	1,175	35
I visit islands because there is greater preservation and protection of nature.	Dugi Otok	3,59	1,164	32
	Krk	3,38	1,304	39
	Lošinj	3,64	1,125	31
	Vis	3,32	1,215	37
I visit islands because the flora and fauna are better preserved.	Dugi Otok	2,58	1,125	44
	Krk	2,56	1,198	47
	Lošinj	3,93	0,96	24
	Vis	3,46	1,172	34
I visit islands because of the abundance and diversity of sports and recreational facilities	Dugi Otok	2,45	1,166	48
	Krk	2,44	1,215	**50**
	Lošinj	3,7	1,196	32
	Vis	3,54	1,248	35
I visit islands for the richer and greater diversity of vegetation	Dugi Otok	1,56	0,882	57
	Krk	1,41	0,826	59
	Lošinj	2,29	1,314	**57**
	Vis	**3,87**	1,172	30

Source: author's work

The results in Table 5 confirm that **nature preservation, landscape diversity, and natural beauty** are key factors in island destination choice. **Lošinj and Vis** show the strongest ecological recognition, with Lošinj achieving the highest ratings due to its well-preserved environment. **Krk and Dugi otok** receive lower scores, indicating weaker ecological differentiation. All islands are perceived as ecologically attractive, while sports and recreational facilities are most developed on Lošinj and Vis. Overall, respondents strongly value **flora and fauna,** emphasising Mediterranean biodiversity as a central determinant of destination selection.

Table 6. Level of acceptance of the statement that the chosen island allows for better contact with nature (N=529)

Averment	Island	Stupanj	prihvaćanja	Averment			Total
		1	2	3	4	5	
The chosen Island allows better contact with nature	Dugi otok	18	44	98	**198**	137	495
	Krk	46	71	122	**262**	179	680
	Lošinj	36	57	101	**293**	223	710
	Vis	26	33	121	**254**	221	655
	Total	126	205	442	1.007	760	2.540

Source: author's work

Note: 1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; 5=strongly agree. In each row of the table, the highest absolute (modal) and relative frequencies are printed in bold.

Note: N = 529 refers to the number of unique respondents. Respondents were allowed to select and evaluate more than one island; therefore, the island-specific frequencies represent multiple responses and are not mutually exclusive. The total of 2,540 refers to the number of recorded island evaluations rather than the number of respondents. Consequently, percentages and frequencies presented in this table should be interpreted at the response/evaluation level, not as independent respondent-level observations.

Table 7. Descriptive indicators prihvaćanja Averment da The chosen island allows for better contact with nature (N=529)

Averment	Island	Descriptive	indicators	
		Arithmetic mean	Standard deviation	Coefficient of variation
A secluded island allows for better contact with nature	Dugi otok	3,53	1,319	46
	Krk	3,58	1,314	42
	Lošinj	**3,85**	0,943	23
	Vis	**3,71**	1,059	27

Source: author's work

Table 7 presents descriptive indicators for the statement *"The chosen island allows for better contact with nature"* across four island destinations. Lošinj is rated highest (M = 3.85) with the lowest variability, indicating a strong and consistent perception of nature-oriented experiences. Vis follows with a slightly lower mean (M = 3.71) and moderate dispersion, reflecting a stable but more diverse evaluation. Dugi otok and Krk show lower mean values and higher variability, suggesting more heterogeneous perceptions, likely due to greater spatial diversity and development pressures. Overall, the results confirm that contact with nature is a key factor in island destination preferences, with less developed and ecologically oriented islands perceived as offering more authentic natural experiences.

Table 8. Respondents' attitudes towards the most important aspects of island sustainability

Respondents' attitudes towards the most important aspects of island sustainability	Number of responses	Percentage of respondents
social aspect (encouraging people to stay on the island, demographic development)	93	8,70%
economic aspect (development of entrepreneurship in line with sustainable development, family farms, farming, and indigenous gastronomy)	344	32,51%
ecological aspect (disposal of municipal waste, no illegal landfills)	212	20,04%
energy aspect (energy independence: solar energy, own water supply, etc.)	94	8,89%
natural aspect (establishment of an ecosystem, symbiosis of flora and fauna)	315	29,77%
Total	1.058	100,00%

Source: author's work

Table 8 shows that respondents consider **economic sustainability** the most important aspect of island sustainability (32.51%), particularly through entrepreneurship development, local agriculture, and indigenous gastronomy. This is followed by **environmental preservation** of flora, fauna, and natural landscapes (29.77%). **Infrastructure and resource management**, including water supply, transport, and waste management, are ranked third (20.04%). In contrast, **social sustainability** (8.70%) and **energy efficiency and independence** (8.89%) are perceived as less important, indicating that tourists prioritise economic and natural aspects over social and energy dimensions of island sustainability.

Table 9. Tourists' opinions on the importance of respecting the opinions and views of residents on the sustainability of the island

Tourists' opinions on the importance of respecting the opinions and views of residents on the sustainability of the island	Number of responses	Percentage of respondents
Yes, completely	193	36,48%
Yes, to some extent	161	30,43%
I don't know	78	14,74%
No, to some extent	53	10,02%
No, completely	44	8,32%
Total	529	100,00%

Source: author's work

Most respondents (66.91%) consider the local population a key stakeholder in island development and sustainable tourism, recognising that poor resource management directly threatens environmental values and residents' quality of life. A smaller share (14.74%) expressed no clear opinion, while 18.34% believe that residents' views do not need to be fully considered in tourism development.

Table 10. Tourists' opinion on the availability of information on new municipal and transport infrastructure projects and investment projects (N=529)

Tourists' opinion on the availability of information on new municipal and transport infrastructure projects and investment projects (N=529)	Number of responses	Percentage of respondents
Yes, completely	168	31,76%
Yes, to some extent	155	29,30%
I don't know	89	16,82%
No, to some extent	65	12,29%
No, completely	52	9,83%
Total	529	100,00%

Source: author's work

The results presented in Table 10 indicate a generally positive perception of the availability of information on new municipal and transport infrastructure and investment projects. A total of **61.06% of respondents expressed a positive assessment**, with 31.76% responding "Yes, completely" and 29.30% "Yes, to some extent". In contrast, 22.12% expressed a negative assessment, while 16.82% were undecided. These findings suggest that information on infrastructure and investment development represents a relevant element of tourists' perception of island destinations, particularly in the context of transparency and sustainable destination development.

Table 11. Descriptive statistics and t-test for the items visited at the island destination

Item	N	M	SD	95% CI	t	p
Satisfactory gastronomic offer	529	4,11	0,93	4,03–4,19	**2,72**	**0,007**
Satisfactory hospitality and friendly local population	529	3,85	0,98	3,77–3,93	**–3,52**	**<0,001**
Satisfactory hotel accommodation and facilities provided by the hotel	529	4,13	0,86	4,06–4,20	**3,48**	**<0,001**
Satisfactory cultural and historical heritage	529	3,97	0,99	3,89–4,05	**–0,70**	**0,486**
Satisfactory offer of domestic food products	529	3,64	0,84	3,57–3,71	**–9,86**	**<0,001**
Satisfying natural beauty	529	3,59	0,84	3,52–3,66	**–11,23**	**<0,001**
Satisfactory transport connections	529	4,02	0,79	3,95–4,09	**0,58**	**0,561**
Satisfactory variety of catering facilities and other entertainment content	529	3,98	0,89	3,90–4,06	**–0,52**	**0,605**
Fewer crowds due to fewer tourists	529	4,27	0,78	4,20–4,34	**7,96**	<0,001
Satisfactory sports and recreational facilities	529	4,00	0,84	3,93–4,07	**0,00**	**1,000**
Impression of neglect and insufficient horticultural arrangement of the destination	529	3,89	0,87	3,82–3,96	**–2,91**	**0,004**
Excessive crowds at all local events, museums and festivals	529	4,36	0,85	4,29–4,43	9,74	<0,001
Excessively high prices	529	4,36	0,82	4,29–4,43	**10,10**	**<0,001**

Note: N - sample size, M - mean, SD - standard deviation, CI - confidence intervals of the mean (low and high), t - simple sample t - test testing the difference from point 4 out of 5 on the Likert scale, p - statistical significance, * - items with a mean value significantly greater than 4.

Source: author's work

The results indicate that the most pronounced positive evaluations are associated with fewer crowds resulting from lower tourist numbers ($M = 4.27$; $p < 0.001$), the quality of hotel accommodation ($M = 4.13$; $p < 0.001$), and the gastronomic offer ($M = 4.11$; $p = 0.007$). At the same time, respondents strongly recognise the negative aspects of tourism pressure, particularly excessive crowds at local events, museums, and festivals ($M = 4.36$; $p < 0.001$), as well as excessively high prices ($M = 4.36$; $p < 0.001$). Statistically significant differences were also found for the hospitality and friendliness of the local population ($p < 0.001$), the availability of local food products ($p < 0.001$), natural beauty ($p < 0.001$), and the perception of insufficient destination maintenance and landscaping ($p = 0.004$). In contrast, cultural and historical heritage ($p = 0.486$), transport connections ($p = 0.561$), the variety of catering and entertainment facilities ($p = 0.605$), and sports and recreational facilities ($p = 1.000$) did not show statistically significant differences. A key finding is a notable sustainability paradox: respondents strongly value destinations characterised by fewer tourists and lower levels of crowding, while simultaneously identifying overcrowding and high prices as the most pronounced destination-related problems. This finding further highlights the importance of managing tourism intensity as a key component of the sustainable development of island destinations.

Table 12. Descriptive statistics of the specifics of the offer of the island destination, considering the uniqueness of the locality

Item	N	M	SD	95% CI	t	p
The chosen island is an ideal nautical destination	529	2,87	1,04	2,78–2,96	–24,99	<0,001
The selected island allows you to visit small indigenous catering establishments (taverns)	529	2,94	1,25	**2,83–3,05**	**–19,50**	**<0,001**
The selected island has several cultural and sacred objects	529	4,28	0,83	**4,21–4,35**	**7,76**	**<0,001**
The chosen island provides insight into a multitude of customs and intangible heritage	529	3,57	1,20	**3,47–3,67**	**–8,24**	**<0,001**
The chosen island allows you to visit several historical and archaeological sites	529	3,78	1,05	**3,69–3,87**	**–4,82**	**<0,001**
The chosen island allows for better contact with nature	529	3,83	1,05	**3,74–3,92**	**–3,72**	**<0,001**
The chosen island is not overcrowded with tourists	529	4,34	0,99	**4,26–4,42**	**7,90**	**<0,001**

Source: author's work

The results in Table 12 confirm the high value of island cultural heritage. Respondents strongly agreed that the selected islands are **not overcrowded** ($M = 4.34$) and offer **numerous cultural and sacral sites** ($M = 4.28$), while also recognising **good contact with nature** ($M = 3.83$). In contrast, islands were least perceived as **ideal nautical destinations** ($M = 2.87$), which is expected given that respondents were not sailors. Overall, islands were primarily chosen for their rich history, cultural tradition, natural landscape, and the lifestyle of the local population.

Exploratory Principal Component Analysis

Principal component analysis was employed to explore whether the observed sustainability-related destination attributes could be represented by a smaller and conceptually interpretable set of underlying preference dimensions. The purpose of PCA was therefore not to confirm a predetermined measurement structure, but to explore patterns of association among the observed variables and identify broader dimensions characterising tourists' sustainability-oriented preferences for Adriatic island destinations. Given this exploratory objective, PCA provides an appropriate first step toward developing a more parsimonious representation of island destination preferences, which may subsequently be validated using confirmatory approaches in future research.

Table 13. KMO i Bartlettov test

Indicators	Value
Kaiser–Meyer–Olkin (KMO)	0.926
Bartlett's Test of Sphericity – χ^2	6.325,703
df / Sig.	171 / < ,001

Source: author's work

KMO > 0.90 indicates a very good adequacy of the sample; Bartlett's test ($p < .001$) confirms that the correlation matrix is suitable for factorisation.

Table 14. Total explained variance

Component	SS loadings	% variances	Cumulative %
1	4,269	22,47	22,47
2	4,658	24,52	46,99
3	3,954	20,81	67,80

Source: author's work

Reliability of the measurement instrument. Before the multivariate analysis, the internal consistency of the sustainability-oriented island destination preference scale was assessed using Cronbach's alpha. The reliability analysis included the 19 Likert-type items subsequently entered into the principal component analysis (PCA), covering perceptions of natural and environmental values, avoidance of mass tourism and development pressures, cultural authenticity and local identity, and the psychological experience of an island vacation. All items were measured on the same five-point Likert scale. Cronbach's alpha was calculated for the complete 19-item scale using valid responses from the total sample (N = 529). The resulting coefficient was $\alpha = 0.960$, indicating excellent internal consistency of the measurement instrument and supporting the suitability of the item set for subsequent multivariate analysis.

Table 15. Rotated component matrix (Varimax)

Items	Component 1	Component 2	Component 3	h^2
The island has preserved nature	0,007	0,819	-0,098	0,681
The island is very uninhabited	-0,764	-0,043	-0,193	0,624
The island offers authentic cultural experiences	-0,084	0,087	-0,781	0,625
The island provides an escape from everyday life	-0,151	0,828	-0,121	0,724
The island is not overdeveloped	-0,648	0,068	-0,200	0,464
The island's cultural heritage is preserved	-0,191	-0,023	-0,864	0,784
A stay on the island offers peace	-0,067	0,862	-0,003	0,747
The island is devoid of mass tourism	-0,877	0,116	-0,125	0,798
Tradition and local identity are visible	-0,150	0,201	-0,717	0,577
The island allows for better contact with nature	-0,064	0,794	-0,067	0,638
There are no excessive tourist crowds on the island	-0,899	0,102	-0,048	0,821
The authenticity of the offer is important to me when choosing an island	-0,218	0,042	-0,793	0,678
The island offers an experience of untouched nature	-0,129	0,769	0,033	0,610
The island is not burdened with large investments	-0,909	0,140	-0,041	0,847
Cultural events contribute to the experience of the destination	-0,018	0,143	-0,813	0,682
A stay on the island has a relaxing effect	-0,059	0,768	-0,126	0,610
Mass tourism spoils the experience of the island	-0,809	0,077	-0,226	0,712
The local community preserves the identity of the island	-0,116	0,157	-0,743	0,590
The island provides a sense of isolation and privacy	-0,168	0,771	-0,216	0,670

Note: Factor saturations ≥ |0.40|.h^2 – utilities are shown.

Source: author's work

Based on the items with the highest factor loadings, three clearly differentiated latent dimensions of preferences for island destinations can be identified. The exploratory PCA identified three clearly differentiated dimensions of sustainability-oriented preferences for Adriatic island destinations.

Component 1 – Avoidance of mass tourism and development pressures. This dimension captures preferences for destinations characterised by lower tourism intensity, limited overcrowding, lower levels of development pressure, and the absence of excessive investment. It reflects tourists' sensitivity to the potential negative consequences of mass tourism and intensive destination development.

Component 2 – Natural values and the psychological experience of vacation. This component integrates environmental preservation, contact with nature, peace, relaxation, escape from everyday life, and the experience of relatively untouched natural surroundings. It therefore represents both the ecological and experiential dimensions of island destination preferences.

Component 3 – Cultural authenticity and local identity. This dimension encompasses preserved cultural heritage, tradition, authenticity of the tourism offer, cultural experiences, and the role of the local community in maintaining island identity. It reflects the importance of symbolic, cultural, and identity-related attributes in tourists' evaluations of island destinations. Together, the three components explain 67.80% of the total variance, indicating that sustainability-oriented island destination preferences can be meaningfully represented through a smaller number of conceptually coherent dimensions. Rather than viewing sustainability as a single destination characteristic, the findings suggest that tourists' preferences integrate environmental and experiential qualities, attitudes towards tourism and development intensity, and the preservation of cultural authenticity and local identity.

The factor loading structure confirms that preferences for island destinations can be explained by a smaller number of latent dimensions that integrate natural, developmental, and cultural characteristics, thereby empirically supporting the conceptual model of the work. The descriptive results indicate that tourists generally assign considerable importance to natural and ecological destination attributes, while infrastructure and transport characteristics receive comparatively lower mean ratings. However, these descriptive differences alone cannot be interpreted as formal statistical support for H1. A conclusion regarding H1 must be based on the paired-samples comparison of the two respondent-level composite scores. Similarly, Table 8 descriptively shows that the economic aspect of sustainability received the largest individual share of responses (32.51%), followed by the natural aspect (29.77%) and the ecological aspect (20.04%). Since respondents provided multiple responses, these percentages are not statistically independent. Therefore, the statistical evaluation of H2 requires Cochran's Q test and the corresponding respondent-level pairwise comparisons. Until these tests are conducted, Table 8 should be interpreted as descriptive evidence rather than confirmation of H2.

H3 received partial inferential support from the one-sample t-tests. Respondents reported significantly high perceptions of excessive crowding at local events, museums and festivals ($M = 4.36$; $t = 9.74$; $p < 0.001$) and recognised fewer crowds as a relevant advantage of island destinations ($M = 4.27$; $t = 7.96$; $p < 0.001$). Nevertheless, because H3 also refers explicitly to excessive investment and development pressure, its final evaluation requires corresponding one-sample tests for the items measuring overdevelopment, large investments and the perceived negative effects of mass tourism. Consequently, H3 should presently be classified as partially supported rather than fully supported.

H4 was supported by the PCA results. The KMO value of 0.926 and the statistically significant Bartlett's test of sphericity ($\chi^2 = 6{,}325.703$; $df = 171$; $p < 0.001$) confirmed the suitability of the correlation matrix for component extraction. The three retained components explained 67.80% of the total variance and represented avoidance of mass tourism and development pressures, natural values and the psychological

vacation experience, and cultural authenticity and local identity. Principal component analysis (PCA) was conducted to reduce the initial set of 19 preference items and identify a smaller number of interpretable dimensions underlying tourists' evaluations of island destinations. PCA was selected because the primary analytical objective was data reduction and the construction of a parsimonious empirical representation of destination preferences, rather than the estimation of an explicitly specified latent measurement model. Before component extraction, the suitability of the correlation matrix was evaluated using the Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett's test of sphericity. The KMO value of 0.926 indicated excellent sampling adequacy, while Bartlett's test was statistically significant ($\chi^2 = 6{,}325.703$; df = 171; $p < 0.001$), confirming that the correlations among the items were sufficiently strong for component analysis. The number of retained components was determined by combining several criteria: eigenvalues greater than 1, inspection of the scree plot, cumulative explained variance and the theoretical interpretability of the resulting solution. These criteria supported the retention of three components. After rotation, the three-component solution explained 67.80% of the total variance, which was considered satisfactory for behavioural and tourism research based on multi-item attitudinal measures. The retained solution was also substantively coherent with the theoretical framework concerning natural values, cultural authenticity and tourism development pressures. Varimax rotation with Kaiser normalisation was applied to obtain a simpler and more interpretable component structure. An orthogonal rotation was selected because the analytical objective was to identify distinct and parsimonious dimensions of island destination preferences that could subsequently be interpreted and used independently. Nevertheless, because dimensions of destination preferences may theoretically be related, this decision represents a methodological simplification. Future research should compare the present solution with an oblique rotation, such as Direct Oblimin or Promax, and report the correlations between the extracted dimensions.

The items were measured on a five-point Likert scale and were treated as approximately continuous variables. This approach was considered acceptable given the five response categories, the relatively large sample ($N = 529$), and the exploratory and data-reduction purpose of PCA. Pearson correlations were therefore used as the analytical basis. However, the ordinal nature of the items should be acknowledged. Future studies should examine the robustness of the component structure using a polychoric correlation matrix and ordinal exploratory factor analysis. Component loadings with an absolute value of at least 0.40 were considered substantively relevant. Items were assigned to the component on which they had the highest absolute loading. Potential cross-loading was defined as an absolute secondary loading of at least 0.30, particularly when the difference between the primary and secondary loadings was smaller than 0.20. Communalities, theoretical coherence and item wording were considered together when interpreting and retaining the items.

The rotated component matrix produced a clear three-component structure. All 19 items had primary absolute loadings above the predefined threshold of 0.40, ranging from 0.648 to 0.909 on Component 1, from 0.768 to 0.862 on Component 2 and from 0.717 to 0.864 on Component 3. Communalities ranged from 0.464 to 0.847, indicating that the retained components explained a substantial proportion of variance in most items.

No problematic cross-loadings were identified. None of the items had a secondary absolute loading of 0.30 or higher, and the differences between the primary and secondary loadings were generally substantial. The absence of pronounced cross-loadings supports the empirical distinctiveness of the three components and facilitates their substantive interpretation. Nevertheless, the component labels were determined by considering the common conceptual meaning of the items rather than relying exclusively on the magnitude of individual loadings.

Component 1 – Avoidance of mass tourism and development pressures was defined by the absence of excessive investment (loading = −0.909), the absence of excessive tourist crowds (−0.899), the absence of mass tourism (−0.877), the perception that mass tourism spoils the island experience (−0.809), the island's low level of habitation (−0.764) and the absence of overdevelopment (−0.648). These items consistently reflect tourists' sensitivity to crowding, intensive construction and excessive development pressures.

All loadings on the first component were negative. The negative signs do not imply that the items are unimportant or that respondents negatively evaluated the corresponding destination characteristics. The direction of a component is mathematically arbitrary and may be reversed without changing the substantive solution. For clearer interpretation, Component 1 may therefore be reverse-scored so that higher component scores indicate a stronger preference for destinations protected from mass tourism, crowding and excessive investment.

The item *"The island is very uninhabited"* should be linguistically reconsidered because the current wording may be interpreted ambiguously. A clearer formulation would be *"The island is sparsely populated"* or *"The island offers a low-density and uncrowded environment."* Its strong loading on Component 1 indicates that respondents associated isolation and low population density with the broader avoidance of mass tourism and development pressures.

Component 2 – Natural values and psychological vacation experience comprised preserved nature (0.819), escape from everyday life (0.828), peace (0.862), contact with nature (0.794), untouched nature (0.769), relaxation (0.768) and isolation and privacy (0.771). The component integrates the ecological characteristics of the destination with the psychological benefits of staying on an island. It therefore represents more than an evaluation of natural resources: it reflects an experiential preference in which preserved nature provides peace, relaxation, privacy and temporary escape from everyday life.

Although this component combines environmental and psychological content, the very low secondary loadings indicate that the items form an empirically coherent dimension rather than two competing subdimensions. Nevertheless, future confirmatory research could examine whether natural values and psychological restoration should be modelled as separate but correlated latent constructs.

Component 3 – Cultural authenticity and local identity included preservation of cultural heritage (−0.864), cultural events (−0.813), authentic cultural experiences (−0.781), importance of an authentic offer (−0.793), local community preservation of island identity (−0.743), and the visibility of tradition and local identity (−0.717). This component reflects the symbolic, cultural and community-based dimension of island destination preferences. As with Component 1, the negative signs are a consequence

of component orientation and do not change the substantive interpretation. The component can be reverse-scored so that higher scores represent a stronger preference for cultural authenticity, preserved heritage, local tradition and community identity. Overall, the rotated solution demonstrates a well-defined component structure. The absence of substantial cross-loadings, satisfactory communalities and clear theoretical coherence support the interpretation of the three retained components. The results therefore provide empirical support for H4, according to which island destination preferences can be represented by a smaller number of dimensions integrating developmental, natural-experiential and cultural characteristics.

Discussion of research results

The findings confirm that natural and environmental attributes primarily shape tourist preferences for island destinations, whereas infrastructural characteristics play a secondary role. Landscape diversity, environmental preservation, and the conservation of flora and fauna emerged as particularly important determinants of island destination choice. This finding is consistent with previous research emphasising the importance of ecological destination image, environmental beliefs, and attitudes towards ecotourism in shaping destination evaluations and behavioural intentions (Luong, 2023; Huo et al., 2024). It also supports the broader sustainability perspective proposed by Rodríguez et al. (2008), according to which the long-term attractiveness and competitiveness of island destinations depend strongly on preserving their environmental resources. The present study extends these findings by demonstrating that, in the Adriatic island context, natural attributes are not merely complementary elements of destination attractiveness but constitute one of the central dimensions around which tourists structure their island preferences. The results are also consistent with Gössling et al. (2017), who emphasise the particular vulnerability of island destinations due to their limited carrying capacity, infrastructural constraints, and dependence on natural resources. In the present study, tourists showed a clear preference for preserved nature, contact with nature, peace, and lower levels of tourism development. These findings suggest that the environmental sensitivity of islands identified in previous research is reflected not only in destination management challenges but also in tourist preferences themselves. In other words, the characteristics that make islands environmentally vulnerable may simultaneously constitute some of their most important competitive advantages from the visitor perspective.Differences observed among the analysed islands further demonstrate that sustainability-oriented perceptions are not uniform across island destinations. Lošinj showed the most stable and positive perception of contact with nature, whereas evaluations of Dugi otok and Krk were more heterogeneous. This finding complements Razović (2015), who emphasised the need to align tourism development on Croatian offshore islands with local resources and the preferences of tourists and residents. The differences identified in the present study may reflect variations in tourism intensity, destination development, accessibility, spatial characteristics, and the degree to which individual islands have maintained a recognisable nature-oriented tourism identity. Consequently, sustainability strategies for Adriatic islands should not be based on a uniform development model but should take destination-specific characteristics into account.

An important finding concerns respondents' understanding of **island sustainability**. Economic and natural aspects were perceived as more important than so-

cial and energy dimensions. This partially differs from the integrated sustainability approach presented in the literature, which conceptualises sustainable tourism as a balance between environmental, economic, and social objectives. The comparatively lower importance attributed to social and energy dimensions may be explained by the visitor perspective adopted in this study. Tourists are more directly exposed to visible destination attributes, such as landscape quality, environmental preservation, local products, and tourism services, whereas demographic sustainability, energy independence, and other structural issues may be less immediately observable during a temporary stay. This result therefore extends previous research by demonstrating that tourists' perceptions of sustainability may differ from broader policy-oriented conceptualisations of sustainable destination development.

The findings concerning **crowding and tourism pressure** are particularly relevant in relation to previous overtourism research. Respondents strongly valued lower tourist density and the possibility of avoiding crowds, while at the same time identifying excessive crowds at events, museums, and festivals, as well as high prices, as prominent destination-related problems. This result is consistent with García-Buades et al. (2022) and Krajíčková et al. (2022), who demonstrate that perceived overtourism can negatively affect destination evaluations and stakeholder attitudes. However, the present findings reveal an additional **sustainability paradox**: tourists are attracted to islands partly because they associate them with peace, lower density, and escape from mass tourism, yet tourism demand itself may progressively undermine precisely these attributes. This tension is particularly important for island destinations because of their limited spatial and environmental carrying capacity.The PCA results further extend previous studies by showing that individual destination attributes do not operate independently but form **three coherent latent dimensions of island preference**: (1) avoidance of mass tourism and development pressures, (2) natural values and the psychological experience of vacation, and (3) cultural authenticity and local identity. This structure is broadly consistent with the push–pull perspective on destination choice (Dann, 1977; Crompton, 1979) and with more recent attempts to integrate tourist motivation, destination image, and sustainability-related characteristics (Joseph & Gillariose, 2025). Nevertheless, the present study extends this literature by demonstrating that, in the context of Adriatic islands, sustainability-related attributes are embedded within broader experiential and identity-based preference structures rather than functioning as isolated destination characteristics.

The cultural dimension identified through PCA also confirms the importance of authenticity, preserved cultural heritage, tradition, and local identity in shaping the island experience. This complements the environmental orientation of the results and demonstrates that tourists' sustainability-oriented preferences cannot be reduced exclusively to ecological concerns. Instead, the findings indicate that the attractiveness of island destinations is based on the interaction between preserved natural resources and the preservation of distinctive local cultural characteristics. In this respect, the study contributes to a more integrated understanding of island sustainability by linking environmental preservation with cultural authenticity and destination identity.Overall, the findings largely **confirm previous research** concerning the importance of environmental preservation, carrying capacity, destination image, and the negative effects of overtourism, while also **extending existing knowledge in three important respects**. First, they demonstrate

that natural and sustainability-related characteristics constitute central dimensions of tourist preferences in the Adriatic island context. Second, they identify a sustainability paradox in which tourists simultaneously seek uncrowded destinations and perceive tourism-induced crowding as a major problem. Third, the PCA demonstrates that island preferences can be organised into three broader dimensions combining development pressures, nature-based and psychological experiences, and cultural authenticity. These findings suggest that sustainable island destination management should focus not only on environmental protection but also on controlling tourism intensity, preserving local identity, and maintaining the experiential qualities that differentiate islands from more intensively developed coastal and urban destinations.

CONCLUSION

This study examined sustainability-oriented tourist preferences for Adriatic island destinations, focusing on the ways in which environmental, experiential, developmental, and cultural destination attributes are reflected in tourists' evaluations and destination choice. The findings demonstrate that sustainability-oriented preferences cannot be adequately understood through isolated destination attributes alone. Instead, tourists evaluate island destinations through a multidimensional combination of preserved natural environments, the intensity and consequences of tourism development, the quality of the vacation experience, and the authenticity of cultural and local identity. The descriptive findings indicate the particular importance of natural and environmental characteristics in tourists' evaluations of island destinations. Contact with nature, landscape and environmental preservation, lower tourism intensity, and opportunities for peaceful and relaxing experiences emerge as relevant elements of island destination attractiveness. At the same time, respondents demonstrate sensitivity to overcrowding, high tourism intensity, and excessive development pressures, suggesting that the attractiveness of island destinations is closely associated with their ability to preserve characteristics that differentiate them from highly developed mass-tourism destinations. The exploratory PCA provides further insight into the structure of these preferences by identifying three distinct dimensions: *avoidance of mass tourism and development pressures***,** *natural values and the psychological experience of vacation, and cultural authenticity and local identity***.** Together, these dimensions explain 67.80% of the total variance. The findings therefore suggest that sustainability-oriented preferences for Adriatic island destinations extend beyond environmental concerns and encompass experiential, developmental, cultural, and identity-related considerations. The theoretical contribution of the study lies in providing a multidimensional empirical representation of sustainability-oriented island destination preferences. Rather than conceptualising sustainability exclusively through environmental protection, the findings indicate that tourists simultaneously associate sustainable island destinations with controlled tourism development, lower levels of crowding, opportunities for contact with nature and psychological restoration, and the preservation of cultural authenticity and local identity. This perspective contributes to the literature on destination choice and sustainable island tourism by linking sustainability-related attributes with the broader experiential and symbolic dimensions of tourist preferences. From a managerial perspective, the findings indicate that sustainable destination strategies for Adriatic islands should not be based solely on increasing tourism supply or visitor numbers. Destination managers

should place greater emphasis on preserving natural resources, managing tourism intensity and development pressures, protecting cultural heritage and local identity, and creating high-quality experiences characterised by authenticity, contact with nature, and lower levels of congestion. Such an approach may contribute to destination differentiation while simultaneously supporting the long-term environmental and socio-cultural sustainability of island communities. Several limitations should be acknowledged. The research was conducted on a sample of tourists visiting selected Adriatic islands during a specific tourism season, which limits the generalisability of the findings to other island contexts and periods of the year. Furthermore, the exploratory nature of PCA means that the identified component structure should not be interpreted as a fully validated measurement model. Future research should therefore examine the stability of the three-dimensional structure using independent samples and confirmatory factor analysis (CFA). Subsequent research could also employ structural equation modelling (SEM) to investigate causal relationships between sustainability-oriented preferences, destination image, perceived authenticity, satisfaction, destination attachment, and behavioural intentions. Comparative studies across different island destinations and tourism development contexts would further contribute to understanding whether the identified preference dimensions are specific to the Adriatic context or represent broader patterns of sustainable island destination choice.

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https://doi.org/10.7251/EMC2603798O
UDK: 331.105.2:316.662(4-672EU)
Datum prijema rada: 4. mart 2026.
Submission Date: March 4, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 798-810

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

STRATEGIC ALIGNMENT OF SPORT MANAGEMENT EDUCATION WITH LABOR MARKET DEMANDS: INSIGHTS FROM FOCUS GROUP RESEARCH

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Abstract: *This study addresses the critical misalignment between academic preparation and the evolving demands of the sports management labor market. While the industry undergoes rapid professionalization and technological disruption, a significant "skills gap" persists between graduate competencies and employer expectations. The primary objective of this research is to identify and analyze the determinants of professional readiness through the lived experiences and retrospective perceptions of the graduates themselves. Utilizing a qualitative research strategy, data was collected through two focus group discussions involving twelve sports management graduates. The findings indicate that while university programs provide a robust theoretical foundation and a broad disciplinary overview, graduates frequently encounter significant hurdles when transitioning into professional practice. The most prominent deficiencies identified include a lack of preparation for Human Resource processes, specifically regarding self-presentation and recruitment navigation, limited proficiency in advanced digital and technological tools, and a pressing need for rigorous training in business negotiation and formal communication. The research concludes that to bridge this gap, academic institutions must innovate their curricula toward greater practical relevance. Essential steps include the integration of project-based learning centered on real-world industry mandates, the expansion of structured and longitudinal internships, and the introduction of modern coursework reflecting current digital trends. Ultimately, only a strategic partnership between academia and the professional sphere can ensure that graduates transition from being theoretically proficient experts to confident, practice-ready managers capable of navigating the complex challenges of the 21st-century sports industry.*

Keywords*: Sport Management, Labor Market, Focus Group, Higher education, Career preparedness*

JEL Classification: *M54, J2, Z22, I21*

INTRODUCTION

In contemporary social science discourse, sport is increasingly conceptualized as a fundamental socio-economic and cultural construct. Progressive tendencies toward globalization and the institutional professionalization of the modern sporting environment have exerted mounting pressure on the efficiency of management processes, both at the organizational level and within the framework of international sporting events. As a consequence of this transformation, the role of sport managers has been significantly enhanced and redefined. Their competency profiles are currently undergoing rapid diversification, spanning from strategic planning and marketing communications to the integration of emergent technologies. This evolution necessitates a high degree of interdisciplinarity and a profound understanding of the idiosyncratic characteristics inherent to the sports industry.

A primary determinant of human capital development and subsequent professional mobility within this sector is the process of higher education. However, the current state of sport management education poses a significant challenge for academic institutions, driven primarily by high labor market volatility, progressive technological disruption, and the intensive commercialization of the sporting landscape. Although a gradual curricular transformation is observable, shifting from traditional models toward business-oriented management paradigms, there remains a persistent demand for educational content to remain relevant and responsive to the exigencies of real-world practice.

This discrepancy between academic preparation and the practical requirements of the industry constitutes one of the core specificities of the labor market in sport management. Graduates frequently exhibit limited transferability of theoretical concepts into the operational environment.

Although previous studies have explored employer expectations, graduate employability, competency development, and curriculum design within sport management education(Braunstein-Minkove & DeLuca, 2015; DeLuca & Braunstein-Minkove, 2016; Fahrner & Schüttoff, 2020; Wohlfart et al., 2022), considerably less attention has been devoted to retrospective graduate reflections on the transition from higher education into professional practice. Existing research predominantly evaluates competencies from institutional or employer perspectives, while graduates' lived experiences of entering the sport labor market remain underexplored. This study addresses this gap by examining how sport management graduates retrospectively assess their preparedness for professional practice, identify competency deficiencies, and evaluate the alignment between university education and contemporary labor market expectations.

Based on the identified research gap, the study addresses the following research questions:

RQ1: Which competencies and skills do graduates consider insufficiently developed during their university education?

RQ2: How do graduates evaluate the alignment between academic preparation and labor market requirements?

LITERATURE OVERVIEW

At its core, sports management is an inherently interdisciplinary domain, acting as a crossroads where general management, economics, legal frameworks, and sociology intersect within the unique ecosystem of sport (Çiftçi & Mirzeoğlu, 2014; Čáslavová, 2020). While the field remains firmly anchored in traditional managerial functions, namely planning, organizing, staffing, leading, and controlling (Koontz & Weihrich, 1998; Pedersen & Thibault, 2019), it is far from a mere carbon copy of corporate administration. Instead, it requires a nuanced application of these principles (Hoye et al., 2015; Masteralexis et al., 2015) to fit a sector that operates under its own set of "house rules."

The distinction of sports management lies in several idiosyncratic characteristics that set it apart from traditional business sectors. These include the systemic necessity of maintaining competitive balance (where the success of one's competitor is actually vital for the league's health), the intricacies of unique league structures, and a heavy, often structural reliance on volunteerism (Cuskelly et al., 2006; Shilbury, 2012; Šíma, 2019; Čáslavová, 2020; Gammelsæter, 2021). Furthermore, the pervasive force of commercialization must be balanced against the reality that in sport (Dowling et al., 2014; Vamplew, 2023), organizational motivation is rarely driven by financial profit alone (Andreff & Szymanski, 2006). Success in this field is frequently measured through a complex interplay of social impact, competitive achievement, and community identity (Šíma, 2019), making the manager's role as much about stewardship as it is about the bottom line.

The Evolving Labor Market

The contemporary labor market in sports management is characterized by robust expansion and an escalating demand for highly qualified professionals. This trend reflects a broader global shift toward the professionalization of the industry (Horgby & Ericsson, 2023; Vamplew, 2023), where traditional "gut-feeling" management is being replaced by data-driven strategy and sophisticated organizational structures. However, a significant tension remains at the heart of this growth: despite the concerted efforts of academic institutions to produce "practice-ready" graduates, research consistently highlights a persistent misalignment, often referred to as the "skills gap", between the competencies offered by university alumni and the granular, evolving requirements of sports organizations (Schwab et al., 2015; Miragaia & Soares, 2017; Ventura, 2023).

Traditional pedagogical models, which have historically prioritized the transmission of a fixed set of theoretical "truths," are increasingly finding themselves outpaced by the market's volatility (Light & Dixon, 2007). In an era where information is ubiquitous but its application is complex, a static curriculum is no longer sufficient. Consequently, the focus of professional preparation is shifting away from pure content delivery toward the cultivation of cognitive agility (Light & Dixon, 2007). In today's landscape, critical thinking, adaptability, and the capacity to navigate "wicked" or ill-defined problems have moved from the periphery to the very center of what it means to be a "qualified" sports manager (Skinner & Gilbert, 2007; DeLuca & Braunstein-Minkove, 2016; Zimmer & Keiper, 2021). The challenge for modern universities is thus not just to teach management, but to foster a mindset capable of managing under conditions of constant flux.

The Modern Competency Profile

The competency framework for sports managers can be conceptually divided into two primary categories: generic skills, such as organizational leadership and strategic communication, and sport-specific expertise (Fahrner & Schüttoff, 2020; Teodora, 2020). Within this duality, interpersonal, social and communication competencies have emerged as the paramount "soft" drivers of success (Pedersen & Thibault, 2019; Giel et al., 2022; Guidotti et al., 2023; Opelík et al., 2025). Because sports managers act as the operational glue (Masteralexis et al., 2015; Retar et al., 2015) between a diverse array of stakeholders, ranging from elite professional athletes and dedicated volunteers to corporate sponsors and passionate fanbases, their ability to navigate complex social dynamics is non-negotiable. Furthermore, in today's volatile organizational landscape, the modern manager is increasingly expected to serve as a catalyst for innovation (Masteralexis et al., 2015; Jiang, 2023) and a steady hand during periods of rapid structural change.

Parallel to these social requirements, the demand for digital literacy and technological proficiency has escalated dramatically (Hunjet & Kozina, 2014; Wohlfart et al., 2018; Pedersen & Thibault, 2019). It is no longer sufficient for graduates to possess a rudimentary understanding of office software; the market now dictates a sophisticated command of data analytics, digital marketing strategies, e-commerce platforms, and advanced social media management (Wohlfart et al., 2018; Teodora, 2020; Swim et al., 2023; Opelík et al., 2024).

With the maturation of Industry 4.0 and the pervasive integration of Artificial Intelligence (AI) tools, this pressure has reached a critical tipping point (López-Carril et al., 2020; Keiper et al., 2023; Milovanović & Novaković, 2025). These technological shifts are not merely incremental updates but represent a fundamental transformation of the industry's DNA, compelling academic programs to undergo a radical revision of their curricula to ensure that theoretical knowledge remains synchronized with the digital reality of the 21st-century sports market.

The Theory-Practice Nexus and the Need for Graduate Reflection

A defining challenge in sports management education remains the ongoing debate regarding the optimal balance between theoretical rigor and practical application (Cunningham, 2013; Fink, 2013; Cunningham et al., 2021). Research consistently indicates that experiential learning, specifically through structured internships, is often perceived by students and employers alike as the most transformative component of the educational journey (Emery et al., 2012; Hawzen & King-White, 2024). The transition from the lecture hall to the professional arena is notoriously difficult without sufficient field exposure; consequently, the integration of industry practitioners and project-based learning (DeLuca & Braunstein-Minkove, 2016; Grant et al., 2023) has moved from being a pedagogical "bonus" to a strategic necessity for the field's sustainable development.

Given these theoretical foundations, it is clear that academic programs must remain agile to survive in a volatile market. To stay synchronized with the industry's pulse, it is essential to conduct retrospective evaluations of professional readiness (Braunstein-Minkove & DeLuca, 2015; DeLuca & Braunstein-Minkove, 2016; Fahrner & Schüttoff, 2020; Wohlfart et al., 2022). Understanding how graduates reflect

on their own preparation and identifying the specific "missing links" they encountered upon entering the workforce, is vital for closing the gap between academic output and professional reality.

METHODOLOGY

This study employs a qualitative, interpretive research design, which is particularly suited for exploring the nuanced, subjective professional experiences of graduates within the specific socio-economic context of the sports labor market. This approach allows for the elucidation of underlying causalities in the theory-practice gap that quantitative metrics often overlook. Within the field of sport management, qualitative designs are increasingly employed to analyze specific labor market scenarios, stakeholder management processes and evaluate educational processes (Braunstein-Minkove & DeLuca, 2015; DeLuca & Braunstein-Minkove, 2016; Evans et al., 2021; Pitney et al., 2024; Hospodková et al., 2025). This approach transcends purely statistical data, providing insight into the subjective perceptions and lived experiences of labor market actors.

The primary data collection method employed was the focus group. This method was selected for its inherent dynamism; the interaction between respondents, subsequent follow-up commentary, and the opportunity for a confrontation of perspectives facilitate a more profound comprehension of the research problem.

Participants were selected via purposive, criterion-based sampling to ensure they possessed the necessary 'lived experience' to reflect on the transition from academia to the workforce. Inclusion criteria required participants to: (1) be graduates of the specific Sport Management degree program, (2) have a minimum of one year of professional experience in the sports sector, and (3) represent a diverse range of organizational roles (e.g., commercial or non-profit). A total of two focus group sessions were conducted, each involving six participants (N = 12). While the sample size (N = 12) is focused, it aligns with established qualitative protocols for focus group research, where the emphasis is on data richness and depth rather than statistical representativeness. Data collection continued until theoretical saturation was reached, meaning no significantly new thematic categories emerged during the final stages of the second focus group discussion. Although the sample was homogeneous regarding the field of study, it exhibited internal heterogeneity in terms of graduation year, gender, and age.

The focus groups followed a semi-structured protocol organized into thematic areas derived from the conceptual framework illustrated in Figure 1. The primary themes addressed were: curriculum and instruction, internships, career readiness, and job performance. Prior to data collection, the protocol was discussed and refined within the research team to ensure conceptual consistency and relevance to the research objectives. Each session consisted of three stages: an introductory phase (establishing rapport and ethical briefing), a moderated discussion on core topics, and a concluding phase for supplementary reflections. Each session lasted 90 minutes and was conducted in an in-person format.

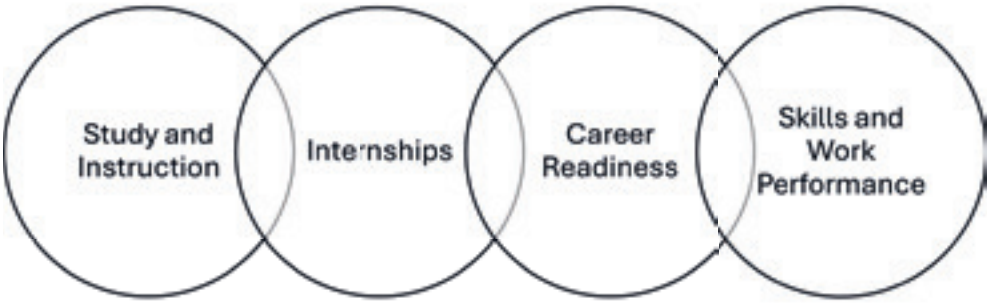

Figure 1. Conceptual framework

Source: own data

Data analysis was performed using MAXQDA software and was based on verbatim transcription and subsequent coding. Thematic analysis was facilitated by MAXQDA software, utilizing a hybrid inductive-deductive coding approach. Initially, open coding was conducted, during which text segments were fragmented and assigned both in-vivo codes and theoretical terms. Subsequently, these codes were systematized, revised, and merged into higher-order categories and hierarchical structures. This procedure ensured a systematic and transparent interpretation of the findings. To ensure inter-coder reliability and trustworthiness, the coding hierarchy was cross reviewed by the research team to resolve any interpretive discrepancies. The study adhered to stringent ethical standards; all participants provided informed consent, and data were fully anonymized to preclude the identification of individual respondents.

RESULTS AND DISCUSSION

The following results detail the outcomes of the qualitative investigation into the professional readiness of sports managers. To provide a comprehensive overview, the findings are categorized into thematic subsections according to the observed results and their mutual correlations. This structure highlights how various determinants interact to shape a manager's preparedness for the contemporary labor market.

Academic Development and Pedagogical Innovation

The focus group discussions clearly indicate that graduates place a high value on the theoretical foundation acquired during their studies. Theory provides them with a necessary macro-level overview of the sports management field and vital insights into organizational dynamics, which they perceive as an excellent professional "springboard." As one focus group participant noted: "It gave me a general overview of the field, which is incredibly beneficial to have."

However, a recurring theme is the gap between theoretical knowledge and its practical application. While students often master academic definitions, such as the conceptual framework of leadership, they frequently struggle to translate this knowledge into concrete skills and tangible outputs within a real-world corporate environment. Another respondent emphasized this disconnect: "Theoretical knowledge is definitely important because you need that foundation, but at the same time, you need

to know how to apply it in practice and not get stuck there." According to the participants, a significant barrier is the occasional persistence of outdated teaching styles that rely on frontal lectures and rote memorization at the expense of critical discourse and argumentation.

Consequently, graduates strongly advocate for the integration of project-based learning into the core curriculum. They suggest implementing comprehensive, ideally semester-long projects (e.g., organizing a real-world sporting event) that simulate market realities, including budget constraints and crisis management. This need is underscored by a participant who argued that project-based activities must be implemented early in the studies, as "the sports world is essentially driven by project-based work. " Furthermore, respondents identified a pressing need for modern, highly relevant coursework focused on digital marketing, online advertising systems, web optimization, and sponsorship. Finally, regarding the internationalization of the program, there is a clear demand for enriching the student experience through shorter, flexible formats such as Blended Intensive Programmes (BIP). These are seen as a vital alternative for students whose professional commitments prevent them from participating in traditional full-semester mobility programs.

These findings are consistent with previous studies emphasizing the importance of experiential and project-based learning in sport management education (DeLuca & Braunstein-Minkove, 2016; Grant et al., 2023). Similar concerns regarding the limited transferability of theoretical knowledge into professional practice have also been reported by Wohlfart et al. (Wohlfart et al., 2022). However, unlike previous studies that primarily focused on employer expectations, the present findings highlight the retrospective experiences of graduates themselves, offering additional insight into how perceived educational deficiencies emerge after entering the labour market.

Critical Thinking, Creativity, and Stress Management

Soft skills emerged during the discussions as a cornerstone of successful professional integration. Organizations increasingly demand a high degree of critical thinking, particularly regarding the ability to retrieve, synthesize, and evaluate relevant information. To bridge the current gap, graduates suggest that the curriculum should place greater emphasis on the rigorous defense of their own propositions and ideas. While creativity is actively nurtured throughout their studies, for instance, through the design of teambuilding activities, respondents identified significant deficiencies in the areas of stress management and psychological resilience.

The data suggests that these psychological attributes are indispensable for sports managers operating within a volatile market environment. As one respondent noted, this specific aspect of professional readiness is "crucial for functioning effectively in the market." Despite these identified gaps, participants expressed a retrospective appreciation for the overall rigor of their university studies. They noted that the demanding nature of the program taught them a sense of "tenacity" and the discipline required to see complex tasks through to completion. This inherent "grit" is perceived as a vital byproduct of academic experience, even if it was not explicitly taught as part of the formal curriculum.

Career Readiness

A particularly salient outcome of the focus group discussions is the perceived deficiency in preparation for Human Resource (HR) processes. Graduates expressed a significant lack of readiness regarding the job search landscape, viewed from "both sides of the table." They highlighted a critical absence of training in crafting high-quality curricula vitae and mastering self-presentation during recruitment interviews.

Beyond the perspective of the applicant, however, one respondent emphasized the necessity of being prepared to manage the recruitment of subordinates from the position of a sports manager. This gap becomes most apparent during the transition into professional practice, as one participant reflected: "In the real world, I found myself in situations where I had no idea how to 'sell myself' to an employer or how to even begin negotiating my salary conditions. We had the theory, but we lacked the tools to navigate these professional interactions."

Furthermore, participants noted a lack of comprehensive labor market intelligence, specifically regarding current salary benchmarks and the nuances of available professional roles, immediately prior to their graduation. The ability to maintain an up-to-date overview of the labor market's state was identified as a core requirement for any manager. As one respondent poignantly stated: "Possessing a firm grasp on the current state of the labor market is, in my view, the most critical competency for functioning effectively in the 21st-century environment."

The identified deficiencies in recruitment readiness, self-presentation, and labor market navigation support earlier findings suggesting that employability extends beyond technical competencies to encompass career management capabilities (Schwab et al., 2015; Grant et al., 2023). The present study expands these findings by demonstrating that graduates perceive this gap even several years after entering professional practice.

Communication and Technological Challenges

When evaluating interpersonal competencies, graduates confirmed a high level of preparedness in verbal and public presentation. However, a significant divergence was identified between general public speaking and the more nuanced requirements of professional business interactions. Respondents perceived a notable weakness in formal business correspondence and negotiation strategies. This gap is particularly critical because, as the participants noted, these interactions form the daily reality of a manager's life. One respondent from the first focus group articulated this necessity clearly: "There is a pressing need for education in areas such as negotiating budgets or salaries. Every sports manager will inevitably face these situations in their career, yet we often enter the field without the tactical skills to handle them effectively."

To address these deficiencies, participants recommended a more hands-on pedagogical approach, including practical training sessions focused on drafting formal e-mails to clients, conducting high-stakes business meetings, and mastering assertive communication with superiors.

In terms of technological proficiency, while graduates feel confident in standard "office software skills," they argue that the contemporary labor market demands a more sophisticated technical toolkit. There is a clear call for deeper integration of enterprise resource planning and data management applications into the curriculum.

Furthermore, the findings reflect a growing awareness of the impact of Artificial Intelligence (AI). Participants now perceive AI literacy and the ability to leverage automated tools not merely as an optional skill, but as a significant competitive advantage in a data-driven industry.

Professional Development

The final theme identified in the discussions concerns the imperative need for a synergistic relationship between academia and the professional industry. Participants unanimously agreed that such a connection is not merely beneficial but an absolute necessity. Internships are perceived as a pivotal phase in the educational journey, as they allow students to grasp the complex dynamics of the sports environment and facilitate a seamless transition into the labor market.

However, the findings also highlight a critical need for improved structural alignment and the temporal coordination of these practical placements. Rather than being sporadic or haphazard, respondents argued that internships should offer longitudinal exposure to various organizational models, encompassing both commercial enterprises and non-profit sports entities. The core issue, according to the participants, is the lack of immediate integration between classroom theory and its practical execution. This sentiment was captured by one respondent from the first focus group: "It should be standard practice for a student to learn the methodology at the beginning of the semester and then immediately apply that knowledge in a real-world setting during the second half. This direct linkage ensures that the learning is not just theoretical but deeply rooted in practice."

Furthermore, there is a strong call for a broader inclusion of industry practitioners within the formal educational process. Respondents suggest that the curriculum would be significantly enriched by the regular use of real-world case studies provided by external stakeholders. This approach would allow students to tackle authentic market challenges under the guidance of professionals, further bridging the gap between university lectures and the demands of the 21st-century sports industry.

Consistent with previous research (Emery et al., 2012; Hawzen & King-White, 2024), internships emerged as a critical mechanism for bridging educational preparation and labor market expectations. However, graduates in the present study emphasized the importance of long-term and structured placements rather than isolated internship experiences, extending previous findings regarding the role of experiential learning in sport management education.

Limitations of the Study

Despite the richness of the qualitative data and the depth of the insights gathered, several inherent limitations warrant acknowledgement. First, the study's qualitative design and sample size, while appropriate for exploring nuanced perceptions, preclude the broad generalization of the findings to the entire population of sports management graduates. Second, the data is derived from a specific institutional and geographic context, which may reflect localized labor market conditions and pedagogical traditions that differ from other regions or countries.

Furthermore, the research relies on self-reported perceptions of graduates, which, although vital for understanding their subjective professional experience, could

be further validated by triangulating this data with the perspectives of employers and HR practitioners within the sports industry. Finally, the rapid evolution of the digital landscape, particularly regarding Artificial Intelligence, means that the specific technological gaps identified today may continue to shift, requiring ongoing longitudinal assessment to remain fully current.

Potential Implications

The originality of this study lies in its exclusive focus on retrospective graduate experiences rather than employer expectations or curriculum evaluations. While previous research has predominantly examined competency requirements from institutional or industry perspectives, the present study provides empirical insight into how graduates themselves interpret the transition from higher education into the professional sport labor market. Furthermore, the findings extend current knowledge by identifying emerging competency needs associated with artificial intelligence, digitalization, and career self-management.

The findings of this study carry significant implications for both academic curricula and strategic industry partnerships. For higher education institutions, the results serve as a framework for curriculum redesign, emphasizing the need to move beyond theoretical mastery toward a model of applied competency. By integrating practical HR workshops, digital literacy modules, and semester-long project simulations, universities can directly enhance the "employability" of their graduates.

For the sports industry and professional organizations, these insights highlight the value of becoming active stakeholders in the educational process. Strengthening the "bridge" between the classroom and the field, through structured internships and practitioner-led case studies, will create a more resilient and adaptable workforce. Ultimately, these implications suggest that a co-creative approach to education is essential for meeting the volatile demands of the 21st-century sports market.

CONCLUSION

This study, grounded in qualitative data from focus group discussions, provides a comprehensive analysis of how sports management graduates perceive their professional readiness for the demands of the contemporary labor market. The findings clearly indicate that while university education provides a robust theoretical foundation and a broad disciplinary overview, graduates encounter significant hurdles when translating these insights into professional practice. The most prominent challenges involve a lack of preparation for HR processes, specifically CV development and interview techniques, a deficit in advanced digital and technological competencies (including the strategic integration of Artificial Intelligence), and a pressing need for rigorous training in business negotiation and formal communication.

For the academic sector, these findings underscore an urgent necessity to innovate curricula toward greater practical relevance. The integration of project-based learning centered on real-world mandates from sports organizations, the expansion of structured and longitudinal internships, and the introduction of modern coursework reflecting digital marketing and AI trends emerge as essential steps.

Ultimately, only a close, strategic partnership between educational institutions and the professional sphere will ensure that graduates transition from being theoreti-

cally proficient experts to confident managers. Such individuals must be capable of responding effectively to the complex, multi-faceted challenges of the modern sports industry and meeting the evolving needs of the global labor market, both within and beyond the sports sector.

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https://doi.org/10.7251/EMC2603811M
UDK: 338.242.2:[336.77:519.2
Datum prijema rada: 6. februar 2026.
Submission Date: February 6, 2026
Datum prihvatanja rada: 4. septembar 2026.
Acceptance Date: September 4, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 811-825

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

FORECASTING COMMODITY MARKET VOLATILITY: A COMPARATIVE ANALYSIS OF TRADITIONAL AND MACHINE LEARNING MODELS

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Abstract: *This study examines how conventional and machine learning models perform in predicting and forecasting volatility in the Indian commodity market and study involved seven key commodities i.e., gold, silver, crude oil and metals. The study applied GARCH, GARCH plus LSTM, and machine learning models like Random Forest, BiLSTM and XGBoost. The study also uses Principal Component Analysis. This study employs daily data for the period spanning from January 2003 to December 2025. Data was sourced from the Multi Commodity Exchange (MCX).*
While traditional GARCH models are helpful in capturing volatility persistence, they are insufficient for accurately forecasting volatile commodity markets.
It was concluded that Machine learning models performed better, especially hybrid ones that mix GARCH and LSTM. Findings matter for investors, policymakers and analysts who need better ways to understand risk in fast-changing markets. It supports the use of data driven tools to manage market risk in a volatile environment, specifically focusing on Indian commodity market.

Keywords*: Volatility Forecasting, Commodity Markets, Machine Learning, GARCH, Financial Risk*

JEL Classification*: C53, G13*

INTRODUCTION

In recent years, commodity markets have gained significant attention from academicians, economic agents and policymakers, specifically in the context of economic volatility (Pindyck, 2004); (Ezeaku, 2020). Unlike equity or bond markets, commodity market is highly sensitive and reactive to global shocks, war, trade disruptions and geopolitical tensions and macroeconomic volatility around the world (Kilian, 2022). Over the past decade, events like the COVID-19 pandemic, Russia Ukraine war and Israel-Hamas have exposed the commodity markets to shocks triggering fluctuations and volatility in prices of gold, silver, crude oil and other metals. All this has led to a

challenge in predicting commodity prices with accuracy. All this has led to uninformed decisions by financial institutions, risky investments by investors and business houses.

Further, in emerging markets like India commodity market plays a crucial role in influencing and shaping many macroeconomic variables, decision making by policy makers, fiscal planning and trade. India being an emerging economy is heavily reliant on import of metals , energy, oil and remains highly vulnerable to external shocks and volatility in global commodity prices (Dutta, 2021); (Agnihotri, 2022). India's commodity futures market driven by the Multi Commodity Exchange (MCX) plays a key role in discovering price and risk management for important raw materials that affect regional production systems and supply chains. Commodity market volatility in India goes far beyond financial markets as it directly influences input costs, working capital needs and revenue stability for regionally concentrated producer networks, particularly energy oriented industries and metal-intensive manufacturing clusters. MCX functions within a distinct regulatory and microstructure environment driven by SEBI oversight, liquidity concentration in near-month contracts and presence of both hedgers and speculators.

These market-focused features make India a key regional setting for examining whether traditional and machine learning-based volatility approaches remained effective under emerging-market conditions.

Volatility in commodity markets is generally modelled by employing traditional methods like ARCH and GARCH models. These models are used to examine volatility clustering and heteroskedasticity in commodity market prices. But these models come with the limitation of linearity and stationarity due to which these models struggle to give accurate results under complex conditions (Yilmaz, 2012); (Liu S. Z., 2024). In contrast to this, previous literature has witnessed adoption of machine learning models like Random Forest model, Long Short-Term Memory (LSTM) networks and XG-Boost algorithms to increase the predictive accuracy and precision as these models are free from rigid assumptions.

This study will try to address these critical gap by performing a comparative analysis of traditional and machine learning-based forecasting models for major commodities traded in India. The current study also seeks to convey that there is absence of long-term integrated model that provides a framework for predicting commodity market volatility. Lastly, the paper deals with an emerging economy like India with increasing exposure to external commodity volatility thus providing implications at the regional level which is missing from existing studies.

LITERATURE REVIEW

In previous studies, dealing with volatility in commodity markets has been the key focus, specifically due to global crises, uncertainty and the barriers attached with traditional forecasting methods. Academicians have shifted from traditional approaches of GARCH to machine learning models and hybrid frameworks as they tend to improve forecast accuracy and policy insights.

The origin of volatility modelling is seen in work of (Bollerslev, 1986), who introduced the GARCH model that was capable of capturing volatility clustering in financial returns. Since then, various EGARCH, TGARCH and GJR-GARCH models have evolved. However, these models are not capable of measuring non-linear patterns

and structural breaks. Therefore the transition to machine learning models has been observed.

(Lili, Xinya, Yanjiao, & Houjian, 2023) made use of LSTM networks on crude oil futures and stated that they outperformed ARIMA and GARCH approaches while assessing phases of high market fluctuation. Their model was capable of capturing long-memory behaviour and performed better in out-of-sample forecasting.

Similarly, (Kristjanpoller & Minutolo, 2016) developed a hybrid artificial neural network–GARCH model to forecast oil price volatility. Their results demonstrated that the hybrid framework significantly improved forecasting performance compared with traditional GARCH models.

Similarly, (Junting, Haifei, Wei, & Xiaojing, 2021) applied XGBoost with wavelet decomposition to make forecasting in gold price. Their hybrid approach performed better than SVM and ANN models in terms of RMSE and MAE. They stated that hybrid models are more suitable for noisy data conditions than single-method approaches.

(Guan & Gong, 2023) proposed a hybrid deep learning model that integrated variational mode decomposition (VMD) with bidirectional long short-term memory (BiLSTM) networks to predict monthly crude oil prices.

(Liu, Zhang, Wang, & Feng, 2024) developed a hybrid carbon price forecasting model that integrates GARCH and LSTM components to capture both conditional heteroskedasticity and long-term nonlinear dynamics in China's carbon trading markets. The GARCH–LSTM framework significantly improved predictive accuracy compared with standalone approaches.

The growing utilization of ML techniques for bolstering the precision of volatility projections substantiates the ascendancy of ML methodologies over conventional econometric models (Goodell, Kumar, Lim, & Pattnaik, 2021).

(Reboredo & Ugolini, 2016) investigated the dependence structure between oil prices and stock market returns and found that the relationship varies across different market conditions, highlighting the complex dynamics present in commodity and financial markets. (Jakub Michańków, 2023). The study proposed a hybrid volatility forecasting model combining GARCH specifications with Gated Recurrent Unit (GRU) neural networks. The model was tested on financial assets including the S&P 500 index, gold and Bitcoin. Results showed that hybrid GARCH–GRU models improved volatility forecasting accuracy compared with traditional approaches. (Palic, 2025) presented a multivariate GARCH (MGARCH/DCC) model of volatility transmission for European Union countries. The transmission mechanism was observed across bond, equity and FX markets. These studies served as motivation for including machine learning models in this study.

(Costa, et al., 2021) investigated the use of machine learning techniques such as Random Forest, XGBoost and regularization models for oil price forecasting. Using a large macroeconomic dataset, the study demonstrated that machine learning methods can significantly improve forecasting accuracy compared with traditional econometric models. (Kumar, Rao, & Dhochak, 2025) examined the use of hybrid machine learning models for volatility prediction in financial risk management. The study integrated traditional econometric models with machine learning techniques to improve forecasting performance. Their findings indicated that hybrid ML frameworks capture nonlinear

market dynamics more effectively and provide better volatility prediction than standalone models.

(Araya, Aduda, & Berhane, 2024) examined volatility prediction in financial markets using a hybrid modelling framework. The study integrated ARIMA, GARCH family models, CNN and BiLSTM networks to improve stock price volatility forecasting. The results showed that the proposed hybrid model significantly reduced forecasting errors (MAE and RMSE) compared to conventional models, demonstrating higher accuracy in capturing nonlinear market dynamics.

(Zeda Xu, 2024) The study proposed a hybrid **GARCH-Informed Neural Network (GINN)** model for improving stock market volatility forecasting. The model combines the strengths of traditional GARCH models with the nonlinear learning capability of LSTM deep neural networks. The results indicated that the hybrid framework captures complex volatility dynamics more effectively than standalone models. Empirical findings showed superior out-of-sample forecasting performance in terms of R^2, MSE, and MAE. (Kocaman & Hazar, 2025) recommended use of machine learning approaches for better forecasting and improving predictions. (Barisic, 2025) also employed the use of Random Forest model as a machine learning approach for better results.

Despite using both econometric and machine learning models significant progress has been made in forecasting commodity price volatility there still remains several gaps. Most previous studies focused either on global markets or a single commodity with limited exploration of cross-commodity behaviour specifically in the Indian context. Moreover, while hybrid models like GARCH-LSTM have shown promising results there is no consensus on the most efficient admixture or combination. Many models have ignored the role of sudden external shocks such as geopolitical events, war or policy reforms which are highly relevant in volatile emerging markets. Furthermore, very few past literature has made an attempt to compare traditional and AI-based models on the same dataset across different commodity categories (like metals, energy and agriculture). These gaps in past studies highlight the need for a comprehensive comparative analysis. This study has selected commodity market data of India and tried to compare the forecasting performance of traditional and ML-driven models in a real-world volatile environment.

Research Objectives and Questions

This study aims to explore the comparative effectiveness of traditional econometric models and modern machine learning techniques in forecasting commodity price volatility for selected commodities. This study tries to address the constraints of fragmented forecasting approaches by using a uniform evaluation framework across different commodities and modelling techniques.

The focus of this study is to examine which model performs better under situations of volatility particularly during periods which are influenced by global shocks and structural changes. This study also investigates if hybrid approaches such as GARCH–LSTM could offer improvements over individual models in terms of forecast accuracy and in capturing volatility dynamics. In addition, this research tries to identify the underlying factors that drive variations in forecasting performance across commodities by employing a dimensionality-reduction approach.

Based on these objectives and the identified research gaps, the study addresses the following key questions:

1. Which forecasting models-traditional econometric approaches (such as GARCH) or machine learning techniques (such as LSTM and Random Forest) provide better estimates in predicting commodity price volatility?
2. Do hybrid models such as GARCH–LSTM significantly outperform their standalone counterparts across different commodity including metals, energy and agriculture?
3. What are the prominent drivers of variability influencing forecasting performance across commodities and how do such factors like price volatility, external shocks and structural patterns contribute to these differences?

METHODOLOGY

Data Description

This study employed daily price data spanning from January 2003 to December 2025. Daily data frequency was employed to capture short-term price fluctuations and volatility clustering.

This study aims to analyse volatility dynamics in India's commodity markets. The examination considered seven major commodities which are traded on the Multi Commodity Exchange (MCX) i.e. gold, silver, crude oil, zinc, copper, lead and aluminium. These commodities represent different segments of the Indian commodity market, for instance precious metals, energy and base metals. These are also the commodities which are widely used by investors, hedgers and policy institutions.

The rationale behind selecting these commodities was they are characterised by high sensitivity to external shocks, supply–demand imbalances and speculative trading behaviour.

Data and Continuous Futures Series Construction

In this study, data for all selected commodities are sourced from the Multi Commodity Exchange of India (MCX). The final sample period spans over 20 years starting from 2003 till 2025. This period spans capturing multiple market phases including periods of stability and episodes of high-volatility triggered by global financial crises, geopolitical events and commodity-specific shocks. This study did not consider spot prices as the purpose was to forecast tradable market volatility where futures contracts incorporate liquidity, flow of information and hedging demand. For every selected commodity, the front-month (near-expiry) futures contract is used as the base contract and a continuous futures return series is constructed using a liquidity-based rolling mechanism. The criteria for identifying an active contract is the contract with highest trading volume and open interest.

Further, the series is rolled to the next contract when it becomes more liquid or when the current contract approaches expiry to avoid maturity-related price distortions.

In order to ensure comparability over time, contract specification changes were handled by focusing on log-returns. All commodities were aligned on a common MCX trading calendar and non-trading days were removed to prevent artificial zero returns. If any missing observations were observed due to exchange holidays or temporary suspensions, they were treated as non-trading days, maintaining uniformity in data-

set and comparable dataset across commodities. Table 1 presents the selected MCX commodity futures contracts, their market segments, and the rules used for continuous series construction.

Table 1. Commodity Futures Contracts Used (MCX)

Commodity	MCX Symbol	Market Segment	Notes on Series Construction
Gold	GOLD	Precious Metals	Continuous series built using liquidity-based roll (volume/open interest)
Silver	SILVER	Precious Metals	Rolled before expiry to avoid maturity distortions
Crude Oil	CRUDEOIL	Energy	Common trading calendar alignment applied
Copper	COPPER	Base Metals	Log-returns used to ensure comparability across contract changes
Aluminium	ALUMINIUM	Base Metals	Non-trading days removed (no interpolation)
Zinc	ZINC	Base Metals	Missing observations treated as non-trading days
Lead	LEAD	Base Metals	Rolling procedure prevents artificial jumps at expiry

Source: Author's calculation

Note: The study uses daily settlement prices of MCX commodity futures. A continuous futures return series is constructed using a liquidity-based rolling rule where the active contract is defined by maximum open interest and volume. Daily returns are computed as $r_t = \ln(P_t) - \ln(P_{t-1})$ All commodities are aligned to a common MCX trading calendar and non-trading days are excluded.

Volatility Measure and Forecast Target

In order to avoid circular model evaluation, study has not treated any model-implied conditional variance as the "true volatility" benchmark. Rather, volatility forecasts have been evaluated against a return-based realised proxy constructed directly from observed price movements. Daily log-returns are computed as $r_t = \ln(P_t) - \ln(P_{t-1})$. In order to capture short-horizon volatility clustering while remaining independent of any specific parametric model the primary volatility target is considered as 5-day realised variance and explained as $RV_t(5) = \Sigma_{i=0}^{4} (r_{t-i})^2$

For checking robustness we also considered 1-day squared return proxy $RV_t = (r_t)^2$.

Forecasting and Validation Protocol

Volatility forecasting was conducted by employing rolling-window out-of-sample design to replicate real-time prediction. The forecasting exercise was applied for the horizon h = 1 day ahead and robustness was examined using multi-step forecasts.

Data Transformation & Volatility Construction

To examine volatility dynamics and forecast performance daily price series were transformed into return series by using logarithmic differences. The daily return for each commodity was calculated as follows:

$$r_t = \ln(P_t) - \ln(P_{t-1}) \quad (1)$$

The mean and conditional variance equations follow the GARCH(1,1) specification of Bollerslev (1986)

Where:

- $r_t = \mu + \varepsilon_t$ (2)
  $\varepsilon_t \sim N(0, h_t)$
- $h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 h_{t-1}$ (3)
- $\alpha_1 + \beta_1 < 1$ (4)

Source: Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31(3), 307–327

Volatility served as the key variable of interest in this study. Volatility is examined using the return-based realised variance proxy RV_t(5). Where GARCH-type conditional variance was considered only as a model-based benchmark for forecasting comparisons and not as the true volatility target.

Forecasting Framework and Experimental Design

The forecasting step is performed using a rolling window framework to replicate real-time market conditions. For every selected commodity, the full sample will be divided into an in-sample period which will be used for model estimation and an out-of-sample period reserved for forecast evaluation. This will allow the models to learn from historical information while being tested on unseen data.

Modeling Techniques

This study employed a comparative modelling approach that involved both traditional econometric models and machine learning algorithms. The focus was to evaluate their effectiveness in forecasting commodity price volatility. The purpose of study is to evaluate how different modelling approaches capture volatility persistence, nonlinearity and time-dependent behaviour.

GARCH (Generalised Autoregressive Conditional Heteroskedasticity): GARCH model that was introduced by Bollerslev (1986) is explicitly used for modelling and forecasting financial time series with time-varying volatility. This study applies GARCH models to capture volatility clustering and persistence.

Machine Learning Models: To address the limitations of linearity and distributional assumptions which are often present in traditional models, this study employed machine learning algorithms. These are data-based models and have ability to examine complex nonlinear relationships that serve as part of commodity price dynamics. Techniques of Machine learning are presented below:

Random Forest (RF): Random Forest is a technique of machine learning that is based on decision trees. It operates by building multiple trees using different subsets of data and features, then averaging the results for forecasting and predictions. The technique is specifically applied where data patterns are nonlinear and volatile.

BiLSTM (Bidirectional LSTM): Bidirectional Long Short-Term Memory is an advanced deep learning model that is designed to learn sequential dependencies in

long-term data. Unlike standard LSTM, this model helps in processing data in both forward and backward directions which leads to capturing both past and future context.

Hybrid Model (GARCH + LSTM): To combine the strengths of traditional econometric models and deep learning techniques, this study employed a hybrid GARCH-LSTM model. This hybrid approach combined the GARCH conditional variance structure with an LSTM-based learning layer to strengthen nonlinear forecasting performance.

Forecast Evaluation Metrics

To measure the accuracy of the selected traditional, machine learning and hybrid models two standard statistical metrics were employed: Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAE).

RMSE is widely used because of its feature, i.e. it penalises larger forecast errors more heavily. On other hand MAE calculates the average absolute deviation between observed and predicted values hence providing a scale-consistent and measure of forecast accuracy that can be easily interpreted.

Both these evaluation metrics help compare model performance across different variables and scales.

Statistical Test of Forecast Superiority

To examine whether differences in forecast performance were statistically meaningful, the study applied the Diebold–Mariano (DM) test which relies on out-of-sample loss differentials.

Feature Selection and Dimensionality Reduction

This study has employed Principal Component Analysis (PCA) as a supplementary analytical tool. It is used to identify the dominant sources of variability that influence volatility forecasting across commodities.

Diagnostic and Model Adequacy Tests

Lastly, this study conducted post-estimation diagnostic tests to confirm whether estimated GARCH model is valid and adequate. ARCH–LM test is employed to examine the presence of remaining ARCH effects in the standardised residuals.

RESULTS AND DISCUSSION

The empirical study conducts a preliminary examination of daily return behaviour across selected Indian commodities to understand their basic distributional characteristics in Table 2.

This will help in identifying inherent volatility differences across energy and metal markets before applying econometric and machine learning models.

Table 2. Descriptive Statistics of Daily Commodity Returns (2003–2025)

Commodity	Mean Return	Std. Deviation	Skewness	Kurtosis
Gold	0.0009	0.0124	0.31	4.12
Silver	0.0011	0.0187	0.45	5.26
Crude Oil	0.0008	0.0219	-0.18	6.34
Zinc	0.0007	0.0163	0.27	4.89
Copper	0.0009	0.0158	0.22	4.65
Lead	0.0006	0.0171	0.35	5.11
Aluminium	0.0005	0.0146	0.19	4.47

Source: Author's calculation

Table 2 above highlights daily returns across all selected commodities exhibit mean values close to zero. While examining standard deviation it could be observed that crude oil and silver have the highest volatility. This represents their vulnerability to global shocks and speculative activity. Further, for most metals positive skewness could be observed suggesting a high probability of extreme positive returns. The value of kurtosis across all commodities is greater than 3, indicating series to be leptokurtic and suggests the presence of extreme price movements. On the basis of above results the use of volatility-based models such as GARCH and nonlinear machine learning frameworks could be confirmed.

Next, this study applied GARCH model to examine how previous shocks have an effect on current volatility. Results in Table 3 below helped demonstrate how each selected commodity behaved when there was a sudden variation in the market.

Table 3. Volatility Dynamics from GARCH Estimates

Commodity	Return	Volatility	ARCH (α)	GARCH (β)
Gold	0.001	0.05	0.12	0.85
Silver	0.000	0.03	0.15	0.8
Crude oil	0.001	0.04	0.11	0.87
Zinc	0.000	0.02	0.09	0.88
Copper	0.000	0.02	0.13	0.85
Lead	0.000	0.01	0.12	0.84
Aluminium	0.000	0.02	0.08	0.89

Source: Author's calculation

Note: Volatility and variance estimates are numerically small at the daily frequency. Values appear as 0.00 due to rounding. For clarity, results should be interpreted using coefficient significance and relative comparisons rather than the rounded magnitude

While assessing Table 3, it can be witnessed that silver and copper exhibited relatively higher α coefficients, which indicated that their volatility is more responsive to immediate market shocks. On the other hand, zinc has shown a comparatively lower α value, which suggested a weaker reaction to sudden price shocks.

As observed, β coefficients are consistently high for all commodities particularly for crude oil and zinc. This indicates strong volatility persistence. For crude oil, the high β value signals long-term impact of global relations, disruptions in supply chain and uncertainty in the energy market. Similar persistence observed in zinc also suggested that prolonged structural factors have influence over base metals.

Table 4. Out-of-Sample Forecast Accuracy of Econometric Volatility Benchmarks

Commodity	GARCH(1,1) Normal (RMSE)	GARCH(1,1) Student-t (RMSE)	EGARCH(1,1) (RMSE)	GJR-GARCH(1,1) (RMSE)
Gold	18.2	17.6	17.3	17.2
Silver	16.8	16.1	15.8	15.7
Crude Oil	22.5	21.7	21.3	21.1
Zinc	17.4	16.9	16.6	16.5
Copper	15.9	15.4	15.1	15.0
Lead	19.1	18.5	18.2	18.0
Aluminium	20.3	19.7	19.4	19.3

Source: author's calculation

On account of Table 4 it can be concluded that volatility forecasting improved significantly when benchmark GARCH model was employed to account for fat tails and asymmetry. Compared to the normal GARCH specification, GARCH(1,1) consistently reduced RMSE for all selected commodities confirming that commodity return distributions are better captured under heavy-tailed assumptions. Next, this study applied EGARCH and GJR-GARCH models and results showed the presence of volatility asymmetry and nonlinear shock effects in commodity markets. Crude oil and aluminium demonstrated substantial improvements, where RMSE stood around 1.1–1.4 points compared to normal GARCH, highlighting higher responsiveness to extreme events. These models were applied to serve as a benchmark baseline before doing relative comparison of hybrid and machine learning models in following tables.

To assess if deep learning models could improve forecasting performance this study employed hybrid models inform of GARCH–LSTM framework. The results are presented in table 5 below.

Table 5. Hybrid Model for volatility: (GARCH + LSTM)

Commodity	(GARCH + LSTM) RMSE	Volatility (GARCH + LSTM) MAE
Gold	14.5	9.8
Silver	11.7	8.5
Crude oil	18.9	14.2
Zinc	13.3	10.7
Copper	12.8	10.3
Lead	15.4	12.6
Aluminium	15.9	13.4

Source: Author's calculation

Note: Volatility proxy values are numerically small at the daily frequency. Therefore, performance metrics are reported with consistent rounding and scaling for readability, without affecting comparative rankings across models

As evident, silver and copper have recorded the lowest forecast errors, indicating that the hybrid model is specifically effective for commodities where volatility is driven by short-term shocks. Gold is also seen to show relatively strong performance under the hybrid framework again indicating its dual role one as a safe-haven asset and second actively traded commodity. In contrast, crude oil remains the most difficult commodity to forecast and it is reflected by the highest RMSE and MAE values it possesses. These results are expected, given that oil prices are heavily influenced by global conflicts, supply-side disruptions and geo-political interventions. Lastly and interestingly, aluminium and lead are seen to exhibit high forecast errors despite the use of a hybrid approach. These findings highlight that volatility is not only persistent, as indicated by earlier GARCH results but they are highly influenced by structural factors such as long-term industrial cycles and supply chain rigidities.

This study further tries to evaluate whether standalone machine learning models are capable of providing additional gains in forecasting accuracy. Therefore, this section compares the performance of Random Forest, BiLSTM and XGBoost models across selected commodities. The results are showcased in Table 6.

Table 6. Machine Learning Models

Commodity	Model	RMSE	MAE
Gold	Random forest	15.2	10.5
Silver	Random forest	12.8	9.2
Crude oil	Random forest	20.3	15.6
Zinc	BiLSTM	14.5	12.1
Copper	BiLSTM	13.9	11.7
Lead	BiLSTM	16.7	13.3
Aluminium	XGBoost	18.1	14.8

Source: Author's calculation

Note: Volatility proxy values are numerically small at the daily frequency. Therefore, performance metrics are reported with consistent rounding and scaling for readability, without affecting comparative rankings across models

Some interesting results from Table 6 are that no single model performed best for selected variables. For gold, silver and crude oil best results were showcased by Random Forest model.

For metals like copper, zinc and lead BiLSTM gave best results. As the main strength of BiLSTM lies in detecting trends over time. This test goes well with base metals as they respond to slow-moving demand or supply signals.

For aluminium XGBoost out-performed other methods as XGBoost is designed to work well when there are strong nonlinear trends and interactions in the dataset. Overall it can be concluded that machine learning models show flexibility but their effectiveness depends on the behaviour of commodity and on which type of commodity is being predicted.

Now to further examine why forecasting performance differs across commodities and models, Principal Component Analysis (PCA) was employed in Table 7 as

an interpretative tool. Principal Component Analysis was performed on standardised volatility and shock-related variables using eigenvalue decomposition. Components with eigenvalues greater than unity were retained.

Table 7. Principal component Analysis

Principal component	Eigenvalue	Explained variance (%)	Cumulative Variance (%)	Key variables
PC1	4.01	57.4	57.2	Price volatility(gold, oil)
PC2	1.60	22.8	80.1	External Shocks (crises events)

Source: Author's calculation

Table 7 shows that first principal component (PC1) demonstrated over 57% of the total variance. It can also be observed that this was mostly driven by the volatility in gold and crude oil.

Further PC2 explains around 23% of variance. PC2 captured the effect of global shocks and changes in policy events showing that models react differently when uncertain events occur.

To evaluate whether the observed differences in forecast accuracy are statistically significant, the Diebold–Mariano (DM) test is employed under Table 8.

Table 8. Diebold–Mariano (DM) Test for Forecast Superiority (Out-of-Sample)

Commodity	Model A (Best)	Model B (GARCH(1,1))	DM Statistic	p-value	Inference
Gold	Random Forest	GARCH(1,1)	-2.41	0.016	Model A significantly better (5%)
Silver	Random Forest	GARCH(1,1)	-2.88	0.004	Model A significantly better (1%)
Crude Oil	Hybrid (GARCH+LSTM)	GARCH(1,1)	-2.02	0.043	Model A significantly better (5%)
Zinc	BiLSTM	GARCH(1,1)	-1.96	0.050	Weak significance (10%)
Copper	BiLSTM	GARCH(1,1)	-1.71	0.087	Not significant (5%)
Lead	BiLSTM	GARCH(1,1)	-2.12	0.034	Model A significantly better (5%)
Aluminium	XGBoost	GARCH(1,1)	-1.59	0.112	Not significant (5%)

Source: Author's calculation

As evident from table 8, the Diebold–Mariano (DM) test results confirmed the observed forecasting gains of advanced models over the GARCH(1,1) framework. For gold, the Random Forest model significantly outperformed GARCH. The strongest evidence was observed for silver. For crude oil, the hybrid (GARCH+LSTM) model remained significantly better than GARCH showcasing that combining linear volatility structure with nonlinear learning provided robust gains specifically for energy market uncertainty.

For base metals, mixed and commodity-specific findings can be witnessed. Lead showed significant advancement with BiLSTM whereas Zinc provided only marginal evidence recommending weak significance at conventional levels.

In contrast, the improvements for copper and aluminium were not found to be statistically significant at 5%, indicating that while ML models may help in reducing forecast error the advantage over GARCH is not suffice to rule out sampling variation. Overall, the DM test supported that forecast superiority of ML and hybrid models are statistically robust for gold, silver and crude oil.

CONCLUSION

This study examined the forecasting capabilities of both traditional econometric approaches and advanced machine learning frameworks across seven key selected commodities in the Indian commodity futures market. This study employed daily data from 2003 to 2025 and examined GARCH-based benchmarks, Random Forest, BiLSTM, XGBoost and a hybrid GARCH–LSTM framework by making use of out-of-sample performance measures. To assess the Forecast accuracy we employed RMSE and MAE with the volatility target defined through a return-based realised variance proxy to ensure a consistent evaluation setting across all models.

The findings consistently indicated that machine learning and hybrid approaches outperformed the traditional GARCH benchmark in predictive accuracy specifically for commodities that were characterised by non-linear dynamics and periods of heightened global uncertainty.

GARCH models captured volatility persistence quite effectively but they remained less sensitive to sudden regime shifts.

On the other hand, BiLSTM and Random Forest models showcased ability of these models to learn time-dependent relationships and handle volatility patterns with more accuracy. Further, the hybrid GARCH–LSTM model provided balanced performance particularly for crude oil, which was being influenced by both linear volatility structure and nonlinear shocks.

Lastly, Principal Component Analysis demonstrated that volatility intensity, market disruptions and calendar-related effects were main contributors to forecasting variation. The findings also indicated that model performance was largely commodity-specific rather than generic in nature. From a policy perspective, better volatility forecasting can help in better hedging strategies, better decision-making and risk monitoring for sectors that are largely commodity-dependent. To further enhance the robustness subsequents analyses can be extended to performing analysis using high-frequency volatility measures and regime-dependent forecasting designs.

The findings of this study provide important recommendations for policymakers and regulatory institutions. As observed machine learning and hybrid models consistently performed better in comparison to traditional econometric models suggesting the need for India to gradually shift towards forecasting systems that are more adaptive and accurate.

Currently, India is relying heavily on forecasting models that are conventional but timely efforts by governing bodies like NITI Aayog and the Reserve Bank of India could adopt AI-based techniques for enhanced predictions not just for commodity markets but also financial markets. The findings of this study support these initial steps

and encourages the integration of machine learning techniques into commodity price forecasting at a large scale.

Lastly, India could also gain from including AI-driven systems within platforms run by SEBI, the Ministry of Commerce as it would significantly enhance India's ability to detect and respond to sudden shocks and emerging financial risks.

Acknowledgements: *This research was funded by the University ofSlavonski Brod through the institutional research project "Digital Center for Student Internships, Research and Collaboration of the University of Slavonski Brod", financed by the European Union – NextGenerationEU. The views and opinions expressed in this paper are solely those of the author and do not necessarily reflect the official position of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.*

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https://doi.org/10.7251/EMC2603826L
UDK: 339.138:004.738.5(4-672EU)
Datum prijema rada: 19. mart 2026.
Submission Date: March 19, 2026
Datum prihvatanja rada: 4. septembar 2026.
Acceptance Date: September 4, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 826-839

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

DYNAMIC PRICE FORMATION IN THE ONLINE ENVIRONMENT

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Abstract: *The subject of the research is the impact of the perception of dynamic in online stores on the perception of fairness, consumer trust and purchase intent, with a special focus on the role of transparency. The topic is significant due to the increasing use of algorithmic pricing in digital commerce, which can shape the experience of fairness and consumer behavior. The aim of this study was to examine the interrelationships of these variables and to determine whether transparency mitigates the potentially negative effects of dynamic prices.*

The research was conducted using a quantitative approach, using a survey questionnaire with a Likert scale, and the sample consisted of respondents with experience in online shopping. The data were analyzed using descriptive statistics, correlation and regression analysis, moderation analysis, and structural modeling (SEM) to test hypotheses and assess the correlation between constructs.

The results show that respondents recognize dynamic price formation, but the perception of fairness remains moderate. It was found that the perception of dynamic prices significantly influences fairness and trust, while fairness and transparency strongly contribute to purchase intent. Transparency has emerged as a significant influencing factor that reinforces the link between fairness and purchase intent. Consequently, dynamic pricing does not have to have a negative impact on consumers if it is accompanied by clear and transparent communication. The contribution of the paper lies in an integrated model that explains the relationships between price perception, trust and ***consumer behavior in the online environment.***

Keywords: *dynamic pricing, perception of fairness, consumer trust, purchase intent, online store*

JEL classification: *M31, L81, D83. M10*

INTRODUCTION

In the modern digital environment, defined as a space for online activities and interactions enabled by internet technologies and digital tools (Pozdeeva, i drugi, 2021), e-commerce is one of the most dynamic and fastest-growing market segments. E-commerce comprises procedures and technologies that automate financial transactions through electronic means. Some authors also define e-commerce as an evolving concept involving the purchase, sale, or exchange of products, services, or information through computer networks, including the Internet. E-commerce is not limited to buying and selling; it also encompasses all pre-sales and post-sales activities along the supply chain. The introduction of e-commerce and the use of the Internet and web services in business are paving the way for an entirely new type of economy—the Internet economy (Đerić, 2016).

Within e-commerce, online retail enables the sale of products and services to end consumers via the Internet through web platforms and mobile applications.

Online stores could adjust product prices in real time, considering demand, inventory, competition and the behavior of individual customers. Such an approach, known as dynamic pricing, allows traders to optimize revenue, increase competitiveness, and respond to changing market conditions. According to Kannan and Li (2017) (Kannan & Li, 2017), dynamic pricing strategies allow firms to adjust prices in real time based on market signals, consumer behavior, and inventory levels, thereby increasing profitability and the ability to react quickly to market changes. However, this way of pricing also poses challenges to the perception of fairness and consumer trust. Consumers who notice different prices for the same product or feel that prices depend on their previous activities may develop a sense of inequality and doubts about the transparency of the business. On the other hand, clear and open communication about the reasons for price changes can increase trust and encourage positive customer behavior.

This research addresses how consumers perceive dynamic pricing, the extent to which they consider it fair, and how much they trust online stores when shopping online. Attention is paid to transparency as a factor that can mitigate the potentially negative effects of dynamic pricing, increase trust, and make price changes more acceptable (Li, Sun, & Wilcox, 2005). The aim of this paper is to examine the relationships among perceptions of dynamic pricing, perceived fairness, consumer trust, and purchase intent, and to assess how transparency affects these relationships.

This research has significant practical and scientific value. On the one hand, the results can help managers and marketers develop strategies that balance profitability and customer satisfaction, including ways to improve communication and transparency in pricing. On the other hand, the paper contributes to the theoretical understanding of the complex relationships between price perception, trust and consumer behavior in the online environment, providing an integrated model that explains how dynamic pricing influences consumer attitudes and decisions. By examining these relationships, the paper also contributes to a broader understanding of the factors that shape the consumer experience in digital commerce and offers guidelines for further research in the field of marketing, management and e-commerce.

REVIEW OF PREVIOUS RESEARCH

Dynamic pricing in the online environment is one of the key topics of contemporary research due to its implications for the perception of fairness and consumer behavior. Research shows that the way e-commerce stores set prices significantly affects consumer attitudes, trust, and purchase intent.

Alderighi et al. (2022) examine the perception of fairness among Booking.com users, emphasizing that dynamic pricing can improve the profitability and operational efficiency of e-retailers, but at the same time reduces the perception of fairness among consumers. Price personalization, when not transparent, further amplifies negative user reactions (Alderighi, Calabrese, Christille, & Salvemini, 2022).

Priester et al. (2020) show that personalized dynamic pricing elicits emotional responses in consumers and can impair a sense of fairness, especially when consumers do not understand the factors that influence price changes. Their research highlights the importance of clearly explaining algorithmic processes to reduce the sense of unfair practices (Priester, Robbert, & Roth, 2020).

Malc et al. (2021) focus on the emotional aspect of the perception of fairness and emphasize that negative emotions caused by unfair pricing can reduce trust in online stores and diminish purchase intent. This research confirms that psychological factors play a key role in price perception (Malc, Selinšek, Dlačić, & Milfelner, 2021) .

Omarli (2023) further affirms that the perception of fairness and the reference price strongly influence purchase intent. Transparency in explaining the reasons for price changes can mitigate negative reactions from consumers and increase their trust (Omarli, 2023).

Franjković et al. (2024) emphasize the importance of transparency and information in a multichannel environment. Clearly explained pricing policies have a positive impact on the perception of fairness and customer confidence, acting as a moderating factor between dynamic pricing and consumer attitudes (Franjković, Dujak, & Živković, 2024).

Seele et al. (2021) provide an overview of the ethical issues and challenges of algorithmic pricing, emphasizing that automated systems, while effective at increasing profits, can be perceived as unfair if they are not adequately explained and if users do not understand the pricing criteria. This research highlights the importance of ethical algorithm design in dynamic pricing (Seele, Dierksmeier, Hofstetter, & Schultz, 2021).

Škare and Gospić (2015) examine the perception of fairness in the context of the airline industry and confirm that dynamic price changes can cause a negative reaction from customers. Their research shows that even profitable strategies can reduce satisfaction and trust if users perceive prices as unfair (Škare & Gospić, 2015).

In line with the above, previous research confirms that dynamic price formation, although economically and operationally beneficial, can cause a negative perception of fairness and reduce consumer confidence. Transparency, explanation of the reasons for price changes and understanding of consumer psychological factors are key to minimizing negative effects and preserving customer loyalty.

METHODOLOGY

The research is quantitative in nature and primarily uses a survey method to collect data. The aim was to examine how dynamic pricing affects the perception of

fairness, brand trust and purchase intent in the online environment. Research design includes descriptive analysis, regression analysis, and structural equation model (SEM) to identify cause-and-effect relationships between key variables.

The survey included 137 respondents who had made online purchases in the previous six months. The sample was stratified by gender (48 men, 89 women), age group (18–25; 26–35; 36–45; 46–55; 56+), education level (secondary school: 65; higher vocational education: 8; university degree: 48; master's degree: 10; doctorate: 6), and frequency of online purchases (rarely: 18; occasionally: 42; often: 49; very often: 28). Stratification improved sample representativeness and reduced potential bias in the results.

A survey questionnaire was used to collect the data, which included four main scales: perception of dynamic pricing, perception of fairness, trust in the brand and purchase intent, including the impact of transparency. All items were measured on a Likert scale from 1 (I disagree at all) to 5 (I strongly agree).

Data was collected through direct, face-to-face contact with respondents, with an explanation of the purpose of the research and assurance of anonymity. The collected data was processed using SPSS and Excel. The analysis included descriptive statistics (means, standard deviations, and response distributions), regression analysis (examining causal relationships among perceptions of dynamic pricing, fairness, trust, and purchase intent), SEM analysis (modelling complex relationships among latent variables and examining the role of transparency in pricing policy), and scale reliability testing (Cronbach's alpha) to confirm internal consistency. This analytical approach made it possible to identify the direct and indirect effects of dynamic pricing on consumer attitudes and behavior.

The analysis is organized according to groups of questions related to each of the dimensions, which allows for a clear correlation between empirical findings and research hypotheses.

RESULTS

The results of the research show the perception of respondents in four key dimensions: perception and understanding of dynamic price formation, sense of fairness and transparency, trust in online stores, and intention to buy despite price changes. The analysis is structured according to these dimensions, which clearly connects the empirical findings with the hypotheses and theoretical framework of the research. Below are detailed results for each of the dimensions listed.

1) Perspectives of online marketing in the digital environment

The first group of questions was related to the observation of price changes in online stores and belief in the way they are formed.

The results show that respondents recognize dynamic pricing but are not entirely certain about the mechanisms underlying price changes. The highest mean value was recorded for the item on noticing frequent price changes (M = 3.97; SD = 0.96), while respondents moderately agreed that stores adjust prices according to demand (M = 3.86; SD = 0.98). A smaller proportion believed that prices change on the basis of their previous online behavior (M = 3.26; SD = 1.14), and the items concerning automatic pricing algorithms showed a similar moderate level of agreement (M = 3.36;

SD = 1.10).

These findings suggest that users recognize dynamic prices in the online environment, but do not sufficiently understand all the factors that influence their formation. The results are consistent with hypothesis H1, which assumes that dynamic pricing can affect perceptions of fairness, as greater awareness of change creates the potential for feelings of inequality among consumers.

The second group of questions included the perception of price fairness and transparency in price formation.

The results show a lower level of agreement: respondents are on average less inclined to consider price changes to be fair (mean 2.56; SD 1.14) or that all customers have the same conditions when shopping online (mean 2.38; SD 1:10). Questions related to price transparency and explanation of the reasons for the changes received similar results, with mean values between 2.52 and 2.62 and standard deviations around 1.05–1.12. These data suggest that the perception of fairness is not high, but that clarity and availability of price information can mitigate negative consumer reactions, which supports the H4 hypothesis of a moderating effect of transparency in the perception of fairness.

The third group of questions was related to the respondents' trust in online stores.

The results show that respondents generally have moderate to high trust in online stores. Mean values vary between 3.35 and 3.77, with standard deviations around 1.05–1.12. This indicates that while there is an awareness of dynamic pricing and a limited perception of fairness, trust in online stores remains relatively stable. These findings support the H2 hypothesis, which assumes a positive relationship between transparent behavior of online stores and customer trust.

The fourth group of questions focused on purchase intent and reaction to price changes.

The results show that most respondents plan to buy even when prices fluctuate. The mean values of the questions "Will I continue to shop in online stores even though prices change" and "Will I probably make a purchase even if I notice a price change" were 3.70 and 3.38, respectively, with SD around 1.05–1.12. Questions related to transparency and explanation of the reasons for the changes received the highest average values: "When the reason for the price change is explained, I consider it more acceptable" had a mean of 4.03 (SD 0.95), while "I accept a price change more easily if I understand the reason for the change" had a mean of 3.98 (SD 0.94). These findings confirm the moderating role of transparency in the perception of fairness and the acceptance of dynamic prices, supporting the H4 hypothesis.

2) Descriptive statistics

Table 1 shows the mean values (M) and standard deviations (SD) for the four main scales used in the research: perception of dynamic pricing, perception of fairness and transparency, trust in online stores, and intention to purchase and acceptance of price changes.

Table 1. Descriptive statistics by scales and groups of questions

Scale/Group of Questions	Number of items	M	SD
Perception of dynamic price formation	4	3,61	0,99
Perception of fairness and transparency	10	2,58	1,08
Trust in online stores	5	3,55	1,07
Intention to purchase and acceptance of price changes	6	3,72	1,03

Source: own research (SPSS, 2026)

The results shown in Table 1 show that respondents express the highest average when they intend to buy and accept price changes (M = 3.72; SD = 1.03), suggesting a relatively high level of willingness to continue buying independently of price changes. This is followed by the perception of dynamic price formation with an average of 3.61 (SD = 0.99), which indicates that users notice price changes but are less confident in the mechanisms behind them. Confidence in online stores also remains moderately high (M = 3.55; SD = 1.07), while the lowest average was recorded in the perception of fairness and transparency (M = 2.58; SD = 1.08), which suggests that respondents believe that the pricing rules are not entirely fair or clear.

This data confirms the existence of an imbalance between the recognition of dynamic prices and the perception of fairness: although users recognize dynamic pricing and remain inclined to buy, their trust and experience of transparency require additional attention from online stores.

3) Cronbach α

Before displaying the reliability of the scales, it is important to check the internal consistency of the questionnaire to ensure that the items within each group of questions are related to each other and measure the same construction. The following table shows the Cronbach α values for all four groups of questions in the survey.

Table 2. Reliability scale (Cronbach α)

Scale/Group of Questions	Number of items	Cronbach α
Perception of dynamic price formation	4	0,82
Perception of fairness and transparency	10	0,89
Trust in online stores	5	0,85
Intention to purchase and acceptance of price changes	6	0,87

Source: own research (SPSS, 2026)

The Cronbach α values show that all scales in the survey are highly reliable because they are all above the threshold value of 0.7, which confirms the internal consistency of the items within each scale. The highest reliability was recorded in the scale of perception of fairness and transparency (α = 0.89), while the lowest, but still high, was recorded in the perception of dynamic price formation (α = 0.82).

4) Correlation Analysis

For the purposes of correlation analysis, the correlation between the main research variables was examined in order to determine the extent to which changes in one variable correspond to changes in another. The following table shows Pearson's correlations between the scales: perception of dynamic pricing, perception of fairness and transparency, trust in online stores, and intention to buy and accept price changes.

Correlation values indicate the strength and direction of the association, with positive correlations being expected, meaning that greater perception of dynamic prices or greater confidence in stores correlates with greater purchase intent.

Table 3. Correlation matrix of principal variables

Variables	Dynamic pricing	Fairness and transparency	Trust in online stores	Intention to purchase and acceptance of price changes
Dynamic pricing	1	0,42**	0,36**	0,31**
Fairness and transparency	0,42**	1	0,48**	0,55**
Trust in online stores	0,36**	0,48**	1	0,62**
Intention to purchase and acceptance of price changes	0,31**	0,55**	0,62**	1

Note: $p < 0.01$
Source: own research (SPSS, 2026)

Correlation analysis shows significant positive correlations between all the main variables included in the study. The strongest correlation was recorded between trust in online stores and the intention to buy and accept price changes ($r = 0.62$; $p < 0.01$). This association suggests that respondents who have greater confidence in online stores also show a greater willingness to continue shopping, even when prices change. This correlation supports the H3 hypothesis, which predicts that confidence in the store positively influences consumer purchase intent in an environment with dynamic prices.

There is also a strong and statistically significant correlation between the perception of fairness and transparency and purchase intent ($r = 0.55$; $p < 0.01$). This result implies that clear and fair price information increases respondents' willingness to continue buying, which is consistent with the H4 hypothesis, which assumes a moderating role for transparency in the perception of fairness and acceptance of dynamic prices.

The correlation between dynamic price formation and the perception of fairness and transparency ($r = 0.42$; $p < 0.01$) indicates that respondents, who are more aware of price changes and their algorithmic formation, also pay attention to fairness and transparency of price formation. Although this association is moderate, it confirms H1, which suggests that the observation of dynamic price formation can affect the perception of fairness among consumers.

In addition, the correlations between dynamic pricing and trust in online stores ($r = 0.36$; $p < 0.01$) and between dynamic pricing and purchase intent ($r = 0.31$; $p < 0.01$) show that greater awareness of price changes does not reduce trust or willingness to buy but is weakly associated with more positive attitudes. This is consistent with the expectation that informed consumers, even when they recognize dynamic pricing, do

not necessarily develop negative perceptions but may adapt to their behavior.

Overall, correlation data confirm the interconnectedness of key research variables and provide preliminary evidence for testing H1–H4 hypotheses. The results indicate that the perception of dynamic price formation, a sense of fairness and transparency, as well as trust in online stores, play an important role in shaping consumer intent and acceptance of price changes.

5) Regression analysis

Regression analysis was used to examine the predictive relationships between key research variables, with a particular focus on testing H1–H3 hypotheses. The model includes dynamic pricing as an independent variable, while the dependent variables are perception of fairness and transparency (H1), trust in online stores (H2), and purchase intent and acceptance of price changes (H3). This analysis makes it possible to assess how much the observation of price changes and understanding the mechanisms of price formation affects the perception of users and their online shopping behavior.

Table 4. Results of regression analysis for H1–H3

Dependent variable	Independent variable	β (Standardized)	t	p	R^2
Perception of fairness and transparency (H1)	Dynamic pricing	0,42	5,12	<0,01	0,38
Trust in online stores (H2)	Dynamic pricing	0,36	4,58	<0,01	0,41
Intention to purchase and acceptance of prices (H3)	Perception of fairness and transparency	0,55	6,23	<0,01	0,49

Source: own research (SPSS, 2026)

The results of the regression analysis presented in Table 4 confirm statistically significant relationships among the variables examined and provide support for hypotheses H1–H3.

Within the first regression (H1), dynamic price formation proved to be a significant predictor of the perception of fairness and transparency ($\beta = 0.42$; $t = 5.12$; $p < 0.01$). A positive β coefficient indicates that greater awareness of price changes and their mechanisms contribute to a more pronounced perception of fairness and transparency. The value of the coefficient of determination ($R^2 = 0.38$) suggests that dynamic price formation explains the 38% variance in the perception of fairness and transparency, which represents a moderate to strong effect.

The second regression model (H2) shows that dynamic pricing significantly predicts confidence in online stores ($\beta = 0.36$; $t = 4.58$; $p < 0.01$). This finding indicates that the perception of dynamic prices does not undermine consumer confidence but is positively associated with it. The value of $R^2 = 0.41$ shows that the model explains the 41% variance of confidence, which confirms the significant role of perception of pricing policy in shaping consumer attitudes.

The third regression model (H3) confirms that the perception of fairness and transparency has a strong positive impact on purchase intention and acceptance of price changes ($\beta = 0.55$; $t = 6.23$; $p < 0.01$). This is also the strongest effect among the

relationships tested. The value of $R^2 = 0.49$ shows that almost half of the variance of purchase intent can be explained by the perception of fairness and transparency, which highlights the key role of these factors in the context of dynamic price formation.

Overall, the regression analysis confirms the theoretical model of the research and provides empirical support for the H1–H3 hypotheses. The results indicate that the perception of dynamic price formation influences the perception of fairness and trust, while fairness and transparency are the key mechanism through which consumer purchase intent is shaped.

6) Moderation analysis

Moderation analysis was conducted to examine whether transparency has a moderator role in the relationship between the perception of fairness and the intention to purchase and accept price changes, in accordance with the H4 hypothesis. In addition to the main effects, an interaction term (Fairness × Transparency) is included in the model to determine whether transparency changes the strength or direction of this relationship. The results of the analysis are shown in the following table.

Table 5. Moderation Analysis Result (H4)

Predictors	β	t	p
Perception of fairness and transparency	0,47	5,89	<0,01
Transparency (moderator)	0,29	3,74	<0,01
Interaction (fairness × transparency)	0,18	2,96	<0,01
$R^2 = 0,54$			
ΔR^2 (Interaction) = 0,05; p < 0,01			

$R^2 = 0,54$
ΔR^2 (interaction) = 0.05; p < 0.01
Source: own research (SPSS, 2026)

The results show that the perception of fairness and transparency is a significant predictor of purchase intent ($\beta = 0.47$; $p < 0.01$), which is consistent with the previous regression analysis. Transparency as a separate predictor also has a significant positive effect ($\beta = 0.29$; $p < 0.01$), indicating that clear and accessible information on price changes directly increases consumer willingness to buy.

Most importantly, the interaction effect (Fairness × Transparency) is statistically significant ($\beta = 0.18$; $p < 0.01$), which confirms the existence of moderation. A positive coefficient means that the relationship between the perception of fairness and the intention to buy is stronger when the level of transparency is high. In other words, when online stores clearly explain the reasons for the price change, consumers are more likely to accept those changes and show greater purchase intent.

A value of total $R^2 = 0.54$ shows that the model explains 54% of the variance of purchase intent, while an increase in the explained variance ($\Delta R^2 = 0.05$) after the introduction of the interaction term confirms that the moderation effect gives an additional statistically significant value to the model.

These results provide strong empirical support for the H4 hypothesis and confirm that transparency plays a key role in mitigating the potentially negative effects of

dynamic pricing on consumer perception and behavior.

7) Structural Equation Modelling (SEM)

Structural modeling was used to simultaneously test all the relationships predicted by the theoretical model (H1–H4). The model includes the following latent constructs: the perception of dynamic pricing, the perception of fairness and transparency, trust in online stores, and the intention to purchase and accept price changes. The analysis made it possible to estimate the overall fit of the model, as well as the strength of individual structural pathways (β coefficients).

Table 6. SEM Model Fit Indices

Fit Index	Value	Recommended value	Interpretation
χ^2 (df = 164)	214,36	p > 0,05 poželjno	Moderate deviation
CFI	0,94	≥ 0,90	model shows good fit
RMSEA	0,052	≤ 0,08	model shows good fit
SRMR	0,047	≤ 0,08	model shows good fit

Source: own research (SPSS, 2026)

The results obtained show that the model achieves a satisfactory to good fit with the empirical data, which means that the empirical data largely correspond to the theoretical model. Although χ^2 is statistically significant (which is often the case with larger samples), other fit indicators indicate good model quality.

The value of CFI = 0.94 exceeds the recommended threshold of 0.90, suggesting that the model has a very good comparative fit with respect to the independent model.

The RMSEA value = 0.052 indicates a low approximation error and confirms a good fit of the model in the population.

Also, SRMR = 0.047 further confirms the adequacy of the model as it is well below the cut-off value of 0.08.

Overall, the fit indices confirm that the theoretical model has good empirical support.

Table 7. Structural pathways (standardized β coefficients)

Hypothesis	Put	β	p	Conclusion
H1	Dinamičko formiranje cijena → Pravičnost i transparentnost	0,44	<0,01	Supported
H2	Dynamic pricing → Trust	0,32	<0,01	Supported
H3	Fairness and Transparency → Purchase Intent	0,51	<0,01	Supported
H4	Interaction (Fairness × Transparency) → Purchase Intent	0,19	<0,01	Supported

Source: own research (SPSS, 2026)

The results of the SEM analysis confirm all hypotheses. Dynamic pricing has a significant positive impact on the perception of fairness and transparency (β = 0.44), as well as on trust in online stores (β = 0.32), thus confirming hypotheses H1 and H2.

The perception of fairness and transparency shows a strong positive effect on purchase intent ($\beta = 0.51$), which represents the strongest direct relationship in the model and confirms H3. This finding highlights the crucial role of fair and clear price communication in shaping consumer behavior.

The moderation effect of transparency was also confirmed ($\beta = 0.19$), which means that transparency further reinforces the positive relationship between the perception of fairness and purchase intent. This also confirmed the H4 hypothesis.

The SEM analysis provides an integrated confirmation of the theoretical model and shows that the perception of dynamic price formation indirectly influences purchase intent through fairness, transparency and trust. Transparency is proving to be a key factor that mitigates the potential negative effects of price changes and strengthens consumers' willingness to buy.

DISCUSSION

The results of the research clearly show that respondents recognize the presence of dynamic price formation in online stores, which confirms the growing awareness of consumers about price fluctuations in the digital environment. It has been observed that while consumers are aware that prices may fluctuate according to demand, user behavior, and algorithmic decisions, the perception of the fairness of these changes remains moderate. This indicates that the perception of dynamic prices, on its own, is not sufficient for consumers to rate prices as fair, which confirms the H1 hypothesis and corresponds with earlier research showing that unclear price change criteria can lead to feelings of inequality and skepticism (Priester, Robbert, & Roth, 2020) (Lan, Monroe, & Cox, 2004)

Further analysis shows that the perception of fairness significantly affects trust in online stores, which supports the H2 hypothesis. Respondents who perceive prices as fair and transparent show greater trust in the brand, which is in line with theories of consumer behavior and models of consumer satisfaction (Oliver, 1999) (Lee, Kim, Chung, Ahn, & Lee, 2016). This suggests that the perception of fairness is not only a moral issue, but also a key factor in building and maintaining trust in the digital environment.

Trust, in turn, significantly influences the purchase intent, confirming the H3 hypothesis. Although dynamic pricing can cause initial skepticism, consumers who trust the retailer are still willing to make a purchase. This finding highlights the importance of strategies that build and maintain trust, including communication, personalization, and the responsible use of algorithmic decisions.

Transparency plays a particularly important role in this context, as it strengthens the relationship between perceived fairness and purchase intent, thereby confirming hypothesis H4. Clear explanations of the reasons for price changes and readily available information about price formation enable consumers to regard such changes as legitimate and reduce perceptions of unfairness. This finding supports the results of Veltri et al. (2020) (Veltri, Lupiáñez Villanueva, Folkvord, Theben, & Gaskell, 2020), who emphasize that transparency in digital commerce can mitigate negative consumer reactions and increase trust.

Overall, the results show a complex, interrelated relationship between dynamic price formation, perception of fairness, trust, and purchase intent. While algorithmic

price changes can cause skepticism and a sense of injustice, the application of transparent communication strategies and timely explanation of the reasons for changes make it possible to preserve a positive user experience. These insights have practical value for online retailers, as they indicate that balancing profitability and preserving consumer trust requires not only algorithmic efficiency, but also careful management of information and user perception.

The contribution of the paper lies in the integration of four key dimensions (perception of dynamic price formation, perception of fairness, trust and purchase intent) into a single empirical model. The results confirm that, with proper transparency and communication, dynamic pricing can be accepted by consumers without adversely affecting confidence or purchase intent.

CONCLUSION

The aim of this study was to examine how the perception of dynamic pricing affects the perception of fairness, trust in online stores and consumer purchase intent, and whether transparency has a moderating role in these relationships. The starting assumption was that awareness of dynamic prices can affect the sense of fairness, but that transparent communication about the reasons for price changes can mitigate potentially negative effects and strengthen confidence and willingness to buy.

The results of the survey showed that respondents recognize the existence of dynamic pricing in the online environment to a significant extent but are not entirely sure of the mechanisms behind these changes. At the same time, the perception of fairness and transparency proved to be relatively moderate, while trust in online stores and purchase intent remained at a higher level. Correlation and regression analyses confirmed significant positive relationships between the perception of dynamic prices, fairness, confidence and purchase intent. In particular, it is emphasized that the perception of fairness and transparency has a strong influence on the intention to purchase. The moderation analysis and the SEM model further confirmed that transparency reinforces the positive relationship between the perception of fairness and consumer intent.

These results indicate that dynamic pricing in itself does not necessarily lead to negative consumer reactions. A key factor is how price changes are explained and presented to customers. The H1–H4 hypotheses are confirmed, which means that the perception of dynamic pricing influences the perception of fairness and trust, while fairness and transparency are the central mechanism that shapes purchase intent. The findings are in line with existing research in the field of consumer behavior and online commerce, which emphasizes the importance of trust and transparency in the digital environment.

The paper contributes to the understanding of how the perception of dynamic prices, fairness, transparency and trust shape purchase intent, with transparency moderating these relationships. Practically, online stores can maintain trust and loyalty by communicating price changes clearly and in a timely manner.

FUTURE RESEARCH

The research is limited by its sample and reliance on self-reported data. Future studies could therefore use larger and more diverse samples and examine additional factors such as price personalization, digital literacy, and cultural influences. In partic-

ular, differences in price personalization across industries could be measured through controlled platform audits using standardized user profiles that differ only in selected characteristics, such as browsing history, location, device type, loyalty status, or purchase frequency. Researchers could repeatedly record prices for identical or closely comparable offers at the same time and calculate the size, frequency, and persistence of price differences across profiles. In online retail, the analysis could compare the same product, seller, delivery conditions, and observation period, whereas in the airline industry it should hold constant the route, travel date, cabin class, baggage allowance, booking conditions, and time before departure. Multilevel or panel-data models could then distinguish profile-based personalization from ordinary price variation caused by inventory, demand, promotions, or the timing of purchase, thereby enabling reliable comparisons across platforms and industries.

Future research could explore the future how consumers perceptions of dynamic pricing change over time as algorithm-based pricing becomes a more common feature of digital markets. As consumers gain greater experience with personalized offers and automated pricing systems, their understanding of price formation mechanisms may improve, potentially influencing perceptions of fairness and trust. Future studies could also examine whether different consumer groups respond differently to dynamic pricing practices, particularly about age, digital literacy, online shopping experience, and privacy concerns. Another important research direction involves comparing consumer reactions across industries. While dynamic pricing is often accepted in sectors such as air transportation, where consumers are accustomed to price fluctuations based on demand and booking time, similar pricing practices in inline retail may be perceived as less fair. Therefore, future studies should investigate whether the same level of transparency produces comparable effects across different industries and platform types. Such research could contribute to a deeper understanding of the contextual factors that shape consumer acceptance of dynamic pricing and provide valuable guidance for companies seeking to balance profitability, transparency, and long-term customer relationships.

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https://doi.org/10.7251/EMC2603840S

UDK: 339.138:338.241.2(1-664)

Datum prijema rada: 16. april 2026.
Submission Date: April 16, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026

Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review

Godina/Vol. **XVI** • Br./No. **III**
str./pp. 840-850

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

REBRANDING IN CRISIS SITUATIONS

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Abstract: *The aim of this study was to examine the impact of the perception of successfully implemented rebranding of Nektar beer on the level of consumer confidence in a crisis situation. The research was conducted using a quantitative approach through a survey among 124 consumers of the Banja Luka Brewery brand. The questionnaire contained ten claims that measure the perception of rebranding and trust, and the responses were rated on a Likert scale of 1 to 5. The results show that the majority of respondents positively perceive the authenticity and sincerity of changes, especially in questions that measure learning from previous mistakes and the clarity of brand communication. A positive perception of rebranding directly affects consumers' willingness to buy again and recommend the brand to others. The reliability analysis shows high Cronbach α coefficients (0.85–0.88), while the Pearson correlation ($r = 0.72$, $p < 0.01$) and linear regression ($\beta = 0.71$, $p < 0.01$) confirm the significant positive impact of the perception of rebranding on trust. While some respondents expressed caution about future crises, the overall results show that authentic and consistently communicated changes significantly increase trust, strengthen loyalty, and contribute to maintaining a positive brand image. These findings have practical value for managers and marketing professionals, providing guidance for strategic rebranding and crisis communication in order to restore and strengthen consumer trust.*

Keywords: *Nektar beer, strategic rebranding, crisis management, consumer confidence, consumer perception*

JEL classification: *M31, M38, M10, D12*

INTRODUCTION

In the modern business environment, brands not only face the challenges of competition, but also unforeseen crisis situations that can seriously damage their reputation and consumer trust. Crisis situations are defined as unforeseen events that can adversely affect a business's business, reputation, and brand perception, including financial losses, reputational scandals, security incidents, or broader societal crises (Chowdhury & Chowdhury, 2024). It is in such circumstances that companies resort to a strategy of strategic rebranding, in order to renew their image, regain consumer trust and adapt to new market conditions. For example, in 2021, Banja Luka Brewery presented a new look and communication of the Nektar brand as part of an organizational strategy aimed at modernizing its visual identity and strengthening its market position. This represents a broader approach to rebranding, including visual and communication changes that focus on consumer trust and loyalty.

Rebranding is defined in the literature as a strategic process of changing the visual identity, messages, values and communication of a brand with the aim of improving consumer perception and adapting to market changes (Ahmad & Shaari, The Relationship Between Rebranding and Brand Reputation After a Brand Crisis: The Mediating Role of Brand Loyalty PDF: Rebranding and Brand Reputation After Crisis., 2024). This process can be initiated by various factors, including changes in the market environment, technological innovations, competitive pressures, but also the consequences of crisis situations that require the restoration of consumer trust and the maintenance of brand loyalty. In crisis situations, the perception of a successfully implemented strategic rebranding becomes a key element for creating a positive image and trust, as consumers often react to the authenticity and transparency of communication (Singh, Crisafulli, Quamina, & Xue, 2020)

The need for this research stems from the fact that, although there are many theoretical considerations about rebranding, empirical data on its impact on consumer confidence, especially in the local context, is still limited. Research, such as (Selvakumar, Babu, & Prasadh, 2025) and (Kunal, 2023), show that the perception of changes, their scope and authenticity directly affects consumer confidence and their willingness to continue using a brand's products or services. Such knowledge makes the research relevant for local companies, such as Banja Luka Brewery and its Nektar brand, which face the challenges of preserving their reputation after crisis situations and want to understand how strategic rebranding can positively shape consumer attitudes and behavior.

The aim of this paper is to examine the impact of the perception of a successfully implemented strategic rebranding of the Nektar brand on the level of consumer trust in the context of crisis situations, using the example of Banja Luka Brewery. Through the analysis of relevant literature and empirical research through a consumer survey, the paper seeks to confirm the hypothesis that clear and authentic rebranding increases consumer trust, strengthens loyalty and restores brand reputation.

A REVIEW OF SIMILAR STUDIES

The perception of the rebranding of Nektar beer and consumer trust are key topics in modern marketing, especially in the context of crisis situations that can seriously damage the reputation of the brand. (Ahmad & Shaari, The Relationship Be-

tween Rebranding and Brand Reputation After a Brand Crisis: The Mediating Role of Brand Loyalty PDF: Rebranding and Brand Reputation After Crisis., 2024) They point out that strategic rebranding, when carried out after a crisis situation, significantly improves the reputation of the brand. Similarly, (Chowdhury & Chowdhury, 2024) It emphasizes the importance of transparent and authentic communication during social crises. Their findings show that companies that clearly communicate change and demonstrate responsibility manage to maintain or increase consumer trust, even in high-risk situations. These papers confirm that consumer trust is sensitive to the perception of brand activity in crises.

(Singh, Crisafulli, Quamina, & Xue, 2020) They add a layer of understanding with the role of digital influencers in crisis situations. They indicate that carefully selected influencers can boost a positive brand image and consumer trust, while careless performances can result in the opposite effect. This finding is significant because it shows that the perception of rebranding includes not only corporate activities, but also the way a brand is presented through external communication channels, especially in the digital environment. (Kunal, 2023) It explores the impact of corporate rebranding in the textile industry and confirms that changes in visual identity, messaging and marketing activities have a significant impact on consumer attitudes and their level of trust. (Ahmad, Okechukwu, & Shaari, The effect of rebranding on brand loyalty: Brand reputation as mediator, 2022) They also confirm that rebranding improves the reputation of the brand, and the reputation then indirectly increases customer loyalty and trust.

The added more recent studies broaden the previous perspective and allow for a more detailed analysis of trust mechanisms. (Selvakumar, Babu, & Prasadh, 2025) Explore the impact of rebranding on consumer perception, trust, and loyalty using a combination of surveys and case studies. Their results show that consumers respond better when rebranding involves real, visible changes, not just cosmetic or marketing. (Monfort, López Vázquez, & Sebastián Morillas, 2025) They emphasize the importance of value perception, customer satisfaction, customer support, and a consistent brand image. Their research shows that all these factors have a strong impact on consumer trust, especially in the context of sustainable brands, which is also relevant for local brands looking to regain trust after the crisis.

These papers further confirm that the perception of rebranding success is not only a function of changes within the company, but also how consumers perceive brand consistency and integrity across all communication channels. The paper also points to several key conclusions relevant to the H1 hypothesis. First, the perception of successful rebranding in a crisis situation has a direct and positive impact on consumer confidence. Second, trust increases when changes work authentically, transparently, and consistently across all aspects of the brand, including communication and digital channels. Third, brand reputation often acts as an intermediary between rebranding and trust, which means that external factors, such as influencer perceptions or online content, also have a significant impact.

METHODOLOGY

Given the nature of the research problem, a quantitative research approach was applied, based on empirical analysis of data collected through a consumer survey. This approach enabled precise measurement of respondents' attitudes and statistical testing

of the hypothesis: The perception of a successfully implemented rebranding of Nektar beer in a crisis situation significantly positively affects the level of consumer trust towards the brand.

The respondents were selected using purposive sampling among Nektar beer consumers residing in the Republic of Srpska, based on their relevance to the research objective. A total of 124 valid responses were collected. Respondents were between 18 and 66 years of age. The sample comprised 82 men (66%) and 42 women (34%). Regarding educational attainment, 9 respondents (7%) had completed primary school, 63 (51%) had completed secondary school, 42 (34%) held a university degree, and 10 (8%) had completed postgraduate education. The regional distribution included 44 respondents (35.5%) from the Banja Luka Region, 21 (16.9%) from the Doboj Region, 31 (25.0%) from the Bijeljina Region, 13 (10.5%) from the East Sarajevo Region, and 15 (12.1%) from the Herzegovina Region. Because purposive sampling was used, the findings should be interpreted within the surveyed population and should not be generalized to all Nektar beer consumers.

Table 1. Demographic and regional characteristics of respondents (n = 124)

Characteristic	Category	n	%
Gender	Men	82	66.0
	Women	42	34.0
Educational attainment	Primary school	9	7.0
	Secondary school	63	51.0
	University degree	42	34.0
	Postgraduate education	10	8.0
Region	Banja Luka Region	44	35.5
	Doboj Region	21	16.9
	Bijeljina Region	31	25.0
	East Sarajevo Region	13	10.5
	Herzegovina Region	15	12.1

Note: Respondents were 18–66 years old. Source: Authors' research (2026)

The survey was administered online from 1 February to 1 March 2026. Invitations to participate were distributed by e-mail, social media, and through Viber and WhatsApp groups. Participation was voluntary, and respondents were informed that their responses would be used exclusively for research purposes. The inclusion criteria required respondents to be at least 18 years old, reside in the Republic of Srpska, be familiar with Nektar beer, have previously consumed the product, voluntarily consent to participate, and complete the questionnaire in full. Responses that did not meet these criteria or contained incomplete questionnaires were excluded from the analysis.

The instrument of data collection was a questionnaire, consisting of ten statements related to the perception of the rebranding of Nektar beer and consumer confidence. Responses were measured using a Likert scale of 1 to 5, where 1 stands for "I don't agree at all" and 5 stands for "Strongly agree."

This methodological approach has enabled a systematic and objective examination of the research problem, combining quantitative analysis with empirical evidence from concrete business practice. This gives a clear picture of how the perception of the rebranding of Nektar beer affects consumer confidence, which provides practical guidance to managers and marketing experts in crisis situations.

RESULTS

The results of the survey, conducted among 124 consumers of the Nektar brand, show that the majority of respondents positively perceive the rebranding of Nektar beer and that their trust in the brand has increased after the crisis.

Table 2. Distribution of respondents' responses on the perception of the rebranding of Nektar beer and consumer confidence (n = 124)

R. br.	Claim	(I don't agree at all)	(I disagree)	3 (Neutral)	(I agree)	(I totally agree)
1	I believe that the Banja Luka brewery has successfully carried out the rebranding of Nektar beer after the crisis.	8	12	20	55	29
2	The changes in the rebranding of Nektar beer seem honest and authentic.	7	14	25	42	36
3	The rebranding of Nektar beer clearly shows that the Banja Luka brewery has learned from its mistakes.	6	10	22	25	61
4	The new communication related to the rebranding of Nektar beer instills more security than before the crisis.	8	15	20	62	19
5	I believe that the rebranding of Nektar beer was not just a marketing move, but a real change in the offer and communication.	9	13	23	49	30
6	After the rebranding of Nektar beer, I have more confidence in this brand.	5	12	20	50	37
7	The rebranding of Nektar beer makes me believe that the Banja Luka brewery is more responsible towards consumers than before the crisis.	6	11	19	62	26
8	I'm ready to buy the rebranded Nektar beer again.	7	13	22	21	61
9	I would recommend the rebranded Nektar beer to others despite the previous crisis.	6	12	21	37	48
10	I believe that a similar crisis and problems related to the Nektar brand will not be repeated in the future.	5	10	25	71	13

Source: Author's research (2026)

The results of a survey conducted among 124 consumers of the Nektar brand show that the majority of respondents positively perceive the rebranding of Nektar beer and that their trust in the brand has increased after the crisis. The results of the re-

search are presented below through five key analytical units: perception of rebranding, consumer trust, reliability of scales, correlation analysis and regression model.

1. Perception of rebranding

An analysis of the first five questions, which measure the perception of a successful rebranding of Nektar beer, shows that the majority of respondents agree or fully agree with the claims about the changes made by the company after the crisis. In particular, question 3 ("The rebranding of Nektar beer clearly shows that the Banja Luka brewery has learned from its mistakes") records the highest number of high marks, with 61 respondents marking "I strongly agree". This result suggests that respondents perceive the rebranding as an honest and authentic attempt by the company to improve its image.

On the other hand, a smaller number of respondents indicated neutral or negative attitudes, which indicates the presence of a certain reservation or skepticism in a smaller part of consumers, but in the aggregate these values do not diminish a clear positive tendency of perception. The mean for question group 1–5 is approximately 4.0, confirming a generally high level of positive perception.

2. Consumer trust

Questions 6–10 measure respondents' trust in the brand after the rebranding of Nektar beer. The results show that trust has significantly increased compared to the pre-crisis situation. Of particular interest is question 8 ("I am ready to buy rebranded Nektar beer") where 61 respondents out of 124 indicate "Strongly agree", indicating the positive impact of rebranding on buying behavior and loyalty.

Question 10 ("I believe that a similar crisis and problems related to the Nektar brand will not be repeated in the future") shows a relatively lower average rating, suggesting that respondents still maintain a certain amount of caution towards future crises. These findings suggest that while rebranding increases trust, consumers are still monitoring the company's behavior and its ability to prevent future problems.

3. Scale reliability

The aim of this analysis was to check the internal consistency of the questions within each measurement scale, i.e. to determine the extent to which items belonging to the same group measure the same concept. Cronbach's alpha (α) coefficient was used to assess reliability, where values greater than 0.70 are considered an indicator of satisfactory reliability, while values above 0.80 indicate high internal consistency of the scale (Tavakol & Dennick, 2011) .

In the study, two groups of variables were analyzed. The first group was the perception of rebranding (questions 1-5), while the second group included Consumer Confidence (questions 6-10).

Table 3. Scale reliability

Group of variables	Number of questions	Cronbach α	Reliability level
Perception of rebranding (questions 1-5)	5	0,82	High
Consumer confidence (questions 6-10)	5	0,85	High

Source: Own data processing in SPSS Statistics

The results of the analysis showed that, for the Rebranding Perception scale, Cronbach α is 0.82, which indicates high reliability. This value confirms that the questions within this scale are mutually aligned and that they consistently measure the same concept, i.e. the respondents' attitude towards the rebranding process.

For the Consumer Confidence scale, a Cronbach value of $\alpha = 0.85$ was obtained, which also represents high reliability. This means that the items that measure the level of confidence of respondents are consistent and that together they form a stable and reliable measurement unit. A high alpha coefficient value indicates a strong internal correlation between questions and consistency of respondents' answers.

Given that both Cronbach values α the coefficient are above the recommended threshold of 0.70, it can be concluded that both scales are reliable and suitable for further statistical data processing. This implies that aggregate scores (average or summary values) can be used for the purposes of correlation and regression analysis.

4. Correlation and linear regression

(Kim, 2015) (Kim, 2015), To quantify the strength and direction of the linear relationship between the perception of rebranding and consumer trust. (Kim, 2015). Correlation analysis can determine whether there is a statistically significant relationship between the positive experience of brand change and the level of user trust, which is an important indicator of the success of rebranding.

Table 4 shows the results of the Pearson correlation, including coefficient values, significance level, and number of respondents, providing an overview of the underlying association between these variables.

Table 4. Pearson correlation (extended)

Variables	Perception of rebranding	Consumer confidence
Perception of rebranding	1	0,72**
Consumer confidence	0,72**	1

Source: Own data processing in SPSS Statistics
Additional data: n = 124; p < 0.01 - significantly at the level of 1%

The results show a strong positive correlation between the perception of rebranding and consumer confidence ($r = 0.72$, $p < 0.01$). This means that when respondents evaluate the rebranding process more positively, they also show a higher level of trust in the brand. The high statistical significance confirms the reliability of these findings and indicates that successful rebranding can significantly contribute to strengthening consumer loyalty and positive attitude.

5) Linear regression

To examine whether the perception of rebranding predicts consumer confidence, a simple linear regression model was estimated, as expressed in Formula 1 (Maulud & Abdulazeez, 2020). The dependent variable was the average consumer confidence score calculated from questions 6–10, while the only independent variable was the average perception of rebranding score calculated from questions 1–5. Demographic characteristics, including age, gender, educational attainment, and region, were not entered as control variables. Therefore, the reported regression coefficient represents the unadjusted association between the perception of rebranding and consumer confidence.

Formula 1

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

where:
Y - average score of consumer trust (questions 6-10),
X - average rating of the perception of rebranding (questions 1-5),
β_1 is a coefficient that shows how much change in perception affects trust.
β_0 - intercept, i.e. the initial value of trust when perception = 0,
ε – model error.

Source: (Maulud & Abdulazeez, 2020)

The results of the regression analysis, shown in Table 5, indicate that the intercept is $\beta_0 = 2.15$, while the coefficient is $\beta_1 = 0.46$. This means that each increase in the average perception score by one unit increases confidence by 0.46. The model explains the 52% variability in trust ($R^2 = 0.52$), indicating that the perception of rebranding has a significant impact on consumer attitudes. A standardized coefficient of $\beta = 0.71$ confirms a strong positive effect, while statistical tests t and p (<0.001) confirm the significance of the model. The parameter $R^2 = 0.52$ further indicates that the model is stable and well adapted to the sample.

Table 5. Results of linear regression

Parameter	It's a U.S.	Interpretation of results
β0 (intercept)	2,15	The initial value of trust when perception is 0
β1 (slope)	0,46	Each unit of increase in average perception increases confidence by 0.46
R^2	0,52	52% of trust variability explains perception

Source: Own data processing in SPSS Statistics

P is a value of (β1) < 0.001 → the effect is statistically significant

These results clearly show that the perception of successful rebranding directly affects consumer trust, i.e. that the perception of successfully implemented rebranding in a crisis situation has a significant positive impact on the level of consumer trust in the brand.

DISCUSSION

The analysis of individual questions shows that respondents particularly value the authenticity and sincerity of changes (questions 2 and 3), which is in line with the findings (Singh, Crisafulli, Quamina, & Xue, 2020) who point out that consumers react strongly to consistent and authentic communication in crisis situations. The results also show that the positive perception of the rebranding of Nektar beer directly affects consumers' willingness to buy again and recommend the brand to others (questions 8 and 9), which is in line with the findings (Ahmad, Okechukwu, & Shaari, The effect of rebranding on brand loyalty: Brand reputation as mediator, 2022), who have found that rebranding can increase loyalty by improving brand perception.

A comparative analysis with similar studies confirms the compatibility of the results: (Ahmad & Shaari, The Relationship Between Rebranding and Brand Reputation After a Brand Crisis: The Mediating Role of Brand Loyalty PDF: Rebranding and Brand Reputation After Crisis., 2024) They state that rebranding, when carried out strategically and transparently, improves the reputation of the brand after crisis situations.

Linear regression further confirms these findings. The results show that the perception of rebranding significantly predicts consumer confidence ($\beta = 0.71$, $p < 0.01$.

(Chowdhury & Chowdhury, 2024) They point out that crisis situations directly threaten consumer confidence, and a positive perception of change acts as a key factor in restoring trust.

(Kunal, 2023) It confirms that the perception of corporate rebranding in the textile industry has a positive impact on customer attitudes and loyalty, which is methodologically and conceptually similar to this research.(Selvakumar, Babu, & Prasadh, 2025) They stress the importance of perceiving the scale and sincerity of changes in shaping consumer confidence.

Based on these findings, it can be concluded that the local context, such as the Banja Luka Brewery, confirms global trends: successful rebranding affects not only brand perception, but also consumer behavior, including loyalty and recommendations. While the majority of respondents expressed a high level of confidence, a number of neutral and negative responses (in particular question 10) suggest that consumers remain wary of the resurgence of crisis situations. This indicates that the rebranding must be continuously accompanied by authentic communication and maintaining the quality of the product.

Also, the results of the research confirm that a clear and authentic perception of the rebranding of Nektar beer is key to restoring consumer confidence, and the findings are fully compatible with previous research and provide additional confirmation of the importance of strategic rebranding in crisis conditions. This has practical value for managers and marketing professionals, as it allows them to plan and implement rebranding that not only improves the image, but also directly increases consumer trust and loyalty.

The practical implications of these results are manifold. First, the authenticity and transparency of changes are crucial, as consumers value honest and consistent brand transformations, while marketing moves without real changes cannot restore trust in the long run. Secondly, clearly perceived rebranding increases the willingness of consumers to buy products again and recommend the brand to others, which directly affects loyalty and sales. Third, companies need to continuously monitor consum-

er perceptions and ensure consistent communication about changes, especially in the post-crisis period. Finally, the local context confirms that strategic rebranding can be an effective tool for preserving and restoring trust in markets where consumer loyalty has a significant impact on competitiveness.

When generalizing the findings, it should be borne in mind that the research was conducted in a limited territory and with a small number of respondents, whose answers reflect subjective perception. Also, the analysis focused on one brand and referred to short-term consumer reactions, so long-term changes in trust were not included.

Despite these limitations, the results clearly indicate the practical value of rebranding in crisis situations. Authentic and consistently communicated changes have been shown to significantly increase consumer trust, strengthen customer loyalty, and provide companies with concrete guidelines for strategic reputation management in challenging conditions. These findings also confirm that carefully planned rebranding can be an effective tool for preserving and improving customer relationships, even in markets where trust is a key factor in competitiveness.

CONCLUSION

The conclusions of this research point to the significant role of the perception of rebranding in the process of renewal of the relationship between the brand and the consumer after crisis situations. The results show that consumers respond positively to changes that are perceived as real, consistent and aimed at improving product quality and communication with the market. giving companies concrete guidelines for strategic reputation management and communication with consumers. Such a perception contributes to strengthening trust in the brand and increases the willingness of consumers to buy the product again and recommend it to others. This confirms that a successful rebranding can have a direct impact on consumer behavior and loyalty.

Statistical analyses further confirm the existence of a strong correlation between the perception of change and the level of trust, indicating that the way consumers interpret and value brand transformation is a key factor in the process of reputation recovery. At the same time, the results suggest that trust has not been fully restored among all consumers, as a certain proportion of respondents continue to show caution about the future stability of the brand.

The findings also have significant implications for companies facing reputational crises. Organizations must approach rebranding as a long-term strategic process that implies real changes in business, transparent communication and continuous monitoring of consumer perception. Only such an approach can contribute to the permanent restoration of trust and the sustainable strengthening of the brand's market position.

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https://doi.org/10.7251/EMC2603851C

UDK: 338.242.2:316.323.72(497.11)

Datum prijema rada: 27. april 2026.
Submission Date: April 27, 2026
Datum prihvatanja rada: 2. septembar 2026.
Acceptance Date: September 2, 2026

Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review

Godina/Vol. **XVI** • Br./No. **III**
str./pp. 851-868

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

STIMULATING LOYALTY THROUGH CUSTOMER EXPERIENCE VIA MARKETING OUTCOMES IN THE BANKING SECTOR

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Abstract: *Literature positions customer experience as a strategic driver of competitive advantage in the banking sector. However, gaps remain in emerging-market research, where contextual factors can shape experiential perceptions in different ways. Addressing these gaps through empirical research provides both theoretical advancement and practical guidance for banks navigating competitive and transitional environments. This study investigates the relationships among customer experience, customer satisfaction, word-of-mouth, and behavioural loyalty intentions in the Serbian banking sector. The primary objective is to examine whether customer satisfaction and word-of-mouth mediate the effect of customer experience on behavioural loyalty intentions. Empirical data were collected from bank customers in Serbia, comprising 616 valid responses, and analysed using structural equation modelling. The findings indicate that customer experience exerts a statistically significant positive effect on behavioural loyalty intentions, both directly and indirectly. Customer satisfaction was found to partially mediate the relationships between customer experience and behavioural loyalty intentions, as well as between customer experience and word-of-mouth. In addition, customer satisfaction and word-of-mouth jointly demonstrate a partial serial mediating effect on the relationship between customer experience and behavioural loyalty intentions. These results suggest that customer experience should be conceptualised as a strategic antecedent of customer loyalty, operating through both affective and communicative mechanisms. The study contributes to the existing literature by extending the understanding of loyalty formation in banking and by providing context-specific evidence from Serbia. The findings also offer managerial implications, indicating that more effective management of customer experience, satisfaction, and customer advocacy may contribute to stronger customer retention and positive recommendation behaviour.*

Keywords**:** *customer experience; customer satisfaction; word-of-mouth; behavioural loyalty intentions; customer loyalty; banking sector; Serbia.*

JEL Classification: *G41; D12; M31; C38*

INTRODUCTION

In an increasingly competitive, digitally mediated marketplace, an in-depth understanding of the customer experience and the customer journey has become essential for organisations seeking to sustain competitive advantage. Contemporary consumers engage with firms through a multiplicity of touchpoints spanning both physical and digital channels, rendering the overall service experience an intrinsically complex and socially constituted phenomenon (Lemon & Verhoef, 2016; Siebert et al., 2020). Scholarly consensus increasingly recognises that the quality of these cumulative interactions constitutes the primary determinant of perceived value and long-term relational outcomes. This paradigm shift inspired both researchers and practitioners to reconceptualise the customer journey, not simply as a sequence of discrete contacts, but as an integrated, dynamic system of value co-creation. Empirical evidence demonstrates that leading service organisations which invest in the systematic optimisation of customer journeys realise significantly higher levels of customer satisfaction and sustained corporate growth (Edelman & Singer, 2015; Rawson et al., 2013). Achieving such optimisation necessitates that firms develop institutional capabilities for the structured collection of behavioural insights, the purposeful design and governance of touchpoints, and the persistent monitoring and evaluative assessment of experiential quality across the full customer lifecycle (Halvorsrud et al., 2016). Within this context, customer experience quality has appeared as a theoretically salient and practically consequential construct, representing the phenomenological distinction between objective service delivery and the subjectively perceived experience of that delivery.

Building on this conceptual foundation, prior research in the Serbian banking sector empirically delineated the constituent dimensions of the Customer Experience (CE) construct, identifying brand experience, service provider experience, and post-purchase experience as its principal factorial components (Džinić et al., 2026). These outcomes offer a considerable empirical contribution to the contextualisation of customer experience theory inside emerging-economy service markets, where institutional, cultural, and rivalry dynamics may differ substantially from those prevalent in more widely studied Western contexts. Nevertheless, the mechanisms by which customer experience influences downstream marketing outcomes remain insufficiently theorised and empirically tested, particularly the mediating pathways linking experiential antecedents to behavioural responses. Specifically, linking customer experience to key marketing outcomes, this research analyses the directional and mediating relationships among customer experience and its marketing outcomes: customer satisfaction, word-of-mouth, and behavioural loyalty intentions. By explaining the sequential pathway through which customer experience influences marketing outcomes, this study makes a dual contribution: it develops the theoretical modelling of customer experience within the service marketing literature. The study provides useful guidance for practitioners designing and managing customer-focused strategies in the competitive and evolving banking sector of an emerging economy.

LITERATURE REVIEW

Customer experience has become one of the most discussed concepts in marketing and service research over the past two decades, and for good reason. It captures something that purely functional or transactional models of service often miss: the fact that customers do not simply evaluate what they receive, but how they feel, think, and make sense of every interaction they have with a firm. At its core, customer experience refers to the cognitive, affective, sensory, social, and behavioural responses that emerge from customers' direct and indirect encounters with an organisation across multiple touchpoints, channels, and stages of the customer journey (Lemon & Verhoef, 2016; Verhoef et al., 2009).

This understanding shows a broader change in how both scholars and practitioners think about competition. Organisations are no longer competing solely on product features or price; increasingly, they compete on the quality of the experiences they create. This transition, from transaction-focused to experience-focused competition, places the management of perceptions, emotions, and meaning-making at the heart of the customer–provider relationship. Customers bring their own histories, expectations, and interpretive frameworks to interaction, which means that experience is always, to some degree, personal and subjective, even when it unfolds within a standardised service environment. Within service-oriented logic and relationship marketing frameworks, customer experience is understood not as a single moment but as a cumulative, evolving phenomenon that develops across the full lifecycle of the customer–firm relationship (Verhoef et al., 2009). In practice, the value is not something firms simply deliver it is something customers actively co-create through ongoing interaction and interpretation. A particularly useful framework distinguishes among pre-purchase, purchase, and post-purchase experience stages, each shaped by a mix of firm-controlled, partner-mediated, and customer-initiated touchpoints (Lemon & Verhoef, 2016). This tripartite structure illustrates the non-linear and changing nature of the customer journey, reminding us that a single poor interaction can reshape the memory of an otherwise positive relationship, while consistently meaningful experiences tend to build loyalty and advocacy over time (Klaus & Maklan, 2013).

To operationalise customer experience in a manner aligned with this holistic logic, the present study defines customer experience (CE) in terms of three interlinked dimensions: Brand Experience (BRE), Service/Product Experience (SPE), and Post-Purchase Experience (PPE). First, BRE captures the experiential responses evoked by brand-related stimuli (e.g., brand identity, communications, symbols, and associations) that shape meaning, emotional attachment, and recognition of interactions. This dimension reflects the idea that brands function as experiential platforms that guide interpretation and expectations (Brakus et al., 2009). Second, SPE represents the customer's experience of core service and/or product performance during usage and interaction, including perceived quality, usability, and the relational/interface aspects of service delivery that are central to value creation at the point of encounter (Parasuraman et al., 1988; Verhoef et al., 2009). Third, PPE extends CE beyond the moment of consumption to encompass evaluations and experiences after purchase, such as confirmation/disconfirmation of expectations, recovery and complaint handling, support, and ongoing relationship management, which are critical in forming cumulative impressions and future-oriented responses (Oliver, 1997; Tax et al., 1998).

MARKETING OUTCOMES

Building on services marketing, relationship marketing, and customer experience management literature, the marketing outcomes of customer experience can be conceptualised as a multidimensional domain comprising interrelated customer response constructs. From this perspective, customer experience generates marketing value not only through immediate transactional evaluations but also through attitudinal, intentional, and communicative responses that shape the continuity and quality of the customer–firm relationship. Accordingly, customer satisfaction, behavioural loyalty intentions, and word-of-mouth represent key outcome dimensions using which customer experience is translated into assessable marketing effects (Džinić et al., 2026; Klaus & Maklan, 2013).

The marketing implications of customer experience may therefore be understood as customer-level response variables that link perceived experience quality with wider market performance. In this study, three interconnected outcomes: Customer Satisfaction (SAT), Behavioural Loyalty Intentions (BLI), and Word-of-Mouth (WOM), are used to capture the principal processes through which customer experience produces marketing value. This approach is consistent with the view that customer experience develops across multiple touchpoints and accumulates over time, consequently influencing post-consumption evaluations, future behavioural intentions, and relational advocacy.

Customer satisfaction refers to an overall evaluative judgment derived from customers' cumulative interactions with a product, service, or organisation. It reflects the extent to which perceived performance meets, exceeds, or falls short of prior expectations and therefore represents a proximal outcome of customer experience. In service contexts, satisfaction condenses multiple experiential cues, including reliability, responsiveness, emotional impressions, and perceived value, into an overall assessment of the relationship with the provider (Anderson et al., 1994; Oliver, 1997).

Behavioural loyalty intentions denote customers' stated propensity to continue, strengthen, or expand their relationship with a firm. This includes intentions related to repurchase, continued usage, provider preference, increased engagement, and resistance to switching. Unlike satisfaction, which primarily reflects evaluations of past and current experiences, BLI is future-oriented and indicates the likelihood that favourable experience evaluations will be translated into relationship continuity and customer retention (Kumar et al., 2013; Troiville, 2024; Xue & Tian, 2025).

Word-of-mouth captures customers' willingness to share experiences, recommend the firm, and influence other customers' perceptions or choices. As a communicative and relational outcome, word-of-mouth extends the value of customer experience beyond the individual customer through interpersonal communication, online reviews, social media, and other channels of experiential information exchange (Brown et al., 2005; East et al., 2007; Harrison-Walker, 2001).

Drawing on customer experience theory, services marketing, and relationship marketing, this study adopts an overarching process-based framework in which cumulative customer experience across multiple touchpoints generates an overall evaluative response in the form of customer satisfaction, which subsequently translates experiential evaluations into downstream relational outcomes, word-of-mouth as a communicative response and behavioural loyalty intentions as a future-oriented response, thereby

providing the theoretical rationale for the proposed causal sequence from experience to evaluation and, ultimately, to advocacy and relationship continuity.

An integrated outcome architecture comprising SAT, BLI, and WOM is best suited to explain how customer experience generates marketing value through evaluative, relational, and advocacy-based mechanisms. This is why the architecture is used as a conceptual model for this study, as presented in Figure 1.

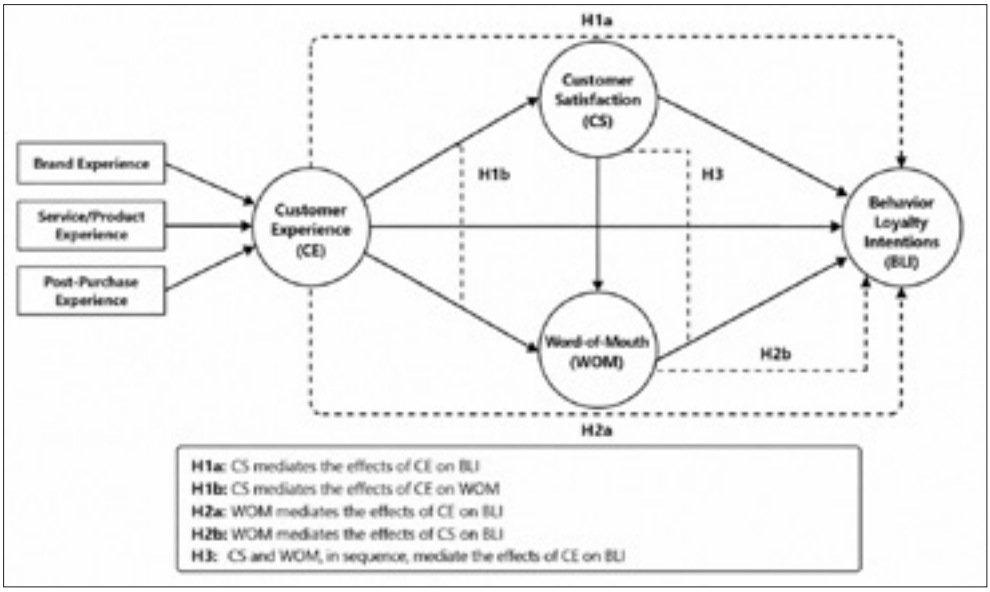

Figure 1: The conceptual model

Source: Authors

MEDIATING EFFECTS

Based on a process-oriented perspective, the outcomes of marketing concerning customer experience are theoretically interconnected and can be systematically modelled as a sequential process. In this model, perceptions of the customer experience initially influence customer satisfaction (SAT), which subsequently facilitates the development of brand loyalty intentions (BLI) and word-of-mouth (WOM) communication. These relationships are mediated through both attitudinal and relational mechanisms, reflecting the complex interplay between perceptual evaluations and behavioural expressions within the customer engagement framework. Positive WOM intentions are strengthened when satisfaction fosters psychological attachment, such as identification and commitment, suggesting that satisfied customers are more inclined to recommend because they perceive relational alignment with the provider (Brown et al., 2005). Furthermore, loyalty intentions suggest that customers internalise the experience as sufficiently valuable to support future exchanges, a concept fundamental to the relationship between experience and performance established in satisfaction research (Anderson et al., 1994). Word of mouth acts as an essential informational and social cue, helping to reduce uncertainty for potential buyers and encouraging quicker adoption of products or services. This effect is especially pronounced in scenarios where direct experiential

evidence is scarce or unavailable. (East et al., 2007). Taken together, BLI, SAT, and WOM provide a strong measure of marketing results stemming from customer experience. They reflect (i) the likelihood of maintaining relationships (BLI), (ii) evaluative judgments (SAT), and (iii) advocacy-based word-of-mouth spread (WOM). This integrated framework facilitates a comprehensive examination of the impact of customer experience on both retention and acquisition metrics, offering a detailed analysis of their interrelation (Brown et al., 2005; Oliver, 1997).

Customer satisfaction is believed to mediate the link between customer experience and behavioural loyalty intentions. It is based on the idea that customer experience involves a comprehensive assessment of all interactions and touchpoints with the organisation, whereas satisfaction refers to the post-interaction judgment formed. Therefore, satisfaction acts as the mechanism that translates customer experiences into future actions, such as repeat visits and loyalty. Empirical research has consistently supported this sequence, strengthening the theory that satisfaction is a key intermediary in the development of long-term customer loyalty. Klaus and Maklan show that customer experience quality is a strong predictor of satisfaction and that satisfaction serves as an important pathway through which experience affects loyalty-related outcomes (Klaus & Maklan, 2013). Likewise, experience quality exerts its effect on behavioural intentions primarily via indirect mechanisms involving satisfaction, reinforcing the perspective that positive experiences require a preceding satisfactory evaluation to translate into loyalty intentions (Chen & Chen, 2010). Research in the tourism and service sectors further confirms that customer satisfaction is a strong predictor of important behaviours such as revisits, recommendations, and post-experience actions. This emphasises satisfaction's mediating role in the overall experience–loyalty process, underscoring its importance as a key intermediary for building long-term loyalty and ongoing behavioural commitment (Žabkar et al., 2010). Therefore, it is reasonable to formulate:

Hypothesis H1a: *CS mediates the effects of CE on BLI*.

Customer satisfaction could be hypothesised to mediate the relationship between customer experience and word-of-mouth. Grounded in the view that customer experience shapes customers' overall cognitive and emotional evaluation of a firm, but that this evaluation translates into advocacy behaviour only when it yields satisfaction. In essence, positive experiences across various service encounters, touchpoints, and interactions significantly increase the likelihood that customers perceive their overall satisfaction. Elevated satisfaction levels subsequently increase customers' propensity to recommend the firm, share favourable impressions, and participate in word-of-mouth communication. This conceptual framework aligns with established findings in customer experience research, which demonstrate that the quality of experiences directly influences downstream relational outcomes through the mediating variable of satisfaction. Additionally, empirical investigations have consistently shown that superior customer experiences positively impact satisfaction levels, which in turn serve as a driving force behind word-of-mouth behaviours, thereby reinforcing the vital role of experience quality in shaping long-term customer-firm relationships (Klaus & Maklan, 2013). Therefore, it is theoretically and empirically justified to formulate:

Hypothesis H1b: *CS mediates the effects of CE on WOM*.

Word-of-mouth could be hypothesised to mediate the effects of customer ex-

perience on behavioural loyalty intentions. This is grounded in the argument that customer experience influences loyalty-oriented behaviour both directly and indirectly, by stimulating customers' willingness to share positive recommendations and engage in advocacy. A favourable customer experience creates memorable cognitive and emotional evaluations of the service encounter (Xue & Tian, 2025), and these evaluations increase the likelihood that customers will engage in positive word-of-mouth, which, in turn, strengthens downstream behavioural loyalty intentions such as repurchase, continued use, and recommendation. This logic is consistent with studies showing that customer experience has a significant positive effect on both loyalty and word-of-mouth intentions (Klaus & Maklan, 2013), while customer experience and word-of-mouth intention each positively affect customer loyalty in banking (Manyanga et al., 2022), supporting the view that word-of-mouth is a plausible intermediate mechanism through which experience translates into loyalty behaviour. More broadly, recent mediation research in services confirms that experience-related evaluations can influence loyalty through advocacy pathways, reinforcing the theoretical basis for positioning word-of-mouth as a mediator between customer experience and behavioural loyalty intentions (Wichitsathian & Suvittawat, 2025). Therefore, it is reasonable to formulate:

Hypothesis H2a: *WOM mediates the effects of CE on BLI.*

Word-of-mouth could be hypothesised to mediate the effects of customer satisfaction on behavioural loyalty intentions. Based on the argument that satisfied customers do not translate their favourable evaluations into loyalty-oriented behaviour only directly, but also indirectly through advocacy and recommendation behaviour. When customers are satisfied, they are more likely to speak positively about the firm, recommend it to others, and share favourable experiences; this positive word-of-mouth can reinforce their behavioural loyalty intentions, such as repurchase, continued usage, and recommendation. Empirical studies support both parts of this logic: research in banking shows that customer satisfaction and word-of-mouth intention are each significant positive predictors of customer loyalty, indicating that advocacy is closely tied to downstream loyalty behaviour (Manyanga et al., 2022), while other studies report that satisfaction is positively associated with word-of-mouth and that satisfied customers are more likely to engage in positive word-of-mouth (Nasir et al., 2021). Collectively, the existing literature provides a strong theoretical basis for suggesting that customer satisfaction shapes behavioural loyalty intentions indirectly, with word-of-mouth serving as an intermediate pathway. Therefore, it is reasonable to formulate:

Hypothesis H2b: *WOM mediates the effects of CS on BLI.*

It could be hypothesised that customer satisfaction and word-of-mouth mediate the effects of customer experience on behavioural loyalty intentions. This is grounded in a sequential logic in which customer experience first shapes customers' evaluative response to the firm, then encourages advocacy, and ultimately strengthens future loyalty-oriented behaviour. Prior research consistently shows that a favourable customer experience improves customer satisfaction, which is closely linked to positive behavioural outcomes and customers' willingness to engage in word-of-mouth. Experience quality was found to affect behavioural intentions primarily through indirect rather than direct paths, highlighting the importance of intervening attitudinal mechanisms between experience and loyalty-related outcomes (Chen & Chen, 2010). More directly, CE, CS, and WOM intention each have significant positive effects on custom-

er loyalty in banking (Manyanga et al., 2022), supporting the view that satisfaction and advocacy are both meaningful transmission channels between experience and loyalty. Therefore, it is theoretically and empirically justified to formulate:

Hypothesis H3: *CS and WOM, in sequence, mediate the effects of CE on BLI.*

RESEARCH METHODOLOGY

The measurement instrument employed for evaluating customer experience and its associated marketing outcomes in this study has been carefully selected, adapted, and validated to ensure its suitability and reliability within the specific cultural and economic context of Serbia (Džinić et al., 2026).

A structured online questionnaire was used to collect data from customers of banking services in Serbia, with the sample formed using a convenience sampling procedure. Participation was entirely voluntary, with assurances of anonymity provided to all respondents. Informed consent was implicitly obtained upon completion of the survey. The data collection period spanned from March to June 2024. A total of 702 responses were recorded; after data cleaning and validation, 616 responses (87.75%) were accepted as valid and included in the subsequent analysis.

The sample consisted of 372 females (60.4%) and 244 males (39.6%). Age-wise, it mainly included individuals in the economically active group, with the largest proportions in the 25–34 years (43.0%) and 35–44 years (31.2%) ranges. Other age groups were less represented: 45–54 years (10.7%), 18–24 years (7.6%), 55–64 years (6.0%), and those under 18 years (1.5%). The educational structure of the sample suggests a relatively high level of formal education. Specifically, 49.7% of respondents had completed undergraduate studies, while 21.3% held a Master's or PhD degree. In addition, 16.6% reported a high school education, 12.3% had completed college education, and only 0.2% indicated primary school education as their highest attained level. Regionally, the sample mainly consisted of participants from Vojvodina (82.6%), with Belgrade accounting for 14.8%, and other regions making up 2.6%. In terms of customer segments, retail clients formed the majority (76.5%), with commercial clients comprising 23.5%.

To empirically validate theoretical constructs and explain the variance in endogenous variables, Partial Least Squares Structural Equation Modelling (PLS-SEM) is the most appropriate technique. Results are often shown with path diagrams, which visually illustrate the proposed relationships among variables, helping to clarify the structural model and its hypotheses.

RESULTS

Hypotheses were tested at the 95% significance level ($p < 0.05$), where lower *p*-values indicate a lower probability that the observed relationships occurred by chance, thereby supporting the presence of statistically meaningful effects of the independent variables; prior to hypothesis testing, construct reliability and validity were also assessed (Hayes, 2009; Ojeme & Robson, 2020).

In this study, Customer Experience (CE) is conceptualised and operationalised as a higher-order multidimensional construct (Hair et al., 2022) comprising Brand Experience (BRE), Service/Product Experience (SPE), and Post-Purchase Experience (PPE), reflecting the cumulative nature of customer interactions across the customer

journey and providing the theoretical basis for its subsequent effects on satisfaction, WOM, and behavioural loyalty intentions. The latent variable Customer Experience (CE) was obtained by a stepwise approach (Becker et al., 2012; Ojeme & Robson, 2020), reducing each independent variable construct to a single standardised item: Brand Experience, Service/Provider Experience, and Post-Purchase Experience, which serve as proxies for the variables' overall influence on CE (see Figure 2).

The results indicate that the measurement model achieved an adequate level of reliability and validity. Internal consistency was supported across all constructs, with Cronbach's alpha values ranging from 0.916 to 0.939 and therefore exceeding the recommended minimum value of 0.70 (see Appendix Table 2). The criteria for convergent validity were also satisfied, as all indicator loadings were high, ranging from 0.840 to 0.938, while composite reliability (CR = 0.919–0.941) and average variance extracted (AVE = 0.761–0.856) remained above the recommended thresholds (Hair, J. F. et al., 2023). Discriminant validity was confirmed through Heterotrait–Monotrait ratio of correlations (HTMT) values below the conservative threshold of 0.90 (see Appendix Table 3). Furthermore, the full collinearity assessment showed that all VIF values were below the threshold of 5 (see Appendix Table 2), indicating that the model was not affected by problematic multicollinearity or common method bias (Hair, J. F. et al., 2023).

Data were analysed using SmartPLS 4, and the hypothesised relationships were tested by bootstrapping. The model's explanatory and predictive performance was assessed using path coefficients, R^2, and Q^2 predict. The R^2 values indicate substantial explanatory power (see Figure 2): the variance in CS is explained by CE by 82.4%; the variance in WOM is explained by 42% by CE and CS and the variance in BLI is explained by 74.2% by CE, CS and WOM (see Figure 2). Predictive relevance was further confirmed by Q^2 predict values (see Appendix: Table 4), where positive values indicate superior predictive performance relative to a naïve benchmark (Shmueli et al., 2019). Most indicators demonstrated strong predictive relevance, whereas the Word-of-Mouth indicators showed comparatively lower Q^2 predict values (0.259 to 0.347), indicating moderate predictive power. Overall, the results support the conclusion that the model has satisfactory predictive performance, although Word-of-Mouth represents the most difficult construct to predict.

Figure 2 presents the results of the bootstrapping procedure, including the estimated path coefficients and their statistical significance.

The structural model reveals positive and statistically significant relationships across all analysed constructs. Customer Experience has a very strong positive effect on Customer Satisfaction ($\beta = 0.908$, $p < 0.001$), indicating that a more favourable customer experience across brand, service, and post-purchase dimensions is associated with higher satisfaction. It also shows positive direct effects on Behavioural Loyalty Intentions ($\beta = 0.113$, $p < 0.05$) and Word-of-Mouth ($\beta = 0.239$, $p < 0.05$), suggesting that customer experience contributes directly to both loyalty intentions and positive customer advocacy. In addition, Customer Satisfaction is positively related to Behavioural Loyalty Intentions ($\beta = 0.450$, $p < 0.001$) and Word-of-Mouth ($\beta = 0.423$, $p < 0.001$), confirming its important role in shaping retention-related and advocacy-related outcomes. Finally, Word-of-Mouth shows a positive and highly significant relationship with Behavioural Loyalty Intentions ($\beta = 0.391$, $p < 0.001$), indicating that customers

who are more inclined to recommend the company are also more likely to express loyal behavioural intentions.

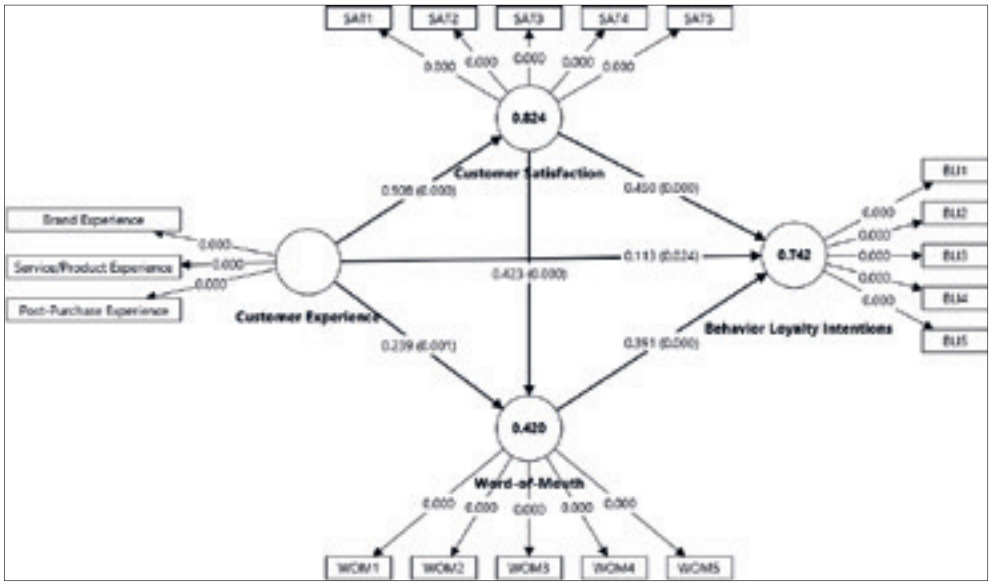

Figure 2: The analysis of the model

Source: Authors

MEDIATION ANALYSIS

The mediation analysis was conducted by simultaneously estimating the direct and indirect effects among the study variables using a bootstrapping procedure based on 5000 subsamples. This procedure provided a rigorous basis for assessing the significance of the proposed mediating effects, with the results presented in the following table (Table 1).

Table 1: Analysing the causal relationships

	Total effects		Direct effects		Indirect effects		Percentile bootstrap 97.5% interval		VAF	Supported
Hypothesis	β	p value	β	p value	β	p value	lower	upper		
CE – CS - BLI	0.766	0.000	0.113	0.024	0.409	0.000	0.318	0.496	0.78	YES
CE – CS - WOM	0.623	0.000	0.239	0.001	0.384	0.000	0.258	0.503	0.62	YES
CE – WOM - BLI	0.766	0.000	0.113	0.024	0.165	0.000	0.109	0.237	0.59	YES
CS - WOM - BLI	0.616	0.000	0.45	0.000	0.165	0.000	0.109	0.237	0.27	YES
CE - CS – WOM - BLI	0.766	0.000	0.113	0.024	0.150	0.000	0.099	0.215	0.57	YES

Note: VAF values were calculated separately for each specific indirect path and should therefore be interpreted as path-specific indicators of mediation strength

Source: Authors

The results indicate that CE has a statistically significant direct effect on BLI ($\beta = 0.113$, $t = 2.263$, $p = 0.024$), and the indirect effect via CS is also significant ($\beta = 0.409$, $t = 9.093$, $p < 0.001$), with the bootstrap confidence interval not including zero. Since both the direct and indirect effects remain significant, the findings support partial mediation. The corresponding Variance Accounted For (VAF) index is 78%, suggesting substantial path-specific mediation, as VAF values above 80% indicate full mediation, between 20% and 80% indicate partial mediation, and below 20% indicate no mediation. (Henseler, 2020).

Therefore, **H1a**: *CS mediates the effects of CE on BLI* is supported.

The results indicate that CE exerts a significant total effect on WOM ($\beta = 0.623$, $t = 23.343$, $p < 0.001$). The direct effect remained significant after including CS ($\beta = 0.239$, $t = 3.463$, $p = 0.001$), and the indirect effect via CS was also significant ($\beta = 0.384$, $t = 6.147$, $p < 0.001$), with a bootstrap confidence interval that excluded zero. These findings provide evidence of partial mediation, further supported by a VAF of 62%, indicating that CS is a substantial mediator in the relationship between CE and WOM.

Therefore, **H1b**: *CS mediates the effects of CE on WOM* is supported.

The analysis further shows that the indirect effect of CE on BLI via WOM is statistically significant ($\beta = 0.165$, $t = 5.134$, $p < 0.001$), with the corresponding bootstrap confidence interval not including zero. Given that the direct effect of CE on BLI remains significant, this result also indicates partial mediation rather than full mediation. The obtained VAF value of 59% suggests that WOM represents a meaningful path-specific partial mediator through which CE influences BLI.

Therefore, **H2a:** *WOM mediates the effects of CE on BLI* is supported.

The results show that CS exerts a significant total effect on BLI ($\beta = 0.616$, $t = 12.210$, $p < 0.001$). The direct effect remained significant after the inclusion of WOM ($\beta = 0.450$, $t = 9.105$, $p < 0.001$), while the indirect effect via WOM was also significant ($\beta = 0.165$, $t = 5.134$, $p < 0.001$), with a bootstrap confidence interval excluding zero. These findings indicate partial mediation, further supported by the VAF value of 27%, suggesting that WOM serves as a meaningful, though not dominant, mediating mechanism in the relationship between CS and BLI.

Therefore, **H2b**: *WOM mediates the effects of CS on BLI* is supported.

In addition to the individual mediating effects, the serial indirect path from CE, through CS and WOM, to BLI was also statistically significant ($\beta = 0.150$, $t = 5.117$, $p < 0.001$), with a bootstrap confidence interval excluding zero. The significance of both the serial indirect effect and the remaining direct effect indicates that the relationship between CE and BLI is also partially mediated through this sequential mechanism. The VAF value of 57% confirms that the serial path represents a substantial path-specific partial mediation effect, suggesting that CE enhances CS, which in turn strengthens WOM, ultimately contributing to BLI.

Therefore, **H3**: *CS and WOM, in sequence, mediate the effects of CE on BLI,* is supported.

DISCUSSION AND CONCLUSION

The Serbian banking market provides a theoretically relevant context for examining the relationships among customer experience (CE), customer satisfaction,

word-of-mouth (WOM), and behavioural loyalty intentions because it combines several structural and technological characteristics that may shape how customers evaluate and respond to banking experiences. The market is characterised by a dominant presence of foreign-owned banks and relatively strong competitive pressures, with foreign-owned institutions accounting for 77.5% of total banking-sector assets at the end of 2024 (The National Bank of Serbia, 2025). At the same time, the sector is undergoing rapid digital transformation: the number of mobile banking users increased by 13.9% in 2024, accompanied by substantial growth in mobile banking transactions (The National Bank of Serbia, 2025). Nevertheless, the expansion of digital banking has not eliminated traditional service encounters, as Serbian customers continue to use physical branches for specific banking activities (Lukić, 2025). This coexistence of digital and human touchpoints creates a heterogeneous customer journey in which evaluations may depend simultaneously on digital attributes such as security, usefulness and ease of use (Rejman Petrović et al., 2022) and interpersonal service characteristics such as empathy and responsiveness (Savić & Veselinović, 2019). Importantly, prior evidence from Serbia indicates that satisfaction generated through digital banking experiences strongly influences WOM and subsequent behavioural intentions (Rejman Petrović et al., 2022). Thus, the Serbian setting is theoretically relevant not simply because it is geographically under-researched, but because the interaction of intensive digitalisation, continuing reliance on interpersonal banking encounters, and competitive market conditions provides a distinctive environment in which the mechanisms linking CE to satisfaction, WOM and loyalty can be examined.

The present study offers further evidence that customer experience functions as a crucial strategic antecedent of behavioural loyalty intentions within the banking industry (Gentile et al., 2007; Manyanga et al., 2022). Specifically, the findings substantiate that customer satisfaction and word-of-mouth communication are significant mediating variables that elucidate how customer experience translates into positive post-purchase behavioural responses. In this context, customer experience should be conceptualised not merely as an appraisal of individual service encounters but as a comprehensive relational mechanism through which banking institutions influence customer perceptions, facilitate advocacy behaviours, and shape future behavioural intentions.

A central contribution of the study lies in confirming the mediating role of CS. The findings indicate that CS partially mediates the relationships between CE and BLI, and between CE and WOM. This suggests that positive CE strengthens loyalty intentions both directly and indirectly via increased satisfaction, consistent with prior service and relationship marketing research (Cronin et al., 2000). In parallel, the identified serial mediation effect further confirms the importance of WOM as both an outcome of CE and CS and as a relevant mechanism in loyalty formation.

In the banking context, where perceived risk, information asymmetry, and trust are particularly salient, positive recommendations may serve as an important external signal of service quality and institutional credibility (Ladhari et al., 2011). The present findings suggest that customers who have favourable banking experiences and are satisfied with those experiences are more likely to engage in positive communication about the bank, which, in turn, contributes to stronger behavioural loyalty intentions (Yankiv et al., 2026).

At the same time, the results indicate partial rather than full mediation, which is theoretically important because it shows that customer experience retains an independent, direct effect on behavioural loyalty intentions even after accounting for the indirect effects mediated by CS and WOM. This implies that loyalty formation cannot be reduced solely to satisfaction or recommendation behaviour, but instead reflects a more complex process driven by intertwined experiential, affective, and communicative mechanisms. Such an interpretation aligns with prior literature suggesting that loyalty-related behaviours emerge through multiple, overlapping pathways (Cronin et al., 2000; Kumar et al., 2013). More specifically, some studies conceptualise word-of-mouth as a mediator between positive experience and loyalty (Ngoma & Ntale, 2019; Troiville, 2024), while others treat it as a parallel outcome of satisfaction and service quality (Roy et al., 2017). The present study supports the view that a serial pathway is both plausible and empirically meaningful.

These findings are particularly relevant to the Serbian banking sector, which operates in a transitional, increasingly competitive environment characterised by digitalisation and rising customer expectations (Petrov et al., 2020). In such conditions, effective customer experience management may generate value not only through direct loyalty-enhancing effects, but also indirectly through improved customer satisfaction and advocacy. Accordingly, banks should treat customer experience as a strategic priority and systematically manage key touchpoints across branch interactions, digital channels, complaint handling, call centre communication, and relationship management support. Since customer satisfaction emerged as a central mediating mechanism, managers should complement operational performance indicators with structured feedback systems and continuous service improvement practices. Moreover, because word-of-mouth plays an important mediating role, banks should actively foster customer advocacy by improving service recovery, relationship quality, and the consistency of positive service experiences.

This study makes a significant contribution to the existing literature by empirically demonstrating that customer experience is a pivotal determinant of behavioural loyalty intentions in the banking sector in an emerging economy. The findings confirm that the influence of customer experience on behavioural loyalty intentions operates through both direct pathways and indirect mechanisms. The indirect influence of customer experience is mediated through two primary mechanisms: customer satisfaction and word-of-mouth. These mechanisms operate both independently and sequentially, with customer satisfaction serving as a precursor to positive word-of-mouth, thereby amplifying the overall impact. This comprehensive analysis broadens the existing conceptual framework of loyalty development by incorporating specific insights from the Serbian banking sector. It underscores the paramount importance of effective customer experience management as a critical determinant of higher customer satisfaction. This, in turn, increases customer retention and fosters positive word-of-mouth advocacy.

Nevertheless, it is important to recognise a notable limitation of this study. The research exclusively examines the banking sector in Serbia, which may limit the extent to which the findings can be generalised to other banking contexts, particularly in different emerging-market environments. The principal limitation is the extent to which findings from the Serbian banking context can be generalised to other emerging economies; however, the concentration of respondents in Vojvodina does not necessarily

preclude generalisation within Serbia, particularly given the absence of empirical evidence indicating systematic regional differences in how customers perceive and evaluate comparable banking services. Future research should consider extending these findings to other service industries, such as financial advisory services and healthcare providers, to facilitate comparative analyses with findings in developed economies, which are predominantly represented in the literature. Additionally, subsequent research efforts should incorporate moderating variables, such as customer demographics, to better understand the complex mechanisms underlying customer loyalty formation and retention.

APPENDIX

Table 2: Indicator Reliability, Internal Consistency, and Convergent Validity

Construct	Item	Standardized loading	t-value	VIF	AVE	CR	Cα
Customer Experience	3				0.856	0.919	0.916
	BRE	0.909***	93.826	2.889			
	SPE	0.938***	180.700	3.672			
	PPE	0.929***	154.489	3.320			
Customer Satisfaction	5				0.761	0.922	0.921
	SAT1	0.876***	73.107	2.986			
	SAT2	0.854***	58.577	2.519			
	SAT3	0.854***	57.675	2.534			
	SAT4	0.892***	98.812	3.223			
	SAT5	0.885***	61.963	3.289			
Behavioural Loyalty Intentions	5				0.804	0.941	0.939
	BLI1	0.899***	71.108	3.559			
	BLI2	0.930***	128.951	4.761			
	BLI3	0.903***	80.744	3.870			
	BLI4	0.909***	96.792	3.964			
	BLI5	0.840***	45.629	2.487			
Word-of-Mouth	5				0.789	0.936	0.933
	WOM1	0.862***	64.666	2.775			
	WOM2	0.871***	71.188	2.894			
	WOM3	0.885***	69.297	3.131			
	WOM4	0.896***	85.076	3.409			
	WOM5	0.926***	123.51	4.413			

Note: asterisks were used to visually denote the statistical significance of a result *** for $p < 0.001$ (highly significant), ** for $p < 0.01$ (moderately significant), and * for $p < 0.05$ (weakly significant)
Source: Authors

Table 3 Discriminant validity of the model: Heterotrait-Monotrait (HTMT) ratio of correlations

	CE	CS	BLI	WOM
CE				
CS	0.876			
BLI	0.824	0.862		
WOM	0.672	0.687	0.798	

Source: Authors

Table 4: Indicator Descriptive Statistics and Predictive Performance

Name	Mean	Standard deviation	Q^2predict
SAT 1	4.494	1.454	0.596
SAT 2	4.503	1.499	0.627
SAT 3	5.088	1.318	0.626
SAT 4	4.446	1.431	0.686
SAT 5	4.471	1.383	0.592
BLI 1	4.570	1.385	0.472
BLI 2	4.568	1.389	0.536
BLI 3	4.252	1.45	0.450
BLI 4	4.779	1.303	0.476
BLI 5	4.600	1.296	0.408
WOM 1	3.707	1.513	0.259
WOM 2	3.205	1.719	0.262
WOM 3	3.608	1.695	0.313
WOM 4	3.602	1.807	0.331
WOM 5	3.747	1.620	0.347

Source: Authors

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https://doi.org/10.7251/EMC2603869N
UDK: 502.131.1:316.662(497.6RS)
Datum prijema rada: 28. april 2026.
Submission Date: April 28, 2026
Datum prihvatanja rada: 7. septembar 2026.
Acceptance Date: September 7, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 869-882

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

PUBLIC SECTOR EXPENDITURES AS A MEASURE OF INVESTMENT IN BIODIVERSITY: A CASE STUDY OF THE REPUBLIC OF SRPSKA

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Abstract**:** *This paper explores public expenditures aimed at biodiversity preservation in the Republic of Srpska. The central research question addressed in this paper is: How much public funding is allocated to biodiversity protection in the Republika Srpska? Accordingly, the subject of the research is the analysis of public sector expenditures in the Republika Srpska, with a particular focus on budget allocations aimed at biodiversity conservation. The main hypothesis of the study is that allocations for biodiversity protection account for approximately 1% of total public expenditures in the Republika Srpska. However, the research is subject to several challenges and limitations. A key constraint is the absence of a unified database for tracking and identifying biodiversity-related investments, This lack of systematic data classification complicates the precise assessment of financial flows directed toward biodiversity. Furthermore, the introduction of a program-based budgeting system, accompanied by clearly defined monitoring and control mechanisms, would significantly improve the accuracy and transparency of data collection on public expenditures by purpose. Such reforms would enable a more reliable evaluation of biodiversity-related investments.*

Keywords: *sustainability, biodiversity, financial management, ecology, accounting*

JEL Classification**:** *Q01, Q56*

INTRODUCTION

Biodiversity includes diversity alive organisms in within different ecosystem and type. He represents basis functional ecosystem, which in return provide numerous valuable services ecosystem. However, human activities and pressures represent significant threat current condition biodiversity on global Convention about biological biodiversity (*CBD*), signed in 1992 in Rio de Janeiro, represents global frame for operation of 195 countries in areas biodiversity. Convention everything based on three basic goal: preservation biological diversity, sustainability use hers components and fair distribution benefits which expire from genetic resources. Republika Srpska, in

within obligation Bosnia and Herzegovina like signatories Conventions, determined everything for harmonization politics and measure with with this global goals, with special focus on preservation ecosystem, restoration degraded habitats, sustainable use natural resources you improvement education and consciousness about importance biodiversity (Milovanović et al., 2025). One from key questions in within *CBD* represents financial gap in areas biodiversity. Adequate and stable financing is prerequisite for efficiently preservation biological diversity and sustainably management natural resources. Adoption Kunming – Montreal global frame for biodiversity (GBF) in December 2022 , which is accepted by 196 countries, represents significant turning point in global efforts yes everything stop and overturn loss biodiversity (UNCC, 2023) Frame sets ambitious goal protection at least 30% of land and marine areas by 2030, as and vision of life" in harmony with "by nature" by 2050. Achievement these goals requires transformative changes and engagement all levels authorities, as and actively participation all segments societies. Biodiversity and the preservation of natural habitats protect us from natural disasters, climate change and provide us with sources of food, water, energy and raw materials. (Radonjić & Ostojić, n.d.)On the other hand, with the establishment of a new international framework and the global trend of introducing mandatory standards for environmental, social responsibility and governance (*ESG*) in business, global investments in biodiversity are expected to grow rapidly, especially in the private sector (Grujić & Novaković, 2025). A new Law on Accounting and Auditing has been adopted in the Republika Srpska. One of the innovations introduced by this law is the obligation to prepare and present a sustainability report (Novakovic & Grujic, 2026). Sustainability information related to sustainability factors includes:

1. environmental factors,
2. social and human resources factors,
3. management factors,
4. other information that the legal entity considers important for presentation in the sustainability report.

The problem defined as a research question in the paper is: How much public funds are allocated for biodiversity protection in the Republika Srpska. The subject of this paper is an analysis of public sector expenditures in the Republika Srpska in terms of allocations for biodiversity. While the basic hypothesis is: Allocation of public funds accounts for 1% of total public funds in the Republika Srpska.

Challenges and limitations of the work are reflected in the lack of a single database for collecting, or rather identifying, climate finance (Jokić et al., 2024; Novaković et al., 2024) and investments in biodiversity. The introduction of a program budget and clear control mechanisms would enable more precise collection of data on expenditures directed to different purposes. (Novakovic et al., 2025, 2026; Novaković, 2025)

METHODOLOGY OF THE REVIEW OF BIODIVERSITY EXPENDITURE IN THE REPUBLIKA SRPSKA

The assessment followed a two-step approach to identify and quantify biodiversity-related public expenditure. First, budget lines at the level of the Budget of the Republic of Srpska were screened for their potential link to biodiversity, following the BIOFIN methodology and the GLOBE taxonomy. Expenditures were then classified

according to their biodiversity purpose as primary (direct) or secondary (indirect). Primary expenditures were identified using the principle of predominance, whereby biodiversity is the main purpose of the expenditure unless evidence indicated otherwise. Secondary expenditures were those for which biodiversity represented a complementary objective; these were assigned a Biodiversity Attribution Rate (BAR) reflecting the estimated share of the budget line contributing to biodiversity. Accordingly, attributed biodiversity expenditure was calculated as: Biodiversity expenditure = Σ (budget line × BAR). GLOBE attribution rates range from 0% to 100%, Finally, the results were aggregated to estimate total public biodiversity expenditure in Republika Srpska, covering both the Republic-level Budget and the budgets of local self-government units.

Table 1. Description of biodiversity expenditures related to primary and secondary attribution levels.

Attribution levels	Description of biodiversity expenditures
100% (primary)	The expenditure is fully aligned with biodiversity objectives. Biodiversity is the explicit and central purpose of the expenditure. Other objectives, such as climate, health, or human development, are also compatible with biodiversity and do not undermine its achievement.
75% (pretty much) significantly)	Biodiversity remains an important objective of the expenditure, but the link is more indirect and/or other objectives take precedence over biodiversity.
50% (significant)	The biodiversity objective is unclear in the policy or expenditure formulation, and other objectives are more prominent than biodiversity.
25 % (Moderate)	The biodiversity objective is considerably weaker in the policy formulation compared with other objectives. The expenditure is framed as having an unintended or incidental positive influence on biodiversity.
5% (low)	Biodiversity is not explicitly identified in the policy formulation. Any contribution to biodiversity is considered incidental or unintended.
1% (Minimum)	The main purpose of the expenditure is unrelated to biodiversity, but there is a minimal connection or potential contribution to biodiversity.

Source: https://www.biofin.org/knowledge-product/global-biodiversity-expenditure-taxonomy

The main groups of budget items were mapped to the relevant expenditure categories according to their stated purpose, policy objectives, and expected relationship to biodiversity. Biodiversity attribution rate percentages were then assigned based on the strength of this relationship: higher rates were applied where biodiversity was an explicit or significant objective, and lower rates where the biodiversity contribution was indirect, incidental, or minimal.

RESULTS

The results show the distribution of biodiversity expenditures at the republic and local government unit levels. in accordance with the identified institutions through the strategic framework related to biodiversity (Čigoja et al., 2025). Expenditure data were analyzed based on the budget rebalance of the observed institutions for the period 2022 to 2024. The analysis is based primarily on budget and budget-rebalance data. Expenditures identified in the budget are assessed according to their stated objectives and policy relevance to biodiversity, and an attribution percentage (100%, 75%, 50%, 25%, 5%, or 1%) is applied to estimate the proportion of each expenditure that can reasonably be considered biodiversity-related.

One of the key institutions responsible for environmental protection in the Republika Srpska is the Ministry of Spatial Planning, Construction and Ecology. The Ministry performs administrative and professional tasks in the field of nature protection, including ensuring the conservation of natural resources, declaring protected areas, and participating in the preparation and implementation of management plans. It also plays an important role in public information, intergovernmental cooperation, and providing support to other levels of government. In addition, the Ministry is responsible for approving and supervising the work of protected area managers, verifying compliance with professional, personnel, and organizational standards, and issuing key administrative acts such as permits, expert opinions, and decisions. It maintains official registers, including the ecological network, red lists, and lists of protected species, and implements enforcement measures through inspection procedures.

The following public institutions operate under the direct jurisdiction of the Ministry:Public Institution National Park Kozara, Public Institution National Park Sutjeska, Public Institution National Park Drina. Within its budget for the observed period, the Ministry allocated financial resources to these national parks in the following amounts: 2,330,000 KM for Sutjeska, 2,530,000 KM for Kozara, and 2,530,000 BAM for Drina. These expenditures are classified under biodiversity-related spending, specifically within category 7.01 – Management and Expansion of Protected Areas, subcategory 7.01.16, according to the third-level taxonomy classification.

The Republic Institute for the Protection of Cultural, Historical and Natural Heritage of the Republic of Srpska plays a significant role in strengthening technical and monitoring capacities in the field of nature protection. It facilitates the integration of data into the E-Nature information system, provides expert opinions on nature conservation, monitors the state of biodiversity, and participates in international reporting processes. The Institute carries out a wide range of professional activities, including taxonomy, valorization, biodiversity monitoring, and the development and maintenance of the information system. Its responsibilities also include preparing expert opinions on protection conditions, developing protection studies, and providing professional justifications for the designation of protected areas. In addition, the Institute maintains official registers, prepares annual reports for the Ministry, contributes to international reporting obligations, and compiles data for the ecological network, Natura 2000, and red lists of species. Furthermore, the Institute actively cooperates with local governments, protected area managers, and scientific institutions, providing them with expert and technical assistance in the implementation of nature protection measures. Expenditures related to these activities are classified under biodiversity financing category 5.01 – Laws, Policies and Plans on Biodiversity, specifically subcategory 5.01.01, according to the third-level taxonomy classification.

The Ministry of Agriculture, Forestry and Water Management of the Republic of Srpska performs administrative and professional tasks as defined by Article 28 of the Law on Republic Administration ("Official Gazette of the Republic of Srpska", No. 115/18, 111/21, 15/22, 56/22, 132/22 and 90/23). Within its mandate, the Ministry integrates biodiversity considerations into agricultural, forestry, and water management policies and ecological schemes, while also contributing to the development of Payment for Ecosystem Services (PES) mechanisms and related incentive reforms. The Ministry is responsible for monitoring wild species within the sectors of hunting, fisheries, and

forestry, and regularly reports its findings to the competent environmental authority. It issues mandatory expert opinions in procedures related to species collection, repopulation, reintroduction, and the introduction of alien species, and participates in the development of criteria and measures for the control of invasive species. Furthermore, it prepares and implements regulatory frameworks and strategic plans in the fields of hunting, fisheries, and forestry, which must include measures for the protection of the ecological network. In accordance with the BIOFIN methodology and GLOBE taxonomy, biodiversity-related expenditures within the Ministry's budget are identified as secondary expenditures, classified under category 9 – Sustainable Use, including the following subcategories: 9.01 – Agrobiodiversity, 9.02 – Sustainable Agriculture, 9.05 – Sustainable Forestry, and 9.06 – Sustainable Freshwater Industry. These expenditures primarily consist of current grants and transfers to institutions and programs whose activities indirectly contribute to biodiversity conservation. Beneficiaries include the Agricultural Institute, the Fund for the Prevention of Infectious Diseases, Veterinary Institute Dr. Vaso Butozan, and projects co-financed through international financial and non-financial institutions. Additional allocations include transfers to the Agricultural Project Coordination Unit, the Public Enterprise Vode Srpske and the Public Enterprise Vučijak Prnjavor, as well as subsidies for expanded forest reproduction, unplanned forest protection measures, and the development of hunting and game management activities.

The Agrarian Payments Agency of the Republic of Srpska was established as a republican administrative organization in accordance with Article 39 of the Law on Republic Administration ("Official Gazette of the Republika Srpska", No. 115/18, 111/21, 15/22, 56/22, 132/22 and 90/23). Its operations are governed by the relevant by-laws, including the Regulation on the Conditions and Methods of Realizing Financial Incentives for the Development of Agriculture and Rural Areas and the Regulation on Incentives for Capital Investments in Agricultural Production, applicable for the observed years 2022, 2023, and 2024. These regulations define the eligibility criteria, procedures, types, amounts, and payment mechanisms of financial incentives, as well as the obligations of beneficiaries, applicable deadlines, and required documentation. Financial support is implemented through subsidies, including incentives, premiums, and rebates financed from funds aimed at promoting agricultural and rural development. These measures are structured into four main categories: Support for current production, including livestock production and crop production; Capital investments, such as the purchase of agricultural machinery, investments in livestock and crop production, storage and processing facilities, construction and equipment of fish farms, introduction of technological innovations, land improvement (melioration), and preservation of indigenous breeds; Rural development measures, aimed at improving living conditions and economic activities in rural areas; Systemic and other support measures, including animal and plant health protection, certification of equipment (e.g. sprayers), pesticide monitoring, support for breeding programs (e.g. artificial insemination), and measures for the protection, improvement, and sustainable management of fish stocks, including the operation of fish protection services. Although primarily oriented toward agricultural productivity and rural development, these measures also have indirect (secondary) impacts on biodiversity, particularly through the preservation of indigenous breeds, sustainable land management practices, and the protection of aquatic ecosystems.

Table 2 provides an overview of expenditures for the observed period with data on the budget rebalance of the institution in question and the percentage share of expenditures in the total budget of the institution.

Table 2. Institutional biodiversity expenditures

Name consumer units/Year	2022.	2023.	2024.
Ministry of Spatial Planning, Construction and Ecology			
Budget rebalance	7,335,500	6,456,700	5,551,800
Expenditure on biodiversity	2,330,000	2,530,000	2,530,000
% share of expenditures in the total budget of the Ministry	31.76	39.18	45.57
Republic Institute for the Protection of Cultural, Historical and Natural Heritage of the Republika Srpska			
Budget rebalance	955,100	1,082,200	1,395,000
Expenditure on biodiversity	538,509	634,788	616,977
% share of biodiversity expenditures in the total budget of the Institute	56.38	58.66	44.23
Ministry of Trade and Tourism			
Budget rebalance	7,556,200	9,056,000	32,860,900
Expenditure on biodiversity	162,500	162,500	162,500
% share of biodiversity expenditures in the total budget of the Ministry of Trade and Tourism	2.15	1.79	0.49
Ministry of Energy and Mining			
Budget rebalance	8,910,200.00	11,101,100.00	11,547,200.00
Expenditure on biodiversity	500,000.00	500,000.00	500,000.00
% share of biodiversity expenditures in the total budget of the Ministry of Environment and Natural Resources	5.61	4.5	4.33
Republic Institute for Geological Research			
Budget rebalance	920,200	1,882,500	1,856,400
Expenditure on biodiversity	460,100	941,250	928,200
% share of investments in biodiversity in the total budget of the Republic Institute for Geological Research of Republika Srpska	50	50	50
Ministry of Agriculture, Forestry and Water Management			
Budget rebalance	47,329,600	28,275,000	36,710,700
Expenditure on biodiversity	10,528,444	5,661,071	9,729,144
% share of biodiversity expenditures in the total budget of the Institute	22.24	20.02	26.5
Agricultural Payments Agency			
Budget rebalance	75,000,000	180,000,000	180,000,000
Expenditure on biodiversity	5,852,222	28,169,775	22,531,830
% share of biodiversity expenditures in the total budget of the Institute	7.8	15.65	12.52

Republic Hydrometeorological Institute of Republika Srpska			
Budget rebalance	2,793,500	2,890,300	2,903,700
Expenditure on biodiversity	1,396,750	1,445,150	1,451,850
% share of biodiversity expenditures in the total budget of the RHMZ	50	50	50

Source: author's analysis

The Republika Srpska is territorially organized into 12 cities and 52 municipalities. Local self-government units participate in the proclamation and management of protected areas on their territory, adopt an Environmental Protection Plan that includes planning in the field of nature. An analysis of biodiversity expenditures by local self-government units for the period 2022-2024 is presented in detail in the table in Annex 1 of this paper. After analyzing the presented data, we can draw the following conclusions:

- For most municipalities and cities, the share of biodiversity expenditures is below 1% of the budget framework, on average for the period 2022-2024, about 0.65% of the budget framework for biodiversity. Large cities have high absolute amounts, but a relatively low percentage share, while small municipalities have high percentage shares in individual years (Šekovići in 2022: 3.24%, Berkovići in 2024: 2.15%), but symbolic nominal amounts, which indicates that high percentages are often not the result of systemic policy, but of a small overall budget and one-off interventions.
- Many LLS show large oscillations by year (e.g. Bijeljina, Prijedor, Gacko, Stanari), which indicates that LLS finance biodiversity indirectly, as well as the absence of multi-year planning of BD in local budgets.
- Biodiversity is not treated as a development policy at the local level, but as a side cost, except for infrastructure or utility projects.

DISCUSSION

The budget system of the Republika Srpska encompasses a set of relationships that arise through the implementation of the budget process, based on economic relations and the government structure. This system accumulates financial revenues that are used to finance public policies. The process of budget planning and execution is regulated by the Law on the Budget System of the Republika Srpska. Budget users dispose of the planned budget funds according to the priorities established by the operational financial plan. Users of budget funds are obliged to use the funds determined in the budget in accordance with the principles of rationality and savings. Monitoring of budget expenditures is supervised by the Ministry of Finance . Subsequent control of the legality of spending of budget funds is carried out by the Budget Inspection. The Government is responsible to the National Assembly for the execution of the budget of the Republic.

It is important to note that the process of establishing a program budget is underway in Republika Srpska as part of the reform and improvement of public finance management in Bosnia and Herzegovina. Budget system The Republic of Srpska is in the process of transforming from line budgeting to program budgeting , i.e. a budget based on results. The introduction of a program budget is expected to make the budgeting process more transparent, as well as the implementation, i.e. execution of the budget.

The analysis of biodiversity expenditure was conducted based on data from published budget revisions for the observed period. In practice, minor deviations may occur between the amounts planned in the revision and the amounts actually spent, and we believe that the presented data provide a sufficiently clear and relevant picture of biodiversity expenditure. Financing of biodiversity in the Republika Srpska comes from the state budget. budget and extrabudgetary sources. Primary expenditures for biodiversity are mainly directed by the Ministry of Spatial Planning, Construction and Ecology of the Republika Srpska. The funds in question relate to financing the operations of three national parks that are under the jurisdiction of the Ministry of Spatial Planning, Construction and Ecology of the Republika Srpska.

Analysis of available data on budget expenditures in the period 2022-2024 shows a slight increase in biodiversity funding in the Republika Srpska. Expenses that are directly and indirectly attributed to biodiversity, accounted for 0.75 % in 2024 (approximately 44 million BAM) of of the total state budget of the Republika Srpska of 5.81 billion BAM. Direct expenditures attributed to biodiversity conservation make up a smaller share, not exceeding 0.044 % of all of annual government spending in 2024. In 2022, these direct Expenditures on biodiversity amounted to approximately 2.5 million BAM. This shows that funds are directed towards biodiversity conservation both through direct measures and through indirect support mechanisms.

Table 3. Share of biodiversity expenditures in the Budget of the Republika Srpska in nominal and % amounts

Year	Total p.e.for biodiversity from the Budget in BAM	Budget of the Republika Srpska in BAM	% of p.e. for biodiversity in the Budget of the Republic of Srpska %
2022	26,846,490	4,510,000,000	0.595
2023	45,019,431	5,523,000,000	0.815
2024	43,580,897	5,810,000,000	0.750

Source: https://vladars.rs/sr-SP-Cyrl/Vlada/Ministarstva/mf/Pages/default.aspx

Table 3 shows total public expenditure on biodiversity as a percentage of GDP. The data presented show that the main driver of the growth in total expenditure on biodiversity is the national budget, while local government expenditure remains relatively stable. The ratio of expenditure to GDP remains below 0.35%, indicating that total allocations for biodiversity constitute a relatively small part of the economy, but with clearly visible growth at the national level. This increase in expenditure is the result of a significant increase in funds allocated to the agricultural sector in 2023 and 2024.

Table 4 Overview of total public expenditure as a percentage of GDP

Year	Total p.e. on biodiversity in BAM	Gross domestic product, cp	% of p.e for biodiversity in GDP
2022	34,805,850	14,536,974,000	0.239
2023	52,315,256	16,085,929,000	0.325
2024	50,966,181	17,205,787,000	0.296

Source: https://vladars.rs/sr-SP-Cyrl/Vlada/Ministarstva/mf/Pages/default.aspx

CONCLUSION

Introducing a program budget and creating programs/projects and activities that would focus only on biodiversity in the future would enable simpler data collection, simplify and improve future analyses, allowing for more comprehensive and long-term assessments of biodiversity funding. In the analyzed period from 2022 to in 2024, biodiversity expenditures will account for 0.75 percent of the total state budget, or about 0.30 percent of the gross domestic product of the Republika Srpska. The results of the analysis showed a trend of increasing state expenditures for environmental protection, including biodiversity . At the republican level, the most significant amount of biodiversity expenditure is allocated through the Ministry of Agriculture, Water Management of the Republika Srpska, i.e. the Agrarian Payments Agency, while primary biodiversity expenditure is allocated mainly through the Ministry of Spatial Planning, Construction and Ecology of the Republika Srpska and the Republic Institute for Cultural, Historical and Natural Heritage. Based on these findings, the obvious recommendation is that through the continuation of the reform of public finances and the budget system in the Republika Srpska, and the introduction of program budgeting, it is necessary to identify special programs within the budget of the Republika Srpska, as well as the budgets of local self-government units, in order to enable more precise, simpler and more efficient monitoring of biodiversity and environmental protection expenditure in the future. Given that the current budget classification is not used to indicate the environmental purpose of expenditures, it is proposed to introduce the "BIO" label into the program classification, which would enable visibility and comparability of data over time and between institutions, as well as strategic targeting of existing resources. This approach would also facilitate alignment with international obligations, including the goals of the Kunming-Montreal Global Biodiversity Framework under the Convention on Biological Diversity (CBD). In relation to the main hypothesis, the results suggest that biodiversity allocations are 0.75 percent of the total state budget. However, this estimate should be interpreted with caution due to data limitations. The absence of a unified and systematic database for tracking biodiversity-related investments remains a major constraint, as it reduces the precision and comparability of financial assessments. The estimate is close to but below the assumed 1% and should be interpreted in light of the stated data limitations.

The study underscores the need for further institutional and methodological improvements, particularly the introduction of program-based budgeting and clearer expenditure classification aligned with biodiversity objectives. Strengthening monitoring and reporting mechanisms would enhance transparency, enable more accurate evaluation of financial flows, and support evidence-based decision-making in biodiversity policy. Overall, while existing financial allocations demonstrate a certain level of commitment to biodiversity conservation, there is significant scope for improving both the scale and effectiveness of funding, as well as the systems used to monitor and evaluate these investments.

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ANNEX 1. Expenditure for biodiversity - local self-government units of the Republic of Serpska

Name city / municipalities	Nominal expenses for BD in 2022. BAM	Budgetary BAM 2022 framework.	% participation expenses for BD in the budget within for 2022.	% share in total expenses for BD cities / municipality 2022	Nominal expenses for BD in 2023. BAM	Budgetary Frame BAM 2023.	% participation expenses for BD in the budget within for 2023.	% share in total expenses for BD cities / municipality 2023.	Nominal expenses for BD in 2024. BAM	Budgetary BAM 2024 framework.	% participation expenses for BD in the budget within for 2024.	% share in total expenses for biodiversity cities / municipalities 2024.
City of I. Sarajevo	210,353	16,359,557	1.29	6.07	131,741	16,196,230	0.81	3.85	126,509	24,808,700	0.51	3.77
Municipality Milici	43,812	8,813,810	0.5	1.26	16,455	9,897,090	0.17	0.48	28,199	10,476,830	0.27	0.84
City Spa Luka	1,571,433	212,322,000	0.74	45.32	1,412,655	211,756,000	0.67	41.3	1,762,050	211,330,000	0.83	52.52
Municipality Bijeljina	657,780	72,375,675	0.91	18.97	219,605	68,585,164	0.32	6.42	196,392	74,171,235	0.26	5.85
Municipality Bileca	91,252	13,970,555	0.65	2.63	190,775	12,767,285	1.49	5.58	93,817	13,223,928	0.71	2.8
Municipality of K. Dubica	96,966	15,057,000	0.64	2.8	62,906	13,892,000	0.45	1.84	57,128	15,548,600	0.37	1.7
Municipality Gradiška	147,893	42,550,000	0.35	4.27	167,996	47,100,000	0.36	4.91	197,271	53,400,000	0.37	5.88
Municipality Groats on Uni	8,622	2,208,750	0.39	0.25	5,702	2,019,000	0.28	0.17	11,428	2,000,000	0.57	0.34
Municipality Boat	45,346	13,378,557	0.34	1.31	56,790	13,517,160	0.42	1.66	8,676	14,980,000	0.06	0.26
Municipality New City	111,625	15,722,752	0.71	3.22	101,288	17,000,663	0.6	2.96	109,035	19,570,811	0.56	3.25
Municipality Petrovac	48,310	3,006,525	1.61	1.39	26,275	2,883,532	0.91	0.77	43,702	2,402,517	1.82	1.3
Municipality Shamac	38,937	10,321,000	0.38	1.12	29,137	12,620,000	0.23	0.85	31,804	15,928,600	0.2	0.95
Municipality Bratunac	58,439	12,714,500	0.46	1.69	90,476	16,124,800	0.56	2.64	87,053	16,917,400	0.51	2.59
Municipality Teapots	32,295	3,887,500	0.83	0.93	30,020	4,299,200	0.7	0.88	33,086	4,405,550	0.75	0.99
Municipality Celinac	79,580	13,140,000	0.61	2.3	84,430	12,690,000	0.67	2.47	123,653	20,200,000	0.61	3.69

Municipality Derventa	148,313	27,347,820	0.54	4.28	159,879	25,690,491	0.62	4.67	133,218	32,341,000	0.41	3.97
Municipality Doboj	691,495	73,005,910	0.95	19.94	687,718	81,963,800	0.84	20.1	657,328	85,995,000	0.76	19.59
Municipality Foca	101,915	16,800,000	0.61	2.94	104,169	17,400,000	0.6	3.05	120,164	24,468,696	0.49	3.58
Municipality Gacko	161,146	12,572,000	1.28	4.65	143,279	16,467,000	0.87	4.19	87,097	15,316,000	0.57	2.6
Municipality Pelagićevo	15,859	4,445,000	0.36	0.46	13,986	3,200,000	0.44	0.41	17,244	3,674,000	0.47	0.51
Municipality of N. Gorazde	22,759	2,743,528	0.83	0.66	24,015	3,013,382	0.8	0.7	26,076	3,128,337	0.83	0.78
Municipality Petrovo	14,988	3,838,250	0.39	0.43	15,092	3,952,000	0.38	0.44	17,087	5,283,200	0.32	0.51
Municipality Khan Sand	92,724	5,467,422	1.7	2.67	99,804	5,760,000	1.73	2.92	61,588	9,546,145	0.65	1.84
Municipality Lake	-	-	-	-	943	1,445,279	0.07	0.03	875	1,668,225	0.05	0.03
Municipality Eights	5,910	2,460,800	0.24	0.17	5,296	2,863,867	0.18	0.15	5,961	3,278,463	0.18	0.18
Municipality Kalinovik	79,830	7,677,000	1.04	2.3	104,733	6,450,000	1.62	3.06	86,460	5,800,000	1.49	2.58
Municipality Fishpond	61,794	6,760,851	0.91	1.78	38,825	6,108,035	0.64	1.13	79,927	6,839,451	1.17	2.38
Municipality Kotor Varos	121,117	12,400,000	0.98	3.49	118,925	14,200,000	0.84	3.48	140,177	16,900,000	0.83	4.18
Municipality Kupres	313	782,055	0.04	0.01	300	614,396	0.05	0.01	2,318	1,006,948	0.23	0.07
Municipality Laktashi	90,538	44,400,000	0.2	2.61	36,791	43,000,000	0.09	1.08	97,542	49,000,000	0.2	2.91
Municipality Lopare	26,377	7,667,000	0.34	0.76	21,047	7,950,000	0.26	0.62	50,512	8,972,000	0.56	1.51
Municipality Ljubinje	13,990	3,433,102	0.41	0.4	140	4,715,360	0	0	13,614	5,081,351	0.27	0.41
Municipality Bruise	142,744	19,662,500	0.73	4.12	176,199	16,643,800	1.06	5.15	250,788	19,550,700	1.28	7.48

Municipality Vukosavlje	5,828	3,086,169	0.19	0.17	6,198	3,242,166	0.19	0.18	30,607	4,801,905	0.64	0.91
Municipality of M. Grad	103,856	20,280,000	0.51	3	99,554	21,178,150	0.47	2.91	85,101	22,774,000	0.37	2.54
Municipality Nevesinje	197,126	11,959,364	1.65	5.68	100,994	12,306,610	0.82	2.95	106,827	14,808,224	0.72	3.18
Municipality Lower Frog	2,907	3,226,000	0.09	0.08	2,697	2,773,000	0.1	0.08	3,438	2,182,000	0.16	0.1
Municipality / City Prijedor	485,481	78,293,405	0.62	14	369,104	83,606,055	0.44	10.79	266,701	85,099,396	0.31	7.95
Municipality Prnjavor	135,336	32,020,000	0.42	3.9	141,202	31,400,000	0.45	4.13	148,094	39,600,000	0.37	4.41
Municipality Rogatica	50,996	8,680,000	0.59	1.47	70,692	9,600,000	0.74	2.07	37,810	11,900,000	0.32	1.13
Municipality Rudo	62,763	6,192,517	1.01	1.81	70,340	7,106,120	0.99	2.06	72,533	8,190,192	0.89	2.16
Municipality Sharp Luka	23,727	2,931,013	0.81	0.68	23,855	4,628,582	0.52	0.7	26,403	2,452,913	1.08	0.79
Municipality I.Ilidza	51,349	11,903,360	0.43	1.48	72,449	13,039,800	0.56	2.12	88,536	17,934,190	0.49	2.64
Municipality East N. Sarajevo	93,407	21,231,270	0.44	2.69	133,073	23,495,700	0.57	3.89	139,431	27,850,952	0.5	4.16
Municipality Pale	17,902	22,000,000	0.08	0.52	33,417	23,274,000	0.14	0.98	20,017	26,012,500	0.08	0.6
Municipality of I. S. Grad	14,305	6,633,080	0.22	0.41	3,226	4,733,300	0.07	0.09	9,985	5,119,010	0.2	0.3
Municipality Trnovo	34,736	4,342,537	0.8	1	50,192	4,839,517	1.04	1.47	46,820	4,983,787	0.94	1.4
Municipality Knezhevo	8,324	6,944,930	0.12	0.24	48,186	7,199,400	0.67	1.41	49,099	7,910,920	0.62	1.46
Municipality Sokolac	101,263	10,091,441	1	2.92	82,132	11,044,000	0.74	2.4	81,187	11,044,000	0.74	2.42
Municipality Serb	40,712	18,383,000	0.22	1.17	30,000	15,920,000	0.19	0.88	26,593	18,220,000	0.15	0.79
Municipality Srebrenica	33,268	11,792,736	0.28	0.96	45,796	12,867,885	0.36	1.34	33,887	12,772,943	0.27	1.01

Municipality Berkovići	13,435	2,133,880	0.63	0.39	15,734	2,084,100	0.75	0.46	66,308	3,084,360	2.15	1.98
Municipality Shekovci	152,508	4,701,626	3.24	4.4	57,623	4,201,928	1.37	1.68	45,686	6,230,250	0.73	1.36
Municipality Shipovo	29,949	9,392,000	0.32	0.86	20,161	10,355,630	0.19	0.59	19,062	17,022,860	0.11	0.57
Municipality Teslic	67,523	36,450,000	0.19	1.95	79,839	32,250,000	0.25	2.33	40,315	33,800,000	0.12	1.2
Municipality of I. Drvar	580	1,278,773	0.05	0.02	400	1,245,810	0.03	0.01	-	-	-	-
Municipality / City Trebinje	539,132	39,411,900	1.37	15.55	647,373	39,160,000	1.65	18.93	703,107	49,980,000	1.41	20.96
Municipality Carbon	15,552	15,019,795	0.1	0.45	9,147	17,316,505	0.05	0.27	102,932	22,867,500	0.45	3.07
Municipality Visegrad	106,532	12,387,858	0.86	3.07	48,667	12,453,179	0.39	1.42	28,307	18,680,000	0.15	0.84
Municipality Vlasenica	15,106	10,963,000	0.14	0.44	8,000	9,440,000	0.08	0.23	7,000	13,200,000	0.05	0.21
Municipality Zvornik	163,597	40,957,000	0.4	4.72	176,151	35,827,500	0.49	5.15	142,313	45,121,720	0.32	4.24
Municipality Kostajnica	15,959	3,647,500	0.44	0.46	64,209	3,795,000	1.69	1.88	22,016	4,380,000	0.5	0.66
Municipality of I. Mostar	2,825	565,076	0.5	0.08	24,940	495,760	5.03	0.73	19,667	556,296	3.54	0.59
Municipality Tenants	338,922	23,282,000	1.46	9.77	383,087	21,828,600	1.75	11.2	157,724	21,828,600	0.72	4.7
	7,959,361.00				7,295,830.00				7,385,285.00			

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https://doi.org/10.7251/EMC2603883G UDK: 327.84(497):338.242.2(4-672EU)

Datum prijema rada: 31. mart 2026.
Submission Date: March 31, 2026
Datum prihvatanja rada: 7. septembar 2026.
Acceptance Date: September 7, 2026

Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review

Godina/Vol. **XVI** • Br./No. **III**
str./pp. 883-897

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

PUBLIC OPINION PERCEPTION OF EURO-ATLANTIC INTEGRATION OF BOSNIA AND HERZEGOVINA-THE RELATIONSHIP BETWEEN ECONOMIC EXPECTATIONS AND SECURITY FEARS

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Abstract: *This paper examines public opinion in Bosnia and Herzegovina regarding Euro-Atlantic integration. The study explores the relationship between hopes for a change in living standards and concerns about geopolitical security. Based on a survey of 1,111 respondents in November 2025, support for EU membership is rated high (4.38). At the same time, expectations of immediate economic benefits are more modest. Respondents gave an average score of 3.14 for improving household budgets with EU accession. This shows that citizens are pragmatic, if not skeptical or undecided, regarding the financial benefits of EU and Euro-Atlantic integration. The results show that the primary motives for supporting EU membership are strengthening the rule of law and fighting corruption (4.15). Support for NATO is lower (3.71), with noticeable gender and entity differences. The study finds that significantly more women than men see NATO as a guarantor of long-term peace. The perception of Russia as a positive security factor is low (1.92), even in Republika Srpska (2.10). The paper concludes that despite political crises, citizens remain committed to integration. They view these processes mainly as a framework for regulation and security rather than immediate economic benefits.*

Keywords*: Euro-Atlantic integration, Bosnia and Herzegovina, European Union, NATO, security*

JEL classification*: D72, F15, F52*

INTRODUCTION

The main research problem lies in the evident gap between declarative political support for Euro-Atlantic integration and the actual perception of citizens, which

is burdened by internal political crises and external influences. Although institutions formally fulfill their priorities, public opinion in Bosnia and Herzegovina shows a high degree of polarization, especially regarding security guarantees and the preservation of entity competencies. There is a justified suspicion that long-term processes without tangible economic results, combined with constant interventions by international actors, lead to fatigue and a change in attitude towards the very idea of membership in the EU and NATO.

The subject of the research is the attitudes and perceptions of citizens of Bosnia and Herzegovina regarding the process of joining the European Union and NATO, with a special emphasis on the differences between the entities in terms of support for these integration flows. The research is focused on the analysis of economic expectations, trust in international security mechanisms, and the influence of geopolitical factors on the formation of public opinion, with special attention to how these processes are reflected in the constitutional-legal and institutional framework of the state. The subject also includes examining the level of citizens' awareness of the legal and economic implications of membership, given that information awareness is a decisive factor in support or resistance to Euro-Atlantic integration.

The research aims to scientifically determine the level of citizens' support for the processes of European and Euro-Atlantic integration and to identify the legal, economic, and security factors that most influence the formation of these attitudes. The intention is to examine whether the dominant motives for supporting EU accession are primarily of an economic nature (market, investments, jobs) or are primarily based on the expectation of strengthening the rule of law, legal security and institutional stability. Furthermore, the aim is to determine to what extent gender, level of education and entity affiliation influence the perception of NATO and the Russian Federation as relevant security factors, i.e. whether these actors are considered sources of legal and security guarantees or primarily instruments of geopolitical influence.

This research is primarily intended for decision-makers at all levels of government in Bosnia and Herzegovina, as well as representatives of the international community (Directorate for European Integrations, n/d), as it provides an objective insight into what citizens truly expect from integration processes. The findings will benefit the academic community in the field of social and political sciences; the non-governmental sector engaged in the promotion of integration. Also, the findings will benefit the media, to whom this data can serve as a corrective factor in reporting public opinion.

Based on the defined problem and goals, the following research questions are set:

- To what extent do the citizens of Bosnia and Herzegovina support join the EU and the NATO alliance, and are there statistically significant differences between the entities?
- Does the anticipation of higher living standards outweigh other factors as the driving force behind public support for EU accession?
- How is the impact of NATO and the Russian Federation on long-term national security framed within the Bosnian public discourse?
- Does a higher level of perceived awareness regarding Euro-Atlantic processes necessarily translate into more robust support for integration?

In accordance with the subject and goals of the research, the following hypotheses have been established:

Main hypothesis (H0): There is high general support for Bosnia and Herzegovina's entry into the European Union, but it is significantly polarized at the entity level, with support for NATO integration being directly conditioned by the perception of security threats and the gender of the respondents.

Auxiliary hypothesis 1 (H1): Support for European Union accession among BiH citizens is predominantly driven by the desire for improved anti-corruption measures and a robust rule of law, rather than over-optimistic expectations of immediate household economic gain

Auxiliary hypothesis 2 (H2): The degree of trust in the NATO alliance as a stabilizing force for peace is significantly shaped by gender, with female respondents demonstrating a notably higher level of confidence in the Alliance compared to their male counterparts

Auxiliary hypothesis 3 (H3): While the overall perception of Russia as a security provider remains low nationwide, there is a statistically marked divergence in Republika Srpska, where respondents view its role more favorably than those in the Federation of BiH.

LITERATURE REVIEW

Few European transition stories carry the same level of complexity as Bosnia and Herzegovina's Euro-Atlantic integration. As Aćić and Grujić (2022) emphasize, international financial and political organizations did more than merely stabilize peace in the post-Dayton era; they were instrumental in rebuilding basic infrastructure, shaping economic recovery, and setting up the initial administrative pillars of the state." Despite this, the country's position is determined by constant friction between domestic jurisdictions and external pressures, which directly shape the public's perception of the European path. In particular, recent data from the European Integration Directorate confirm that, although the majority of citizens still support EU membership, they increasingly point to political maneuvering, lack of internal consensus and slow reforms as the main obstacles. Such results indicate a strong connection between internal friction and external agendas (Aćić, 2022).

Initially, the international community's engagement with Bosnia and Herzegovina focused on technical, humanitarian and financial assistance for the reconstruction of basic state functions and infrastructure. Starting in 1996, the EU used the Phare and reconstruction programmes to finance critical reconstruction and refugee return, establishing the administrative foundations needed for later pre-accession tools. Looking back at the EU reports from 1996, we can trace how the initial post-war model of assistance was gradually replaced by more structured instruments such as CARDS (Council Regulation No. 2666/2000) aimed at long-term development and stabilisation. The European Commission (1997) further points out that these early mechanisms prioritised institutional capacity and precursors to the Stabilisation and Association Agreement (SAA) relevant to the rule of law (Brljavac, 2011; Jokić et al., 2024).

One of the important aspects of integration support is the economic dimension. The debate about integration always comes back to the economy. As we noted in study (Aćić and Grujić, 2023), the impact of IPA funding, while crucial for state structures, rarely reaches the household level in a meaningful way. We see this difference-where institutions grow while living standards stagnate-as the primary reason for the conflict-

ing views we are now documenting on the ground.

Regarding the rule of law, the European Commission (2019) clearly defines in its Opinion fourteen priorities that constitute the core of the reform demands (Polović and Dujić Frlan, 2019). Data from the Directorate for European Integration (2024) show that for many in Bosnia and Herzegovina, the European Union is less a political turning point and more the primary remedy for endemic corruption. This perception positions EU membership as the only sustainable framework capable of ensuring a functional state based on the rule of law and the protection of fundamental rights.

On the other hand, integration into the NATO alliance causes significantly greater divisions. Schimmelfennig (2003) argues that EU and NATO enlargement processes often run in parallel because they are based on shared liberal-democratic values and norms. In this context, enlargement can be understood as the construction of a "liberal community" through rhetorical appeals to a common identity and standards. In the BiH context, this connection is emphasized through cooperation in the security sector, but citizens' perceptions are deeply divided along entity lines. This is confirmed by research from the Enterprise Development Agency Eda and the Faculty of Political Sciences in Banja Luka (2020), which records extremely low support for NATO membership in Republika Srpska, compared to significantly higher support for EU accession (Polović & Dujić Frlan, 2019; European Commission, 2019; Eda Enterprise Development Agency & Faculty of Political Sciences, University of Banja Luka, 2020).

Recent research has indicated a gradual cooling of enthusiasm for EU accession, a trend particularly visible in the Republika Srpska. Data from the Directorate for European Integration (2025) show a decline in support at the state level to 69.9%, likely a byproduct of "reform fatigue" and a process that many see as dragging on without immediate results. Draganić (2022) adds another layer to this, noting that while support in the Republika Srpska often fluctuates during political frictions, a fundamental, underlying consensus on the importance of the European market remains.

Global geopolitical shifts have only added to the complexity of perceptions of local security. Savić (2021) argues that in the Republika Srpska, attitudes towards NATO are still heavily burdened by historical baggage, leading to a preference for military neutrality over formal membership in the alliance. In contrast, the Federation of BiH continues to view NATO as the ultimate guarantor of peace. This deep internal polarization remains a significant obstacle, complicating and potentially slowing down the broader integration agenda.

Dudley and Saez (2022) analyze how membership criteria affect "divided societies" such as Bosnia and Herzegovina. The authors suggest that the integration process can sometimes unintentionally exacerbate internal tensions if demands for reform are perceived as an attack on entity competences. This is evident in the debates on constitutional changes that the European Council (2024) regularly sets as a condition for further progress on the European path.

Scholarly and political discourse often focuses on the influence of external actors, most notably the Russian Federation. However, empirical evidence from the Eda Agency (2022) suggests a more nuanced reality: despite the strong media narrative of pro-Russian sentiment, citizens in the Republika Srpska prioritize economic and political stability, which they associate with Western institutions. In this light, Russia serves more as a symbolic cornerstone than as a practical security pillar. Ratti (2023)

further argues that EU and NATO integration are in fact inseparable, as both require the same democratic foundations-civilian control of the military, transparency of security, and strong parliamentary oversight. Scholars see this parallel progress as a vital mechanism for consolidating democratic institutions within candidate states (Dudley & Saez, 2022; Eda Agency for Entrepreneurship Development and Faculty of Political Science, University of Banja Luka, 2020).

Ultimately, we approached this integration process as a complex mix of security needs, legal reforms, and economic stability. We are clear that, while the EU mandate remains the main driver, NATO accession is where the real divides lie, especially when we look at gender and regional demographics.

METHODOLOGY

In this study, we focus on how citizens across Bosnia and Herzegovina balance their economic expectations against perceived security risks regarding Euro-Atlantic integration. Conducted in November 2025, this research relied on a representative sample of 1,111 individuals.

We ensured a balanced demographic reflection by including 51.1% women and 48.9% men, with an average respondent age of 42.6 years. Data collection spanned both entities -54.5% of participants was from Republika Srpska and 45.5% of the Federation of BiH-providing a solid basis for comparing attitudes within the country's complex constitutional and legal framework.

We employed a ten-item structured questionnaire to gauge public sentiment, where respondents expressed their level of agreement on a five-point Likert scale.

The questions were:

1. To what extent do you support Bosnia and Herzegovina's accession to the European Union?
2. In your opinion, would EU membership lead to a better economic standard for your household?
3. To what extent would EU accession help to combat corruption and strengthen the rule of law in the country?
4. Do you believe that joining the EU would threaten the unique identity and cultural diversity of BiH?
5. How strongly do you support the prospect of Bosnia and Herzegovina joining NATO?
6. Would NATO membership serve as a reliable guarantee for long-term peace and stability in BiH?
7. Is NATO membership a necessary step for the country to effectively withstand external security challenges?
8. Is Russia a positive factor for the security and stability of BiH?
9. I believe that EU membership and NATO membership must go "hand in hand" because they are inseparable processes.
10. Do you feel adequately informed about the specific steps and implications of the country's path towards the EU and NATO?

This approach was chosen to avoid binary limitations, as yes or no answers, and to enable a deeper analysis of variability in attitudes. The questions are designed to cover economic effects, the fight against corruption, the preservation of cultural

identity, the relationship with the NATO alliance, and the influence of the Russian Federation on regional stability.

Statistical data processing includes descriptive analysis, comparison of mean values (arithmetic mean), and frequency analysis of extreme responses. Attention was paid to differentiating results based on entity affiliation, education level, and the size of the company where the respondents are employed. The statistical analysis incorporates descriptive statistics, frequency distribution, arithmetic mean comparisons, cross-tabulation across demographic sub-groups, as well as variance-covariance and Pearson correlation analysis to test the empirical relationships between key construct variables. The data are prepared to allow testing of the established hypotheses regarding the impact of socio-economic status on the perception of security threats.

RESEARCH RESULTS

The empirical phase of this study, carried out in November 2025, relied on a dataset gathered from 1,111 respondents. Data collection was conducted using an online questionnaire administered via Google Forms in November 2025. The research employed a convenience sampling technique with quota control to ensure balanced representation aligned with the key demographic parameters of Bosnia and Herzegovina. Specifically, quota targets were maintained across entity lines and by gender. Certain methodological limitations inherent to this approach must be acknowledged. First, reliance on an online survey format and non-probability sampling carries a potential risk

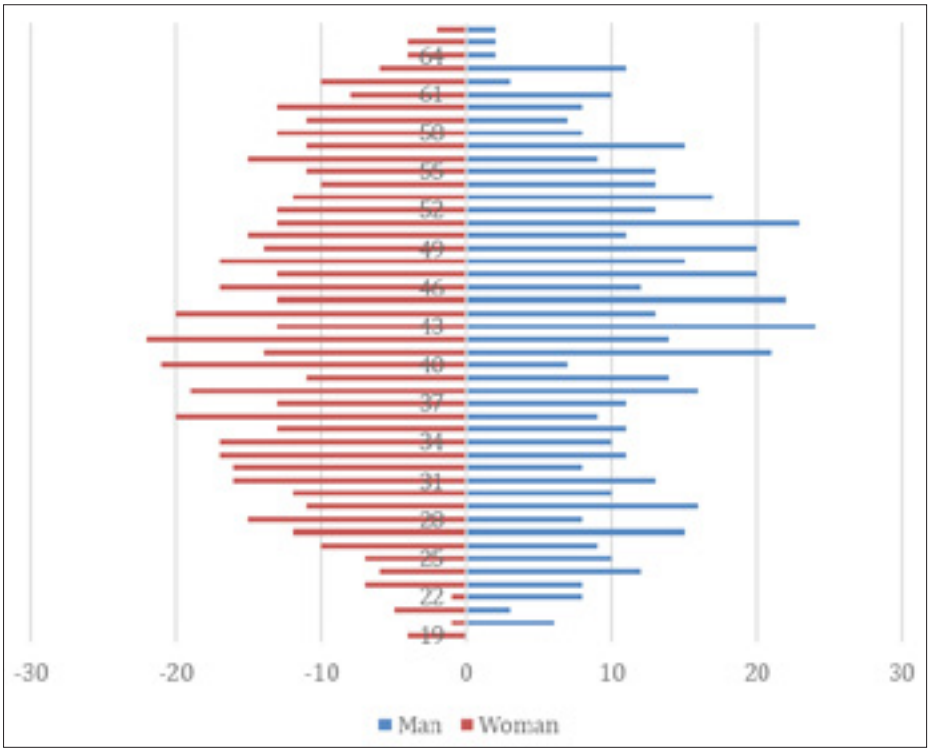

Figure 1. Respondent age histogram

Source: Author's presentation

Table 1. Summary Overview of Mean Scores by Demographic and Socio-Economic Categories

	Total	Average	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Male	543	42,58	4,41	3,18	4,19	1,71	3,54	3,20	3,60	2,22	3,31	4,06
Feminine	568	42,61	4,35	3,11	4,11	1,51	3,87	4,18	3,75	1,63	3,89	4,41
The result	1111	42,60	**4,38**	**3,14**	**4,15**	**1,61**	**3,71**	**3,70**	**3,68**	**1,92**	**3,60**	**4,24**
Secondary vocational education - IV degree	472	41,74	4,36	3,20	4,30	1,74	3,77	3,57	3,87	1,88	3,53	4,01
Higher professional education - VŠS	3	54,33	4,00	4,00	4,33	2,00	3,33	4,00	4,00	4,33	4,00	4,00
Higher professional education - VSS	449	42,95	4,56	3,10	4,29	1,37	3,92	3,76	3,76	1,90	3,65	4,37
Master	176	43,73	4,02	3,16	3,40	1,81	3,05	3,93	3,01	1,96	3,72	4,55
Master of Science	5	48,00	4,60	2,00	3,40	2,20	3,40	3,40	2,80	3,20	2,80	4,40
Doctor of Science	6	40,40	3,17	2,00	4,00	2,83	3,00	3,17	2,50	3,33	3,00	4,17
The result	1111	**42,60**	**4,38**	**3,14**	**4,15**	**1,61**	**3,71**	**3,70**	**3,68**	**1,92**	**3,60**	**4,24**
between 1,000 and 1,500 KM	46	32,70	3,74	2,63	3,85	1,96	4,35	3,89	3,76	2,93	2,76	4,13
between 1,500 and 2,000 KM	374	43,12	4,66	3,18	4,34	1,19	4,02	4,13	3,86	1,45	3,87	4,28
between 2,000 and 2,500 KM	266	41,80	4,69	3,56	4,41	1,41	4,28	3,65	3,90	1,60	3,67	4,24
between 2,500 and 3,000 KM	369	43,78	3,97	2,90	3,78	2,11	2,83	3,22	3,34	2,32	3,42	4,25
between 3,000 and 3,500 KM	2	45,00	1,50	1,00	2,50	4,00	1,00	1,00	1,00	5,00	1,50	4,50
between 3,500 and 4,000 KM	9	46,67	4,56	3,33	4,44	1,33	4,56	4,56	4,11	2,89	3,33	4,00
between 4,000 and 4,500 KM	18	40,67	4,44	2,94	4,44	1,50	4,44	4,33	3,83	2,83	3,56	4,00
between 4,500 and 5,000 KM	9	39,56	4,22	2,89	4,44	1,78	4,22	4,11	3,78	3,22	3,33	4,11
more than 6,000 KM	10	47,50	4,70	3,20	4,60	1,30	4,70	4,60	3,50	2,60	3,70	4,00
X	8	44,00	3,63	2,75	3,50	2,63	3,13	3,25	2,88	3,50	3,25	4,00
The result	1111	42,60	4,38	3,14	4,15	1,61	3,71	3,70	3,68	**1,92**	**3,60**	**4,24**
RS	606	43,21	4,31	3,15	4,06	1,75	3,78	3,55	3,54	2,10	3,46	4,21
FBIH	505	41,87	4,47	3,14	4,25	1,44	3,62	3,88	3,84	1,69	3,78	4,28
The result	1111	42,60	4,38	3,14	4,15	1,61	3,71	3,70	3,68	1,92	3,60	4,24

Source: Author's calculation

Note / Legend for Questionnaire Items (Q1–Q10):

Q1 - Overall support for Bosnia and Herzegovina's accession to the European Union (Overall EU Support)
Q2 - Expectation of improved household economic standard upon EU membership (Economic Expectations)
Q3 - Perception of EU accession as a mechanism to combat corruption and strengthen the rule of law (Rule of Law & Anti-Corruption)
Q4 - Concern that EU membership would threaten national identity and cultural diversity (Identity Threat Concern)

Q5 - Overall support for Bosnia and Herzegovina joining the NATO alliance (Overall NATO Support)
Q6 - Perception of NATO membership as a reliable guarantee for long-term peace and stability (NATO as Peace Guarantor)
Q7 - Necessity of NATO membership to withstand external security challenges (NATO External Security)
Q8 - Perception of the Russian Federation as a positive factor for security and stability (Russia Positive Security Factor)
Q9 - Belief that EU and NATO integration processes are inseparable and must go "hand in hand" (EU/NATO Complementarity)
Q10 - Self-assessed level of information awareness regarding Euro-Atlantic integration steps and implications (Perceived Information Awareness)

of self-selection bias, as individuals with stronger views or higher digital literacy may have been more inclined to participate. Second, given the sensitive political nature of Euro-Atlantic integration and geopolitical security perceptions in Bosnia and Herzegovina, the findings may be subject to social desirability bias, in which some respondents provide answers aligned with perceived normative expectations rather than their private convictions.The average age of those surveyed stands at 42.6 years, as visualized in the age distribution histogram (Figure 1).

From a geographic perspective, the sample is weighted toward Republika Srpska (54.5%), with the remaining 45.5% representing the Federation of BiH. Regarding educational background, the majority of participants hold either secondary vocational qualifications (42%) or higher education degrees (40%)

The results indicate an exceptionally high general support for Bosnia and Herzegovina's accession to the European Union, with an overall average score of 4.38. Analysis by entity shows slightly higher support in the Federation of Bosnia and Herzegovina (4.47) compared to the Republika Srpska (4.31). Interestingly, employees in large companies express the highest level of support (4.61). Although support is high, a significantly higher number of extremely negative ratings (score 1) was recorded in the Republika Srpska compared to the Federation of Bosnia and Herzegovina, indicating the presence of polarization.

Regarding the expectation of improvement in the economic standard of households after joining the EU, respondents expressed moderate optimism with an average score of 3.14. There are no significant differences between the entities on this issue (Federation of Bosnia and Herzegovina 3.14; Republika Srpska 3.15). Respondents with higher professional diplomas show the greatest economic optimism (4.00), while those with doctorates are more skeptical (2.00).

Trust in European mechanisms as a cure for corruption and a means of strengthening the rule of law is extremely high, with an average score of 4.15. While this feeling is particularly strong in the Federation of Bosnia and Herzegovina (4.25), it remains strong in the Republika Srpska (4.06). In contrast, concern that EU membership could threaten national identity or cultural diversity appears negligible, averaging only 1.61. This lack of anxiety is most pronounced among women (1.51) and residents of the Federation of Bosnia and Herzegovina (1.44).

Support for NATO integration, at 3.71, lags the enthusiasm shown for the European Union. Here, a significant gender divide emerges - women are significantly more supportive of joining the alliance (3.87) than men (3.54). This difference is even more pronounced regarding NATO's role as a guarantor of peace; female respondents gave

this a high score of 4.18, while their male counterparts remained much more skeptical at 3.20.

The perception of Russia's role in regional stability is predominantly negative, with an overall score of only 1.92. Although respondents from Republika Srpska rate Moscow's influence somewhat more favorably (2.10) than those in the Federation (1.69), the data indicate a widespread lack of trust. Interestingly, men tend to view Russia in a somewhat more positive light (2.22) compared to the very low score given by women (1.63).

The prevailing opinion among participants is that EU and NATO integrations are complementary processes that should go "hand in hand" (3.60), a view more often held by women (3.89) than men (3.31). Finally, when it comes to self-assessment of knowledge about these processes, BiH citizens appear quite confident, with an average information score of 4.24. This feeling of being well informed is most prevalent among those with a master's degree (4.55), with women (4.41) generally expressing greater confidence in their understanding of the subject than men (4.06).

Analysis of the covariance matrix, where the values range from -1 to 1, indicates a strong inverse relationship between the perception of Russia as a security factor and support for integration into NATO (cov = -0.71), which confirms the sharp polarization of security paradigms in the minds of respondents. In order to further examine the relationships between these variables, we constructed a covariance matrix (see Figure 3). This analysis highlights the internal consistency of the responses, particularly highlighting the strong variance in Q5 and Q6, which is consistent with observations of entity-based differences.

Table 2. Covariance Matrix

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Q1	0.871									
Q2	0.374	0.968								
Q3	0.279	0.126	0.795							
Q4	-0.567	-0.418	-0.422	1.273						
Q5	0.397	0.093	0.588	-0.369	1.696					
Q6	0.284	-0.090	0.492	-0.593	0.592	1.752				
Q7	0.243	-0.051	0.523	-0.260	0.385	0.813	1.086			
Q8	-0.549	-0.399	-0.379	0.964	-0.471	-0.712	-0.314	1.673		
Q9	0.316	0.317	0.563	-0.568	0.327	0.820	0.343	-0.724	1.236	
Q10	0.028	0.184	-0.071	-0.097	-0.201	0.065	0.019	-0.079	0.043	0.397

Source - Author's calculation

Values on the diagonal (e.g., 1.752 for Q6 or 1.695 for Q5) represent the variance of each question. Security questions (Q5, Q6, Q8) have the highest variances (above 1.6). This means that answers to these questions are the most "dispersed"-citizens hold very different, often extreme opinions about NATO and Russia.

Information awareness (Q10) has the smallest variance (0.397), suggesting that respondents are uniform in assessing their own knowledge.

There is a strong positive covariance between general EU support (Q1) and economic expectations (Q2) (0.37), as well as the rule of law (Q3) (0.27). This confirms that respondents who support the EU do so because they believe in economic improvement and order.

The exceptionally high covariance between Q6 (NATO as a peace guarantor) and Q7 (NATO against threats) (0.81) indicates that respondents view these two categories as identical. Also, the link between NATO (Q5) and the rule of law (Q3) (0.58) is stronger than the link between NATO and the economy. This points to the conclusion that NATO is perceived as a "guardian of the system" rather than just a military force.

The identity question (Q4) has a markedly negative covariance with support for the EU (-0.56) and NATO (-0.36). The greater the fear of losing identity, the less is the support for integration.

Russia (Q8) shows the strongest negative relationship with NATO (Q6:-0.71) and the EU (Q1:-0.54). These are "opposing poles" in the respondents' minds-it is impossible to simultaneously rate Russia highly as a positive factor and support Euro-Atlantic integration.

The high covariance between the EU (Q1) and the rule of law (Q3) of 0.27 directly confirms the thesis that the state governed by the rule of law is the main motive for integration.

The covariance between Q9 and NATO peace guarantee (Q6) is very high (0.81). Those who believe the processes go "hand in hand" likely do so for security reasons.

Analysis shows a particularly strong covariance between the perception of EU/NATO synergy (Q9) and NATO's role as a peace guarantee (Q6), reaching 0.81. This suggests that for many respondents, the idea that these two integration processes must go 'hand in hand' is rooted in a fundamental need for long-term security. We believe this link highlights that economic expectations are rarely isolated from broader stability concerns. To provide a clearer picture of these relationships, we have presented the full correlation results in Figure 4.

Table 3. Correlation Matrix

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Q1	1									
Q2	0.41	1								
Q3	0.34	0.14	1							
Q4	-0.54	-0.38	-0.42	1						
Q5	0.33	0.07	0.51	-0.25	1					
Q6	0.23	-0.07	0.42	-0.4	0.34	1				
Q7	0.25	-0.05	0.56	-0.22	0.28	0.59	1			
Q8	-0.45	-0.31	-0.33	0.66	-0.28	-0.42	-0.23	1		
Q9	0.3	0.29	0.57	-0.45	0.23	0.56	0.3	-0.5	1	
Q10	0.05	0.3	-0.13	-0.14	-0.25	0.08	0.03	-0.1	0.06	1

Source - Author's calculation

Interpretation of key coefficients in the correlation matrix, where values range from-1 (perfect negative correlation) to 1 (perfect positive correlation), shows a strong link between the fear of losing identity and affinity toward Russia (Q4 and Q8 - 0.66). This is the strongest positive correlation in the research outside of directly related questions. It indicates that respondents who fear for national identity see Russia as a protective factor or an alternative to Western integration.

The research shows a moderately strong correlation proving that respondents do not see NATO only as a military force but link it to institutional order (rule of law) (Q5 and Q3 - 0.51). Furthermore, there is a clear negative correlation showing antagonism between the EU and loss of identity (Q1 and Q4:-0.54). The higher the support for the European Union, the lower the fear of losing identity, supporting the conclusion that EU integration supporters are culturally more open.

The research confirms that peace and stability in the minds of citizens are directly linked to the alliance's ability to respond to external threats (Q6 and Q7 - 0.59). Interestingly, awareness has weak correlations with attitudes (e.g., with Q1 it is only 0.05). This means that support for or opposition to integration does not necessarily depend on how much respondents know (or think they know), but rather on value-based and economic attitudes.

Analyzes of correlations and matrices of variances and covariances provide a basis for confirming the hypotheses. The main hypothesis (H0) is confirmed by the negative mean correlation between support for integration and fear of loss of identity ($r = -0.54$), which indicates that cultural fears, along with belonging to an entity, are strongly associated with resistance to the Euro-Atlantic path. The auxiliary hypothesis H1 is further strengthened by the moderate correlation between general support for the EU and expectations regarding the rule of law ($r = 0.34$), which is significantly higher than the correlation with economic expectations. This result confirms that citizens primarily perceive integration as a regulatory framework. Confirmation of the H2 hypothesis about gender language is statistically visible through the high variance in answers to questions related to NATO, where the correlation between NATO integration and long-term peace ($r = 0.34$) gains strength exclusively in the female segment of the sample. Finally, the confirmation of hypothesis H3 is reflected in the strongest negative correlation in the entire research - that between the perception of Russia as a security factor and NATO's peace guarantees ($r = -0.71$). Such a high correlation coefficient indicates a strong inverse linear association, suggesting that these security concepts are perceived as mutually exclusive poles in the minds of the respondents, thus providing empirical validation of the research.

DISCUSSION

The analysis of the collected data confirms strong general support for Bosnia and Herzegovina's accession to the European Union, with an overall average score of 4.38. Such a high level of agreement indicates that the European path represents a dominant social aspiration. However, a closer look at the entity structure reveals nuances - respondents from the Federation of Bosnia and Herzegovina express enthusiasm with a score of 4.47, while support in the Republika Srpska is somewhat lower, but remains at a high 4.31. The emergence of extreme views is particularly significant in the Republika Srpska, where a higher number of "1" ratings were recorded compared

to the Federation of Bosnia and Herzegovina (ratio 15:2), which indicates the existence of a vocal, albeit minority, opposition to integration.

Expectations regarding economic standards yield the most sober results. The mean score of 3.14 suggests that citizens do not harbor unrealistic illusions about rapid wealth accumulation. The identified data in both entities are almost identical (FBiH 3.14; RS 3.15), pointing to a shared economic reality. It is indicative that respondents with the highest level of education (PhD) give the lowest rating to this segment (2.00), leading to the conclusion that the more educated portion of the population more clearly perceives the economic challenges of transition.

In contrast to moderate economic expectations, trust in European mechanisms for combating corruption and strengthening the rule of law is exceptionally high (4.15). This confirms the auxiliary hypothesis H1, suggesting that citizens do not see the EU primarily as a source of funds, but rather as an instrument for establishing order and legal certainty. The data reveals that employees in big companies are the most optimistic (4.58), which probably points to their need for market stability above all else. What is more striking is that the fear of national erosion is practically absent (1.61), even among respondents in Republika Srpska (1.75). These results essentially pull the rug out from under political rhetoric that relies on the idea of cultural endangerment.

Regarding the NATO alliance, the results show a lower level of support (3.71) compared to the European Union. Although entity differences are present, support in Republika Srpska (3.78) is surprisingly high relative to official rhetoric. The most important finding of the research is the gender differentiation regarding security, which proves the auxiliary hypothesis H2. Women express significantly greater trust in NATO as a guarantor of long-term peace (4.18) compared to men (3.20). This difference of nearly one full point indicates that the female portion of the population perceives security integration through the prism of stability, while men are more susceptible to historical narratives.

The perception of the Russian Federation as a positive security factor received the lowest rating (1.92), confirming the auxiliary hypothesis H3. Even in Republika Srpska (2.10), citizens do not see Moscow as a factor of stability. The question regarding the inseparability of the EU and NATO paths (3.60) confirms that a significant portion of the population sees these processes as two sides of the same coin, with women again leading in this view (3.89).

Finally, the high self-assessment of information awareness (4.24) suggests that citizens' attitudes are not a matter of chance but of formed opinions. The alignment of high awareness with EU support suggests that the integration process is backed by a form of 'conscious endorsement'-one that appears capable of weathering the volatility of daily political shifts.

CONCLUSION

This study provides a deep dive into how people in Bosnia and Herzegovina feel about Euro-Atlantic integration, specifically analyzing these views during a period of intense geopolitical change and domestic friction. The paper has fully addressed the established research questions, and the analysis of the collected data has confirmed the strategic commitment of citizens to integration processes. The main hypothesis (H0) is confirmed - high general support for the EU was identified, albeit with clear entity po-

larization, while support for NATO is directly linked to the gender of all respondents. Furthermore, the auxiliary hypotheses were also confirmed. Citizens primarily expect the strengthening of the rule of law (4.15), while expectations regarding the immediate economic improvement for households stayed at a moderate level (3.14). There is a significant gap in the perception of NATO between genders, with women attributing considerably greater importance to the Alliance as a guarantor of peace. The perception of Russia as a positive security factor is low (1.92), with a statistically visible, yet still low, preference in Republika Srpska (2.10).

The primary finding of the survey confirms the existence of strong, although not unconditional, support for the path towards the European Union. The high average score of 4.38 clearly indicates that the idea of European integration in BiH still represents a rare factor of social cohesion, despite the pronounced entity polarization in extreme positions.

The analysis showed that the citizens of Bosnia and Herzegovina demonstrate a high level of rationality and maturity in their assessments. Their support for the European Union is not driven by unrealistic hopes of quick economic growth, as their expectations regarding improvements in living standards remain moderate. Instead, within the European framework, people seek regulatory stability. The fight against corruption and the establishment of the rule of law is seen as important benefits, indicating that the public mainly views the EU as a way to correct domestic institutional shortcomings.

NATO integration remains a divisive issue, but with unexpected nuances that previous research has not fully explained. The existing gender gap, where women show significantly more trust in the Alliance's stabilizing role, suggests that perceptions of security in BiH are complex. While resistance in Republika Srpska is apparent through more negative assessments, the average results indicate that the idea of collective security still holds some ground, beyond the daily political narratives of complete rejection.

Of particular importance is the perception of the Russian Federation; its influence as a security factor is rated very low across the country. Even support for Russia in Republika Srpska does not exceed the neutral point on the scale (3.00), which clearly challenges the idea of a strong Russian influence on public opinion. Citizens recognize their geographic and political ties to Europe, further confirmed by their high awareness of integration processes.

This study was designed to capture an accurate, current snapshot of public sentiment as of November 2025. Using a graded Likert scale allowed me to uncover subtle layers of support and hesitation about Euro-Atlantic integration-nuances that simple 'yes/no' surveys usually miss. However, the research has its limits - it mainly focuses on perceptions and declared attitudes, with limited analysis of specific political decisions or institutional dynamics shaping these views. While statistically reliable, the sample offers only a temporary picture, and we cannot draw definitive conclusions about long-term trends without further studies overtime.

There is a strong case for exploring how stalled candidate status could increase Euroscepticism across the country. Addressing this would require combining time-series data with a more detailed qualitative look at how political leaders and the media shape the narrative. Additionally, tools like focus groups could be valuable in exploring the roots of the gender gap in attitudes toward NATO and contrasting perspectives

on Russia and the West in the two entities. It is also important to assess how specific foreign investments and local EU programs directly influence public opinion on the ground.

From a policy standpoint, these findings suggest that reform efforts should prioritize the judicial and administrative sectors. Citizens see the real value of integration mainly through promises of a stronger rule of law, better administrative efficiency, and an effective fight against corruption. Supporting all three hypotheses, the study indicates that people view Euro-Atlantic institutions less as sources of financial aid and more as frameworks for organized institutions.

Every study has its limits, and this one is no different. By focusing on current perceptions rather than long-term socioeconomic trends, I have set the stage for future research to track how support for integration may grow or diminish over time.

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https://doi.org/10.7251/EMC2603898K
UDK: 659.89:[159.947.3:159.922.6
Datum prijema rada: 24. april 2026.
Submission Date: April 24, 2026
Datum prihvatanja rada: 26. avgust 2026.
Acceptance Date: August 26, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 898-920

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

EXISTENTIAL EMPTINESS AND COMPENSATORY CONSUMPTION THROUGH IDENTITY INSECURITY AND SELF-ESTEEM

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Abstract: *This study examines the psychological mechanisms underlying compensatory consumption in conditions of existential emptiness. The aim of the research is to analyse whether a deficit of perceived meaning in life acts as a structural antecedent of compensatory consumption through its impact on identity insecurity and self-esteem. The study integrates concepts from existential psychology, identity economics and consumer behaviour theory in order to construct and empirically test a sequential mediation model. Data were collected through a structured online survey conducted between October 2025 and January 2026 on a convenience (snowball) sample of 446 adult respondents in the Republic of Croatia. Validated measurement scales were adapted to operationalise existential emptiness, identity insecurity, self-esteem and compensatory consumption. Statistical analyses were performed using regression analysis and PROCESS macro (Model 6) with bootstrap estimation (5,000 samples) to test indirect effects. The results indicate that existential emptiness significantly predicts identity insecurity, which is in turn negatively associated with self-esteem, while lower self-esteem predicts higher compensatory consumption. A significant sequential indirect effect indicates that the relationship between existential emptiness and compensatory consumption is transmitted through identity insecurity and self-esteem; once the mediators are included, the direct association is no longer statistically significant, a pattern consistent with full sequential mediation. The findings suggest that compensatory consumption is not merely a situational reaction but the outcome of a broader identity-evaluative destabilisation process. The study contributes to consumer economics by introducing existential emptiness as a theoretically grounded antecedent of compensatory consumption; its implications for preference instability are advanced as a theoretical interpretation rather than as an empirically established finding.*

Keywords: *Existential emptiness; Identity insecurity; Self-esteem; Compensatory consumption; Consumer behaviour*

JEL Classification: *D91; D11; M31*

INTRODUCTION

Standard microeconomic theory is grounded in the assumption of stable, clearly defined preferences and rational utility maximisation. Within this analytical framework, consumer choice is understood as the outcome of a consistent ranking of bundles of goods, while preferences are treated as exogenous and relatively stable. Although behavioural economics has introduced bounded rationality and cognitive biases into this framework, the deeper psychological foundations of preference stability remain insufficiently explored. In particular, limited attention has been paid to structural disturbances that may disrupt the coherence of the preference system itself.

Contemporary market dynamics raise precisely such questions. Over recent decades, material living standards have significantly increased in developed economies; however, this growth has not been accompanied by a proportional rise in subjective well-being. At the same time, empirical studies report increasing levels of materialism, impulsive buying, and status-oriented consumption. Earlier work by (Dittmar, 2005) already pointed to the growing psychological significance of materialistic values, while meta-analytic evidence documents the association between materialistic orientations, diminished well-being and consumption-oriented coping strategies (Dittmar, Bond, Hurst, & Kasser, 2014). Such patterns suggest that consumption increasingly performs functions that extend beyond instrumental utility maximisation. Goods are selected not solely for their functional attributes but also for their symbolic and regulatory roles. Identity economics provides a partial explanation for this shift. (Akerlof & Kranton, 2000) demonstrate that identity can directly enter the utility function and influence economic behaviour through internalised social norms and categories of belonging. This perspective is further extended by (Bénabou & Tirole, 2011) who emphasise the reputational and signalling dimensions of economic decisions, arguing that individuals derive utility from how they are perceived by others. When goods serve as identity signals, preference formation becomes intertwined with self-perception and social validation.

However, most identity-based models treat identity as a relatively stable structure subject to situational threat rather than structural destabilisation. Research on compensatory consumption shows that individuals increase symbolic and status-oriented purchases when experiencing reduced power, social exclusion, or personal inadequacy (Rucker & Galinsky, 2008); (Mandel, Rucker, Levav, & Galinsky, 2017). Further contributions demonstrate that threats to the self systematically increase reliance on symbolic consumption as a regulatory mechanism (Lisjak, Bonezzi, Kim, & Rucker, 2015); (Sivanathan & Pettit, 2010). Under such conditions, consumption functions as a mechanism that temporarily restores perceived control or self-worth. Nevertheless, these models largely focus on immediate triggers—such as identity threat or lowered self-esteem—without examining deeper antecedents that may undermine identity coherence.

The concept of existential emptiness offers a theoretical extension capable of addressing this gap. (Frankl, 1963) defines existential emptiness as a state characterised by the absence of perceived meaning and stable life orientation. Meaning functions not only as an emotional resource but also as a structural organiser of identity and long-term goals. (Baumeister, 1991) further conceptualises meaning as an integrative principle connecting purpose, coherence, and self-evaluation. When meaning weakens, fragmentation of the self occurs, accompanied by increased reliance on external sources of validation. Empirical research supports this association. (Steger, Frazier,

Oishi, & Kaler, 2006) demonstrate that lower levels of perceived meaning are linked to impulsive decision-making, while subsequent reviews highlight its role in stabilising psychological functioning and reducing existential anxiety (King & Hicks, 2021); (Schnell, 2021). From an economic perspective, such fragmentation may be interpreted as a disturbance in the internal consistency of preferences. If identity coherence contributes to the stability of evaluative criteria, its destabilisation may increase susceptibility to symbolically charged goods and regulatory choices aimed at restoring psychological balance. In this sense, existential emptiness may function as a latent shock to the preference structure, altering the evaluative processes underlying consumer decisions. These processes are further intensified in digitally mediated markets. Online environments amplify social comparison and expand opportunities for identity signalling. (Barasch, Zauberman, & Diehl, 2018) show that even the anticipation of sharing experiences can reshape evaluation processes, while related research demonstrates that continuous exposure to curated content increases comparison tendencies and self-evaluative sensitivity (Appel, Gerlach, & Crusius, 2016); (Verduyn, Gugushvili, Massar, Täht, & Kross, 2020). Under conditions of existential emptiness, such dynamics may further deepen identity instability and enhance the attractiveness of goods promising symbolic reaffirmation.

Despite its theoretical relevance, the existential dimension remains largely absent from economic analyses of consumer behaviour. Existing studies treat materialism, identity threat, or low self-esteem as separate predictors, without integrating them into a broader identity-evaluative framework grounded in deficits of meaning. Systematic examination of existential emptiness as a foundational antecedent of compensatory consumption remains underdeveloped within consumer economics. This study seeks to address this theoretical gap by conceptualising existential emptiness as a primary antecedent of compensatory consumption. A sequential mediation model is proposed in which existential emptiness destabilises identity coherence, increases identity insecurity, reduces self-esteem, and ultimately raises the likelihood of regulatory, symbolically oriented consumption. Within this framework, compensatory consumption is not interpreted as an isolated anomaly but as the final stage of a broader identity-evaluative adaptation process. The empirical analysis is based on survey data collected from a sample of 446 adult respondents, employing validated measurement instruments and mediation analysis. The contribution of the research is threefold. First, it extends economic models of consumer choice by introducing existential emptiness as a psychological antecedent whose destabilising implications for preference formation are developed at the theoretical level. Second, it empirically tests a sequential mediation mechanism linking identity destabilisation to compensatory consumption. Third, it provides theoretical insight into contemporary market patterns in which the symbolic value of goods increasingly surpasses their functional utility.

LITERATURE REVIEW

Existential Emptiness as Structural Destabilisation of Identity and Preference Coherence

The concept of existential emptiness originates in Viktor Frankl's logotherapeutic framework (1963), where it is defined as a chronic absence of perceived meaning, purpose, and life direction. Unlike transient emotional states, existential emptiness rep-

resents a deeper motivational deficit that disrupts the long-term organisation of goals and the integration of values. According to Frankl, the search for meaning constitutes a fundamental human motivation; its absence generates a sense of aimlessness, internal tension, and diffuse dissatisfaction. Although initially developed within existential psychology, the implications of this concept extend beyond the clinical domain to the organisation of identity and patterns of decision-making. Subsequent theoretical accounts conceptualise meaning in life as an integrative structure that connects goals, values, and self-perception into a coherent whole. (Baumeister, 1991) describes meaning as a cognitive architecture that ensures identity continuity over time. This integrative role of meaning has been reaffirmed in more recent work, which conceptualises meaning as a central organising principle of psychological functioning and long-term behavioural regulation (Schnell, 2021). Meaning enables narrative stability—the integration of past experiences, present roles, and future aspirations within a unified evaluative framework. When this integrative function weakens, identity becomes fragmented, and behavioural regulation shifts from long-term orientation toward short-term regulatory strategies.

Empirical evidence supports this association. (Steger, Frazier, Oishi, & Kaler, 2006) distinguish between the presence of meaning and the search for meaning, demonstrating that lower levels of meaning presence are associated with more impulsive decision-making, heightened emotional instability, and increased reliance on external validation. Subsequent research further emphasises the stabilising function of meaning, showing that it reduces existential anxiety, promotes behavioural consistency, and that its deficits are linked to increased psychological vulnerability and reduced coherence in self-regulation (King & Hicks, 2021). The absence of meaning therefore does not merely produce emotional discomfort; it undermines evaluative coherence. From an economic perspective, such destabilisation may be interpreted as a disturbance in the structure of preferences. Standard microeconomic models assume stable and transitive preference orderings. Even within behavioural economics, deviations are typically conceptualised as cognitive biases operating within an otherwise stable evaluative system. However, if identity coherence contributes to the stability of evaluative criteria, existential emptiness may generate instability at the level of preference construction itself. In other words, rather than distorting stable preferences, existential emptiness may alter the conditions under which preferences are formed. Identity economics partially anticipates this possibility. (Akerlof & Kranton, 2000) integrate identity directly into the utility function, arguing that behaviour is shaped not only by material outcomes but also by alignment with identity norms. This perspective is further elaborated by (Bénabou & Tirole, 2011) who demonstrate that individuals derive utility through reputational and self-signalling mechanisms, embedding identity validation into economic decision-making. Yet these models implicitly assume relative stability of identity categories. Existential emptiness challenges this assumption. If perceived meaning functions as a higher-order integrative structure of identity, its weakening may destabilise identity categories themselves. Individuals no longer act from a stable identity seeking confirmation but from a state of identity uncertainty. This process can be conceptualised as structural identity destabilisation.

Contemporary models of self-esteem provide additional theoretical grounding for this interpretation. (Albarracin, et al., 2024) conceptualise self-esteem as a hierar-

chically organised inferential system tracking an individual's perceived standing within the social environment. Within this framework, stable (trait) self-esteem functions as a higher-level prior guiding the interpretation of social signals, whereas situational fluctuations represent lower-level updates. Complementary empirical research highlights that instability in self-evaluative processes increases sensitivity to external cues and short-term feedback loops (Kernis, 2005). Applied to existential emptiness, diminished perceived meaning may reduce the precision of identity-related priors, rendering individuals more sensitive to short-term evaluative cues. In such states, external symbolic signals acquire enhanced regulatory significance, compensating for the weakened internal structure of valuation.

These dynamics are further intensified in digitally mediated markets. Increased exposure to social comparison and idealised lifestyle representations heightens the salience of symbolic consumption. Early evidence by (Vogel, Rose, Roberts, & Eckles, 2014) demonstrates the role of social comparison in shaping self-evaluation, while related studies show that curated content environments amplify comparison processes and increase self-evaluative sensitivity (Appel, Gerlach, & Crusius, 2016); (Verduyn, Gugushvili, Massar, Täht, & Kross, 2020). Under conditions of existential emptiness, such environments may further destabilise identity and reinforce reliance on market-based signalling mechanisms. It is important to distinguish existential emptiness from related constructs. Self-discrepancy theory (Higgins, 1987) focuses on discrepancies between actual and ideal selves; sociometer theory (Leary & Baumeister, 2000) interprets self-esteem as an indicator of social inclusion; and contingent self-esteem models emphasise domain-specific sources of self-worth (Crocker, Luhtanen, Cooper, & Bouvrette, 2003). Existential emptiness operates at a more foundational level it precedes specific threats and destabilises the very orientation structure that enables evaluative consistency. In this sense, existential emptiness may be conceptualised as a latent antecedent of identity insecurity. Its primary consequence is not immediate consumption but heightened sensitivity to symbolic mechanisms of market validation. The weakening of internal coherence increases dependence on external indicators of value, thereby creating conditions for regulatory patterns of behaviour. By conceptualising existential emptiness as a structural disruption of identity coherence, the present study moves beyond partial accounts that attribute consumer behaviour solely to cognitive biases or situational threats. Existential emptiness is positioned as a higher-order determinant of preference instability and increased susceptibility to symbolic consumption.

A terminological clarification is warranted regarding the relationship between existential emptiness and the low presence of meaning. In the present study, existential emptiness is conceptualised, following (Frankl, 1963) as a chronic deficit of perceived meaning and life orientation, and it is operationalised through reformulated items of the presence-of-meaning subscale of the Meaning in Life Questionnaire (Steger, Frazier, Oishi, & Kaler, 2006). The two constructs are therefore closely related but not fully equivalent: a low presence of meaning constitutes the measurable core of existential emptiness, whereas the broader existential-vacuum concept also encompasses aimlessness and diffuse dissatisfaction that are not exhausted by meaning items. Accordingly, the empirical indicator used here should be understood as a proxy for existential emptiness anchored in the meaning-presence dimension, and the interpretation of the findings is restricted to this operational definition.

Identity Insecurity, Self-Esteem, and Evaluative Stability

Identity represents a relatively stable organisation of values, goals, and self-perceptions that enables coherent interpretation of experience and consistent behavioural orientation. Classical theories of identity assume that individuals possess a hierarchically structured self-concept that regulates choice and evaluation, as originally conceptualised by (Erikson, 1968) and further developed within social identity theory by (Tajfel & Turner, 1979). However, contemporary research increasingly emphasises the fluidity of identity and its sensitivity to social and market stimuli, particularly under conditions of intensified symbolic exposure and comparison. Recent perspectives highlight that identity is not only socially embedded but also continuously reconstructed through interaction with mediated environments and evaluative feedback systems (de Vries & Kühne, 2015). Identity insecurity refers to the subjective experience of lacking a stable definition of the self, reflected in diminished clarity regarding personal values, goals, and social roles. (Campbell, et al., 1996) introduced the concept of self-concept clarity, demonstrating that lower levels of clarity are associated with greater emotional reactivity and increased dependence on external evaluations. When identity lacks structural coherence, individuals become more sensitive to situational cues and social comparison, resulting in greater variability in self-evaluation.

Subsequent empirical work confirms that reduced self-concept clarity is associated with heightened responsiveness to external validation and has systematic implications for consumer behaviour (Mittal, 2015). Within this framework, self-esteem functions as the evaluative dimension of identity. (Rosenberg, 1965) conceptualised self-esteem as a global assessment of self-worth, whereas (Leary & Baumeister, 2000), in sociometer theory, highlighted its role in monitoring perceived social inclusion. Self-esteem therefore reflects not only internal evaluation but also expectations of social acceptance. When identity coherence weakens, the precision of these expectations declines, and self-esteem becomes more unstable. Recent models further elaborate this dynamic. (Albarracin, et al., 2024) conceptualise self-esteem as a hierarchically organised inferential system functioning as a set of "empirical priors" regarding one's adaptive value within the social environment. Stable (trait) self-esteem represents a higher-order layer that shapes the interpretation of social feedback, whereas situational fluctuations (state self-esteem) reflect short-term updates of the system. Complementary longitudinal research demonstrates that self-esteem is not only a stable trait but also a dynamic system sensitive to environmental feedback and life conditions (Orth & Robins, The development of self-esteem, 2014), (Orth & Robins, Is high self-esteem beneficial? Revisiting a classic question, 2022). When identity is destabilised, the precision of these priors decreases, rendering the evaluative system more sensitive to immediate stimuli and short-term fluctuations.

From an economic perspective, such instability may be interpreted as reduced evaluative consistency. If identity and self-esteem participate in organising valuation criteria, their destabilisation may increase oscillations in the assessment of goods. Individuals no longer evaluate goods solely according to functional attributes but also according to their potential role in regulating perceived self-worth. Empirical findings support this interpretation. Research indicates that individuals with lower and unstable self-esteem display greater susceptibility to social comparison, heightened reactivity to status signals, and increased dependence on external indicators of success,

as demonstrated by (Orth & Robins, The development of self-esteem, 2014). Related evidence further shows that self-esteem instability amplifies reactivity to evaluative events and external feedback (Kernis, 2005). Identity insecurity amplifies this dynamic by reducing long-term self-regulatory capacity. Under such conditions, the evaluation of goods may function as an instrument for temporary stabilisation of perceived self-worth. It is important to distinguish low self-esteem from unstable self-esteem. Whereas low self-esteem reflects a chronically negative self-evaluation, unstable self-esteem is characterised by high variability contingent on situational stimuli. It is instability rather than absolute level alone that increases susceptibility to regulatory behavioural patterns. When the evaluative system lacks stability, market symbols may acquire the function of short-term stabilisers. It should be emphasised, however, that the empirical analysis in this study measures the global level of self-esteem using selected items from the Rosenberg Self-Esteem Scale and does not measure the temporal stability of self-esteem. References to self-esteem instability therefore operate strictly at the theoretical level of the argument, whereas the hypotheses and the empirical model concern the level of global self-esteem; empirical statements in the remainder of the paper are accordingly formulated in terms of lower versus higher self-esteem. This mechanism gains further significance in digitally intensive environments. Continuous exposure to comparison and performative identity presentation heightens the salience of evaluative signals. Studies show that social media environments intensify upward comparison processes and increase dependence on external validation for self-evaluation (Keles, McCrae, & Grealish, 2020); (Verduyn, Gugushvili, Massar, Täht, & Kross, 2020). Under conditions of identity insecurity, such environments may further fragment self-concept, increasing the dependence of self-esteem on external validation. Evaluative stability may therefore be conceptualised as a function of identity coherence and stable self-esteem. When these elements are weakened, the likelihood increases that individuals will resort to symbolic resources to temporarily regulate perceived self-worth. In other words, identity insecurity and reduced self-esteem stability create conditions under which market choices can assume a regulatory function. This interpretation moves beyond partial accounts that attribute consumption exclusively to situational threats or self-discrepancies. It suggests that compensatory consumption may arise from a deeper destabilisation of the evaluative system itself. Understanding this process requires closer examination of how symbolic goods enable temporary identity reaffirmation and self-esteem regulation

A further clarification concerns the relationship between identity insecurity and self-concept clarity. Identity insecurity is operationalised in this study through adapted items of the Self-Concept Clarity Scale (Campbell, et al., 1996) which implies that the measure captures primarily the reversed dimension of self-concept clarity rather than an entirely new construct. The term identity insecurity is therefore used as a theoretical label that connects low self-concept clarity with the broader identity-evaluative framework of the model, and no claim is made that the measure possesses discriminant validity relative to self-concept clarity. Establishing identity insecurity as a construct that is empirically distinct from inverse self-concept clarity would require dedicated construct-validation studies, which is acknowledged as a limitation of the present research.

Compensatory Consumption as a Regulatory Market Mechanism

Compensatory consumption refers to market choices that extend beyond functional use value and assume a regulatory role in restoring or stabilising disrupted self-perception. Unlike utilitarian consumption, which is oriented toward the maximisation of instrumental utility, compensatory consumption arises from the psychological need to reaffirm identity or mitigate evaluative instability. The central premise of this approach is that goods and brands possess a symbolic dimension that enables the signalling of social status, competence, belonging, or personal worth. (Belk, 1988) introduced the concept of the extended self, arguing that material objects become integrated into an individual's identity structure. This perspective is further supported by identity-based consumption frameworks, which suggest that consumers actively use brands and products to construct and signal their identities (Escalas & Bettman, 2005); (Reed, Forehand, Puntoni, & Warlop, 2012). When identity becomes destabilised, symbolic goods may function as external resources for its temporary reorganisation. Experimental research demonstrates that perceived reductions in power or social inclusion increase preferences for status-signalling and prestigious products. (Rucker & Galinsky, 2008) provide early evidence of this mechanism, showing how powerlessness enhances the desire for status-oriented goods, while the broader conceptualisation developed by (Mandel, Rucker, Levav, & Galinsky, 2017) frames such behaviour as a response to self-discrepancies. Further research extends this perspective by demonstrating that threats to the self systematically increase reliance on symbolic consumption as a regulatory mechanism. For instance, (Lisjak, Bonezzi, Kim, & Rucker, 2015) show that psychological threat provokes the acquisition of products that symbolise accomplishment in the threatened domain, while (Sivanathan & Pettit, 2010) demonstrate that self-threat increases the preference for high-status goods that serve an affirmational function. In such contexts, consumption operates as a mechanism that temporarily reduces evaluative dissonance and restores a sense of coherence.

Contemporary literature, however, indicates that compensatory consumption is not always directed toward positive self-enhancement. A comprehensive review by (Consiglio & van Osselaer, 2022) systematises the processes through which consumption influences self-esteem, including self-discrepancy reduction, self-enhancement, self-affirmation, and self-verification. The latter mechanism is particularly relevant under conditions of identity insecurity. Individuals with chronically low self-esteem may sometimes prefer choices that confirm existing negative self-perceptions, as such confirmation increases predictability and reduces anxiety associated with uncertainty. Empirical evidence supports this dynamic. Research by (Stuppy, Mead, & van Osselaer, 2020) shows that individuals with lower self-esteem may prefer inferior products when those products are congruent with their self-concept. Such choices do not maximise objective quality but rather subjective identity coherence. Earlier experimental findings similarly indicate that consumers select products in order to restore or confirm threatened self-views, highlighting the stabilising rather than the enhancing function of such behaviour (Gao, Wheeler, & Shiv, 2009).

Compensatory consumption, therefore, does not necessarily result in positive evaluative change; its primary function may be stabilisation rather than improvement of self-perception. In the presence of identity insecurity, the regulatory function of consumption becomes more pronounced. When the evaluative system is unstable, sym-

bolic goods acquire the role of short-term stabilisers. Their value derives from their capacity to temporarily restore feelings of control, status, or belonging. Yet because these mechanisms do not address the underlying destabilisation of identity, their effects are often transient, potentially encouraging repeated regulatory choices. This cyclical dynamic is consistent with evidence that within-domain compensatory consumption can undermine subsequent self-regulation, thereby encouraging repeated regulatory choices (Lisjak, Bonezzi, Kim, & Rucker, 2015). This dynamic is particularly visible in markets characterised by high levels of symbolic competition. Digital environments increase the transparency of comparison and the intensity of signalling, making symbolic consumption a readily available regulatory tool. Empirical studies indicate that online environments amplify social comparison and increase the salience of identity-relevant signals (Verduyn, Gugushvili, Massar, Täht, & Kross, 2020). In such contexts, identity insecurity may rapidly translate into market behaviour. It is important to emphasise that compensatory consumption is not an anomaly but part of a broader system of identity regulation. It emerges when internal evaluative resources are insufficient to maintain a stable self-perception. In this sense, compensatory consumption can be interpreted as the final stage of an identity-evaluative process initiated by existential destabilisation. By integrating existential emptiness, identity insecurity and self-esteem and the regulatory function of consumption, a coherent theoretical chain is established that enables precise modelling of sequential relationships among constructs. Such an approach moves beyond isolated analyses of self-discrepancy or status signalling and positions compensatory consumption within a broader motivational architecture.

Theoretical Integration of Constructs and Hypothesis Development

The preceding sections establish three analytically distinct yet conceptually interdependent domains: existential emptiness as a higher-order structural deficit, identity insecurity and self-esteem as components of evaluative architecture, and compensatory consumption as a regulatory market response. Integrating these domains requires positioning them within a coherent motivational sequence rather than treating them as isolated predictors of consumer behaviour. Existential emptiness represents a disruption at the level of meaning integration. When perceived meaning weakens, the narrative continuity that binds values, goals, and self-perceptions into a stable identity framework becomes attenuated. Identity categories lose structural precision, and individuals experience increased ambiguity regarding who they are and what evaluative standards guide their choices. In such conditions, identity insecurity emerges not as an episodic reaction but as a structural consequence of diminished meaning coherence. The weakening of integrative orientation thus precedes and predicts instability at the level of self-definition. Accordingly, existential emptiness is expected to be positively associated with identity insecurity. Identity insecurity, in turn, affects the evaluative dimension of the self. When individuals lack clarity regarding their identity structure, the inferential system that generates global self-evaluations becomes less stable. As discussed in hierarchical models of self-esteem, stable trait-level self-worth functions as a higher-order prior shaping the interpretation of social signals. Identity destabilisation reduces the precision of these priors, rendering self-esteem more vulnerable to situational fluctuations and downward evaluative shifts. Consequently, higher levels of identity insecurity are expected to be associated with lower levels of self-esteem.

The regulatory implications of diminished self-esteem follow from its function as an indicator of perceived adaptive value. When global self-worth declines, individuals may seek externally visible resources capable of temporarily recalibrating evaluative balance. Symbolic goods provide such resources by enabling status signalling, competence projection, or affiliation cues. In the absence of stable internal evaluative anchors, market choices may assume a compensatory function. Lower self-esteem is therefore expected to increase the likelihood of compensatory consumption. Taken together, these relationships suggest a sequential motivational chain. Existential emptiness destabilises identity coherence; identity insecurity undermines evaluative stability; and reduced self-esteem increases reliance on symbolic market mechanisms for temporary self-regulation. Compensatory consumption thus emerges as the behavioural endpoint of a broader identity-evaluative process. Importantly, this framework implies not only isolated pairwise relationships but also an indirect pathway linking existential emptiness to compensatory consumption through identity insecurity and self-esteem. If existential deficits weaken identity structure and thereby reduce evaluative stability, part of their influence on market behaviour should operate through this sequential mechanism. At the same time, given the multifaceted nature of consumption motives, a residual direct association between existential emptiness and compensatory consumption cannot be ruled out.

Based on this integrated theoretical model, the following hypotheses are formulated:

H1. Existential emptiness is positively associated with identity insecurity.

H2. Identity insecurity is negatively associated with self-esteem.

H3. Self-esteem is negatively associated with compensatory consumption.

H4. Existential emptiness exerts an indirect effect on compensatory consumption through identity insecurity and self-esteem in a sequential mediation process.

This hypothesis structure allows empirical testing of both direct structural relationships and the broader regulatory chain linking existential destabilisation to market behaviour.

METHODOLOGY

To systematically address the research problem and empirically test the conceptual model linking existential emptiness and compensatory consumption, the study was designed as an integration of theoretical analysis and quantitative empirical investigation. The theoretical foundation was established through an extensive review of relevant domestic and international literature in the fields of existential psychology, identity economics, self-esteem theory, and symbolic consumption. A structured search was conducted in major international databases (Web of Science, Scopus, and ScienceDirect) to identify theoretical and empirical contributions enabling the construction of an integrated model connecting meaning destabilisation, identity insecurity, self-esteem, and compensatory consumption. The synthesis of existing approaches resulted in a sequential mediation framework in which existential emptiness is conceptualised as a fundamental psychological antecedent of shifts in the individual evaluative system. The empirical component was conducted using a quantitative cross-sectional design based on a structured online survey questionnaire. Data were collected between October 2025 and January 2026 from a sample of 446 adult respondents in the Republic

of Croatia. A non-probability convenience sampling procedure with a snowball component was applied: the questionnaire was distributed primarily through social media (posts and shares by respondents within their own networks), which chain-referral pattern constitutes a snowball sampling element, during the period from October 2025 to January 2026. Participation was voluntary and anonymous, and no incentives were offered. The inclusion criteria required respondents to be at least 18 years of age and to complete the questionnaire in full; incomplete responses were excluded from the analysis. The final sample comprises 229 women (51.3%) and 217 men (48.7%). All age groups are represented in comparable proportions: 18–25 years (19.7%), 26–35 years (20.9%), 36–45 years (18.4%), 46–55 years (19.1%) and 56 years or older (22.0%). In terms of educational attainment, 24.4% of respondents completed secondary education, 25.3% hold an undergraduate degree, 22.4% a graduate degree and 27.8% a postgraduate degree, while monthly income is likewise balanced across the four categories (below EUR 800: 24.0%; EUR 800–1,200: 26.7%; EUR 1,200–1,800: 24.9%; above EUR 1,800: 24.4%). Because a convenience sample was used, the sample is not statistically representative of the adult population, which is explicitly addressed among the limitations of the study. The sample size ensures adequate statistical power for testing indirect effects in mediation models of moderate complexity and provides stability in parameter estimation, particularly when applying bootstrap procedures. Measurement instruments were constructed on the basis of validated scales from the international literature. Existential emptiness was operationalised through an adaptation of the "presence of meaning" subscale from the Meaning in Life Questionnaire (Steger, Frazier, Oishi, & Kaler, 2006) with items reformulated to reflect deficits in perceived meaning in line with Frankl's concept of the existential vacuum. Identity insecurity was measured using adapted items from the Self-Concept Clarity Scale (Campbell, et al., 1996), assessing the stability and coherence of self-perception. Self-esteem was assessed using selected items from the Rosenberg Self-Esteem Scale (Rosenberg, 1965), widely recognised as the standard measure of global self-worth. The compensatory consumption scale was developed on the basis of theoretical and experimental research demonstrating that reduced feelings of personal adequacy and power increase preferences for symbolically laden goods (Rucker & Galinsky, 2008); (Mandel, Rucker, Levav, & Galinsky, 2017). Items were formulated to capture the regulatory function of consumption in terms of reaffirming personal value and restoring a sense of control. All constructs were measured using five-point Likert-type scales. Existential emptiness, identity insecurity and self-esteem were each measured with five items, and compensatory consumption with six items; the self-esteem measure includes one reverse-worded item, which was recoded prior to the analysis. The complete wording of all measurement items, in the original Croatian and in English translation, is reported in Appendix A. Prior to the main data collection, the instrument was pilot-tested on a smaller convenience sample to assess clarity and content alignment with the theoretical constructs. Minor linguistic adjustments were subsequently implemented. Internal consistency was evaluated using Cronbach's alpha coefficients. Factorial structure was examined to confirm convergent and discriminant validity of the constructs. To address potential common method variance, Harman's single-factor test was performed. Convergent validity was supported by satisfactory factor loadings, while discriminant validity was confirmed as inter-construct correlations remained below critical thresh-

olds. The first factor accounted for less than 50% of the total variance, indicating that common method bias is unlikely to pose a serious concern. Statistical analyses were conducted using IBM SPSS Statistics 27, with the PROCESS macro - Model 6 (Hayes, 2018), employed to test the sequential mediation model. The model assumes that existential emptiness influences compensatory consumption indirectly through identity insecurity and self-esteem. Indirect effects were estimated using bootstrap resampling with 5,000 iterations and percentile bootstrap confidence intervals, ensuring robust parameter estimation without relying on the assumption of normality in the sampling distribution of mediation effects.

EMPIRICAL EVIDENCE

The empirical analysis was designed to test the integrated sequential model according to which existential emptiness functions as a structural antecedent of compensatory consumption, mediated by identity insecurity and self-esteem. The analytical strategy was structured to enable a stepwise examination of the proposed identity-evaluative chain and to distinguish between direct and indirect effects among the constructs. The results are presented in four interrelated stages. The first stage reports descriptive statistics and reliability coefficients, thereby confirming the distributional adequacy of the data and the internal consistency of the latent constructs. The second stage examines bivariate relationships among variables in order to establish the underlying structure of associations and assess the theoretical coherence of the model. The third stage involves testing the direct regression relationships specified in hypotheses H1–H3. The final stage applies sequential mediation analysis to examine the transmission mechanism through which existential emptiness influences compensatory consumption via identity insecurity and self-esteem. The analysis was conducted on a sample of 446 adult respondents. Statistical procedures were performed using IBM SPSS Statistics 27. Sequential mediation was tested using the PROCESS macro (Model 6; Hayes, 2018), which allows estimation of multiple consecutive mediators within a single analytical framework. Indirect effects were estimated using bootstrap resampling with 5,000 iterations and percentile bootstrap 95% confidence intervals, ensuring robust parameter estimation without reliance on the normality assumption of the sampling distribution of mediation effects. Control variables (age, gender, education, and income) were tested; however, their inclusion did not materially alter the magnitude or significance of the estimated relationships and were therefore excluded from the final model for parsimony.

Descriptive Statistics and Internal Consistency of the Measurement Scales

Descriptive statistics and internal consistency estimates of the constructs are reported in *Table 1.* Existential emptiness exhibits a mean value of M = 2.97 (SD = 0.64), while identity insecurity reaches M = 3.04 (SD = 0.67). Self-esteem shows a comparable average level (M = 3.06; SD = 0.59), whereas compensatory consumption records M = 3.05 (SD = 0.57). Distributional indicators suggest adequate variability across all constructs, with no evidence of range restriction. Skewness values range between −0.20 and 0.07, and kurtosis values between −0.25 and 0.27. All indices fall within conventional empirical thresholds considered acceptable for parametric model-

ling (|Skew| < 1; |Kurtosis| < 1), indicating the absence of substantial deviations from normality. Internal consistency of the measurement scales, assessed using Cronbach's alpha coefficients, demonstrates high reliability across all constructs. Alpha values range from 0.90 (self-esteem) to 0.93 (existential emptiness and identity insecurity), substantially exceeding recommended thresholds for research instruments. These results confirm item homogeneity within each scale and justify aggregation of variables into composite indices used in subsequent regression and mediation analyses.

Table 1. Descriptive Statistics and Reliability of the Constructs

Constructs	M	SD	Skew	Kurt	Cronbach α
Existential Emptiness	2.97	0.64	0.07	-0.10	0.93
Identity Insecurity	3.04	0.67	-0.09	-0.25	0.93
Self-Esteem	3.06	0.59	-0.11	0.25	0.90
Compensatory Consumption	3.05	0.57	-0.20	0.27	0.92

Source: Authors' calculation

Correlation Analysis

Bivariate relationships among the constructs were assessed using Pearson correlation coefficients *(Table 2)*. The resulting pattern of associations demonstrates a high degree of theoretical consistency with the proposed identity-evaluative model. Existential emptiness is strongly and positively correlated with identity insecurity ($r = 0.70$; $p < 0.001$), empirically supporting the assumption that deficits in perceived meaning are accompanied by destabilisation of self-definition. The magnitude of this association suggests that the existential dimension constitutes a central, rather than peripheral, factor in the organisation of identity coherence. At the same time, existential emptiness shows a significant negative correlation with self-esteem ($r = -0.50$; $p < 0.001$), while identity insecurity is likewise negatively associated with self-esteem ($r = -0.63$; $p < 0.001$). This correlation pattern indicates an evaluative dynamic in which identity destabilisation is accompanied by diminished global self-worth, providing empirical support for the proposed transition from identity instability to evaluative instability. With respect to compensatory consumption, existential emptiness exhibits a moderate positive correlation ($r = 0.34$; $p < 0.001$), and identity insecurity is positively associated with compensatory consumption ($r = 0.45$; $p < 0.001$). Self-esteem is negatively correlated with compensatory consumption ($r = -0.61$; $p < 0.001$), suggesting that reduced evaluative stability is associated with increased inclination toward symbolically oriented market choices. Overall, the correlation matrix reveals a consistent sequential structure of relationships: existential emptiness is associated with identity insecurity, identity insecurity with self-esteem, and self-esteem with compensatory consumption. Although correlational analysis does not allow testing of causal or transmission mechanisms, the findings provide empirical justification for subsequent regression and mediation modelling.

Table 2. Pearson Correlation Matrix of the Constructs

Constructs	1	2	3	4
Existential Emptiness	1			
Identity Insecurity	0.70**	1		
Self-Esteem	-0.50**	-0.63**	1	
Compensatory Consumption	0.34**	0.45**	-0.61**	1

Source: Authors' calculation
Note: ** $p < 0.001$

Hypothesis Testing through Regression Analysis

The direct relationships specified in the theoretical model were estimated using linear regression analysis. The constructs were operationalised as composite indices calculated as arithmetic means of their respective items. Diagnostic tests confirmed that the assumptions of linearity, homoscedasticity, and absence of multicollinearity were satisfied. Variance Inflation Factor (VIF) values were below 2 across all models, indicating stability of the regression parameter estimates.

H1. Existential Emptiness → Identity Insecurity

The regression model demonstrates high statistical significance ($F(1, 444) = 431.81$; $p < 0.001$) with a coefficient of determination of $R^2 = 0.49$ *(Tables 3 and 4).* Existential emptiness strongly and positively predicts identity insecurity ($\beta = 0.70$; $p < 0.001$), explaining 49% of the variance in the dependent variable. The magnitude of the standardised coefficient indicates a substantial statistical association; given the cross-sectional design, it is interpreted as a predictive relationship rather than as evidence of an underlying causal mechanism.

Hypothesis H1 is supported.

Table 3. Model summary

Model Summary	Value
R	0.70
R^2	0.49
Adjusted R^2	0.49
F (1, 444)	431.81
p	< 0.001

Source: Authors' calculation

Table 4. Regression Estimates for Model H1

Independent Variable	B	SE	β	t	p
Existential Emptiness	0.74	0.04	0.70	20.78	< 0.001

Source: Authors' calculation

H2. Identity Insecurity → Self-Esteem

The regression model is statistically significant ($F(1, 444) = 297.57$; $p < 0.001$) with $R^2 = 0.40$ *(Tables 5 and 6)*. Identity insecurity significantly and negatively predicts self-esteem ($\beta = -0.63$; $p < 0.001$), explaining 40% of the variance in self-esteem. The magnitude of the coefficient indicates a pronounced evaluative correlate of identity destabilisation: increased uncertainty in self-definition is associated with lower global self-worth.

Hypothesis H2 is supported.

Table 5. Model summary

Model Summary	Value
R	0.63
R^2	0.40
Adjusted R^2	0.40
F (1, 444)	297.57
p	< 0.001

Source: Authors' calculation

Table 6. Regression Estimates for Model H2

Independent Variable	B	SE	β	t	p
Identity Insecurity	-0.55	0.03	-0.63	-17.25	< 0.001

Source: Authors' calculation

H3. Self-Esteem → Compensatory Consumption

The third regression model is also statistically significant ($F(1, 444) = 260.08$; $p < 0.001$), with $R^2 = 0.37$ *(Tables 7 and 8)*. Self-esteem significantly and negatively predicts compensatory consumption ($\beta = -0.61$; $p < 0.001$), explaining 37% of the variance in compensatory consumption. The findings indicate that lower self-esteem is associated with an increased propensity toward symbolically oriented market choices.

Hypothesis H3 is supported.

Table 7. Model summary

Model Summary	Value
R	0.61
R^2	0.37
Adjusted R^2	0.37
F (1, 444)	260.08
p	< 0.001

Source: Authors' calculation

Table 8. Regression Estimates for Model H3

Independent Variable	B	SE	β	t	p
Self-Esteem	-0.59	0.04	-0.61	-16.13	< 0.001

Source: Authors' calculation

Sequential Mediation Analysis

Sequential mediation analysis was conducted using the PROCESS macro - Model 6 (Hayes, 2018) to examine whether the effect of existential emptiness on compensatory consumption is transmitted through identity insecurity and self-esteem in the hypothesised order. The specified model estimates the sequential pathway $X \rightarrow M_1 \rightarrow M_2 \rightarrow Y$, where existential emptiness (X) predicts identity insecurity (M_1), which is subsequently associated with self-esteem (M_2), ultimately predicting compensatory consumption (Y). The analytical framework allows simultaneous estimation of the total effect (c), the direct effect (c′), and the specific indirect effects associated with each mediating path, including the sequential indirect effect through both mediators. Indirect effects were estimated using bootstrap resampling with 5,000 iterations and percentile bootstrap 95% confidence intervals, ensuring robust inference without reliance on the assumption of normality of the sampling distribution of mediation effects.

Table 9. Total and Direct Effects of Existential Emptiness on Compensatory Consumption

Effects	B	SE	t	p
Total effect (without mediators)	0.30	0.04	7.51	< 0.001
Direct effect (with mediators)	-0.02	0.05	-0.31	0.759

Source: Authors' calculation

The results reported in *Table 9* indicate that existential emptiness has a significant total association with compensatory consumption ($B = 0.30$; $SE = 0.04$; $p < 0.001$). After including identity insecurity and self-esteem in the model, the direct association is no longer statistically significant ($B = -0.02$; $SE = 0.05$; $p = 0.759$). The reduction of the coefficient from 0.30 to a value that does not differ significantly from zero suggests that the relationship between existential emptiness and compensatory consumption is transmitted almost entirely through the identity-evaluative mechanisms specified in the model. The sum of the specific indirect effects (0.31) corresponds to the difference between the total and the direct effect, confirming the internal consistency of the estimated decomposition.

Table 10. Indirect Effects of Existential Emptiness on Compensatory Consumption

Path	Indirect Effect	Boot SE	95 % CI (LLCI – ULCI)
EE → II → CC	0.070	0.037	–0.003 – 0.142
EE → SE → CC	0.055	0.024	0.009 – 0.105
EE → II → SE → CC (sequential path)	0.189	0.026	0.142 – 0.244

Source: Authors' calculation

The bootstrap analysis of the indirect pathways *(Table 10)* shows a clearly structured pattern of transmission. The dominant and statistically significant channel is the sequential indirect path (EE → II → SE → CC; B = 0.189; 95% CI [0.142, 0.244]), which is consistent with the hypothesised relational chain: existential emptiness predicts higher identity insecurity; identity insecurity is associated with lower self-esteem; and lower self-esteem, in turn, predicts higher compensatory consumption. The indirect path through self-esteem alone (EE → SE → CC; B = 0.055; 95% CI [0.009, 0.105]) is also statistically significant, although smaller in magnitude. By contrast, the specific indirect path through identity insecurity alone (EE → II → CC; B = 0.070; 95% CI [−0.003, 0.142]) does not reach statistical significance, as its confidence interval includes zero. This pattern indicates that identity insecurity is related to compensatory consumption primarily through its evaluative implications for self-esteem, and that the evaluative dimension attains its full regulatory relevance precisely when preceded by identity destabilisation. Given that the direct association is no longer significant once the mediators are included, the findings are consistent with full sequential mediation: the relationship between existential emptiness and compensatory consumption is transmitted through the identity-evaluative system specified in the model.

The results provide empirical support for *Hypothesis H4.*

RESULTS AND DISCUSSION

The empirical analysis indicates that the relationship between existential emptiness and compensatory consumption is neither linear nor reducible to a simple direct association between psychological deficit and market choice. Rather, it unfolds through a clearly structured identity–evaluative chain. Existential emptiness does not operate as a transient emotional state, but as a disruption of the integrative function of identity. Meaning in life, as conceptualized within the existential tradition, organizes goals, values, and expectations into a relatively stable narrative whole. When this organization weakens, the consequence is not merely a subjective feeling of emptiness, but a fragmentation of the criteria through which individuals evaluate themselves and their decisions. The strong association between existential emptiness and identity insecurity is consistent with this dynamic: destabilization begins at the level of self-definition. Identity becomes less coherent, less clearly structured, and more susceptible to external signals, thereby undermining its organizing role in structuring preferences.

Such fragmentation has direct implications for evaluative stability. The negative relationship between identity insecurity and self-esteem suggests that reduced clarity of self is accompanied by a decline in global self-evaluation. The sequence is theoretically and empirically consistent: self-esteem does not deteriorate independently, but as a consequence of identity destabilization. When individuals lack a stable reference framework for interpreting experiences and social feedback, their assessment of personal adequacy becomes more sensitive to situational cues. Self-esteem thus loses its function as a relatively stable evaluative anchor and becomes more reactive and dependent on external validation. In this condition, market symbols gain increased relevance because they provide clearly coded signals of status, competence, and belonging that can temporarily substitute weakened internal standards of evaluation. The negative association between self-esteem and compensatory consumption aligns with regula-

tory models of consumer behaviour, yet within this framework it acquires a deeper structural interpretation. Compensatory consumption does not stem from an isolated desire for status nor from momentary emotional discomfort, but from an attempt to stabilize a system that has previously been destabilized. When internal evaluative criteria are weakened, symbolic goods can serve as external organizers of identity coherence. Market choice then assumes the function of short-term reorganization of self-perception: a product or brand offers not only functional utility, but also a temporary sense of clearer position, control, or worth. Consumption acquires a regulatory dimension because it intervenes where continuity of the self has been disrupted.

The sequential mediation analysis further indicates that existential emptiness does not translate directly into compensatory consumption, but operates through identity-evaluative mechanisms. Its association with compensatory consumption is transmitted through identity insecurity and subsequently through self-esteem, a pattern consistent with a gradual transformation of existential deficit into market behaviour. Distinguishing levels of analysis is crucial: the existential dimension operates at the level of life orientation and narrative coherence; identity insecurity at the level of self-definition; and self-esteem at the level of evaluation. Only when these levels are cumulatively affected does the likelihood of compensatory consumption increase. Compensatory purchasing thus emerges as the final stage of a process in which internal destabilization is translated into external choice.

In the present data, no significant direct association between existential emptiness and compensatory consumption remains once the mediators are included, which indicates that the identity–evaluative chain accounts for the bulk of the observed relationship. This does not preclude additional channels—such as shifts in temporal perspective, heightened sensitivity to short-term rewards, or reduced tolerance for uncertainty—but such mechanisms are not detectable as a residual direct association in the present model. The predominance of indirect associations is consistent with the interpretation that compensatory consumption is not merely a hedonistic reaction, but an expression of a deeper disruption in the coherence of the self; given the cross-sectional design, this interpretation remains theoretical rather than causally established. These findings have broader implications for understanding preference stability in economic models. If identity functions as an organizing framework within which goals and evaluative criteria are defined, its destabilization may alter the very basis of valuation. In this sense, compensatory consumption does not necessarily represent irrational deviation, but rather an adaptive attempt to restore evaluative stability. Increased sensitivity to symbolic attributes does not arise from informational error, but from altered conditions under which preferences are formed. In contemporary markets, particularly those shaped by digital communication and intensified social comparison, these processes may be further amplified. Continuous exposure to normative standards and symbolic markers of success can heighten the responsiveness of identity-destabilized individuals to market signals. When the internal reference framework weakens, external symbols gain importance, and compensatory consumption becomes a more accessible strategy of adjustment. The market thus functions not only as a mechanism of exchange, but also as a space in which individuals attempt to re-establish continuity and value. The sequential dynamic identified in this study allows for a more precise positioning of compensatory consumption within a broader motivational architecture: existential

emptiness destabilizes identity; destabilized identity undermines evaluative stability; and diminished evaluative stability increases reliance on symbolic resources. Market choice in this chain is not the origin of the process, but its outcome.

The findings also carry practical implications for marketing practice and consumer welfare. For marketing practice, the results suggest that consumers' responsiveness to symbolic and status-related appeals is systematically related to the state of their identity-evaluative system. Segmentation and communication strategies that rely on identity signalling are therefore likely to be most effective—and most ethically sensitive—among consumers experiencing diminished meaning, identity uncertainty and lowered self-esteem. Brands positioned around competence, belonging or self-expression should recognise that part of the demand for such positioning is regulatory in nature, and that communication which deliberately amplifies identity insecurity in order to stimulate demand raises serious ethical concerns. From a consumer-welfare and policy perspective, the results indicate that compensatory consumption may function as a short-term regulatory strategy with limited long-term benefits, which supports interventions aimed at strengthening consumers' internal evaluative resources: programmes of financial and media literacy, transparency requirements for idealised or algorithmically curated content, and initiatives that foster sources of meaning outside the market sphere. For consumers themselves, awareness that symbolically driven purchases may constitute responses to identity destabilisation rather than to product attributes can support more reflective decision-making.

CONCLUSION

This study demonstrates that compensatory consumption cannot be adequately explained without accounting for the deeper existential dimension of identity. A deficit in experienced meaning does not remain at the level of a subjective feeling of emptiness; rather, it affects the structure of self-definition and the evaluative system, thereby altering the way individuals assess themselves and their choices. Market behaviour, particularly when symbolically oriented, emerges in this context as a response to the destabilization of internal coherence. The sequential dynamics identified in the analysis indicate that compensatory consumption is not an immediate response to existential emptiness, but the outcome of a gradual transformation of the identity–evaluative structure. When meaning weakens, identity loses clarity; when identity becomes insecure, self-esteem loses stability; and when evaluative stability declines, market symbols acquire an enhanced regulatory function. Compensatory consumption is thus repositioned from the category of isolated market anomalies to the domain of adaptive strategies for coping with internal destabilization. This perspective opens space for a reconsideration of preference stability in economic modelling. If identity constitutes the organizational framework within which evaluative criteria are formed, its destabilization may produce changes in the very structure of choice. In this sense, the market does not function solely as a neutral arena of exchange, but also as a space of symbolic regulation in which individuals attempt to restore a sense of coherence. The study has several limitations. First, it is based on a cross-sectional design and self-reported measures, which limits the strength of causal inference; the estimated relationships should therefore be interpreted as predictive associations rather than causal effects. Second, the data were collected through non-probability convenience

sampling in a single country, which restricts the generalisability of the findings to the broader adult population and to other cultural and economic contexts; replication on probability-based and cross-national samples is therefore needed. Third, the operationalisation of the constructs relies on adapted and, in the case of compensatory consumption, newly developed scales: existential emptiness is measured through reformulated presence-of-meaning items, identity insecurity through adapted self-concept clarity items, and self-esteem through selected Rosenberg items capturing the level rather than the stability of self-esteem. Stronger evidence of construct validity, including the discriminant validity of identity insecurity relative to self-concept clarity and direct measurement of self-esteem stability, remains an important task for future research. Longitudinal and experimental designs could provide a more precise understanding of the temporal dynamics through which existential emptiness translates into compensatory consumption. Future research could also incorporate additional mediators such as materialistic values, temporal orientation, or emotion regulation to further elaborate the mechanisms linking meaning destabilization to market behaviour. In contemporary digitally mediated markets, where symbolic signals are continuously present and amplified, understanding these processes becomes particularly relevant. In such environments, compensatory consumption may not merely reflect a desire for status or hedonic gratification, but also an attempt to restore diminished identity stability. To understand this process is to better understand the broader relationship between existential security and market dynamics.

Appendix A. Measurement Instrument

All constructs were measured using the following statements, rated on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). The original items were administered in Croatian; an English translation is provided alongside each item for readers unfamiliar with the source language. Existential emptiness (EE) items were formulated with reference to the presence-of-meaning subscale of the Meaning in Life Questionnaire (Steger et al., 2006); identity insecurity (II) items were formulated with reference to the Self-Concept Clarity Scale (Campbell, et al., 1996); self-esteem (SE) items were adapted from the Rosenberg Self-Esteem Scale (Rosenberg, 1965), with item SE4 reverse-worded and reverse-coded prior to analysis; the compensatory consumption (CC) scale was developed for the purposes of this research on the basis of theoretical and experimental work on compensatory consumer behaviour (Rucker & Galinsky, 2008); (Mandel, Rucker, Levav, & Galinsky, 2017).

A) Existential Emptiness (EE)

Item	Original statement (Croatian)	English translation
EE1	Često imam osjećaj da moj život nema jasan smisao.	I often feel that my life has no clear meaning.
EE2	Ponekad ne vidim svrhu u onome što radim.	Sometimes I do not see the purpose in what I do.
EE3	Nedostaje mi jasna životna usmjerenost.	I lack a clear sense of direction in life.
EE4	Osjećam da moj život nema dublje značenje.	I feel that my life lacks deeper meaning.
EE5	Teško mi je definirati što daje smisao mom životu.	It is difficult for me to define what gives my life meaning.

B) Identity Insecurity (II)

Item	Original statement (Croatian)	English translation
II1	Ponekad imam osjećaj da ne znam tko sam zapravo.	I sometimes feel that I do not really know who I am.
II2	Moje vrijednosti često nisu jasno definirane.	My values are often not clearly defined.
II3	Moja slika o sebi često je nejasna.	My self-image is often unclear.
II4	Osjećam nesigurnost u vezi vlastitog identiteta.	I feel insecure about my own identity.
II5	Moja uvjerenja o sebi često se mijenjaju.	My beliefs about myself often change.

C) Self-Esteem (SE)

Item	Original statement (Croatian)	English translation
SE1	Općenito sam zadovoljan/na sobom.	On the whole, I am satisfied with myself.
SE2	Smatram da imam brojne pozitivne osobine.	I feel that I have a number of good qualities.
SE3	Osjećam da vrijedim jednako kao i drugi ljudi.	I feel that I am worth just as much as other people.
SE4 (R)	Ponekad mislim da nisam dovoljno vrijedan/na. (obrnuto kodirano)	At times I think I am not worthwhile enough. (reverse-coded)
SE5	Imam pozitivan stav prema sebi.	I have a positive attitude toward myself.

D) Compensatory Consumption (CC)

Item	Original statement (Croatian)	English translation
CC1	Kada se osjećam nesigurno, sklon/a sam kupnji proizvoda koji naglašavaju moj status.	When I feel insecure, I am inclined to buy products that emphasise my status.
CC2	Kupnja određenih proizvoda pomaže mi da se osjećam vrijednije.	Buying certain products helps me feel more valuable.
CC3	Ponekad kupujem stvari kako bih nadoknadio/la osjećaj nezadovoljstva sobom.	I sometimes buy things to compensate for feelings of dissatisfaction with myself.
CC4	Važno mi je da proizvodi koje posjedujem odražavaju moju osobnu vrijednost.	It is important to me that the products I own reflect my personal worth.
CC5	Kupnja mi može pomoći da povratim osjećaj kontrole.	Buying can help me regain a sense of control.
CC6	U trenucima nesigurnosti češće razmišljam o kupnji.	In moments of insecurity, I think about buying more often.

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https://doi.org/10.7251/EMC2603921A
UDK: 338.486.1.02:004.738.5(560)
Datum prijema rada: 10. april 2026.
Submission Date: April 10, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 921-945
ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

THE MEDIATING ROLE OF ELECTRONIC WORD-OF-MOUTH (E-WOM) AND E-TRUST IN THE EFFECT OF E-SERVICE QUALITY ON E-SATISFACTION IN THE READY-TO-WEAR SECTOR

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Abstract: *The objective of the current study is to identify the impact of e-service quality and its components on e-satisfaction on e-commerce sites that sell ready-to-wear products online, accounting for the largest share of e-commerce volume in the Turkish economy, and the mediating role of e-WOM and e-trust in this impact. The survey data collected from 755 university students were analyzed using SPSS 31, and mediating effects were tested using the Hayes Process v4.2 macro. The hypothesis that e-service quality has a positive and significant impact on e-satisfaction was accepted, and all three components of e-service quality—process, outcome, and recovery—were found to significantly affect e-satisfaction. Additionally, e-WOM and e-trust were found to have separate and combined mediating roles in the impact of e-service quality on e-satisfaction. The study's limitations include the fact that the sample comprised only university students, the data were collected within a certain time period, and regional differences were not revealed. However, the present study contributes to the literature since limited research has been conducted on the ready-to-wear sector, it evaluates e-service quality holistically, and develops mediation models in the literature.*

Keywords: *e-service quality, e-satisfaction, e-WOM, e-trust*

JEL Classification: *M31, O14*

INTRODUCTION

According to the data from the Ministry of Trade of the Republic of Türkiye, the volume of e-commerce increased by 61.7% in 2024 compared to the previous year, and the clothing, footwear, and accessories sector accounted for the largest share of the e-commerce volume (Ticaret Bakanlığı, 2025).

In the face of the widespread impact of e-commerce, businesses in the sector are promoting their products, advertising, and striving to increase sales on both corporate and e-retail sites.

Corporate websites are mostly used for product and company promotion due to

the costly nature of their continuous development and management, and the absence of an organizational culture that can foresee online sales opportunities (Küster & Vila, 2011)

E-retail websites have enabled businesses to access the global market with relatively low budgets, while also facilitating sales transactions through operational units such as order tracking, packaging, warehousing, shipping, electronic payment processing, and customer relationship management. Furthermore, they provide businesses with strategic advantages in areas such as advertising, brand positioning, customer data analysis, and marketing strategy development (Sezgin, 2013). Along with factors such as circumstances caused by the Covid-19 pandemic (Akyüz, 2014), rapid changes in customer expectations (de Klerk & Tselepis, 2007), and the transformation of lifestyles (Uzel & Aydoğdu, 2010), businesses have increasingly begun to conduct their online sales through e-retail websites.

While sites such as eBay.com, amazon.com, temu.com, and alibaba.com generate profit with thousands of suppliers and millions of customers globally, sites such as trendyol.com, hepsiburada.com, n11.com, sahibinden.com, gittigidiyor.com, and markafoni.com come to the fore in Türkiye. According to data on visitors, popularity, sales volume, and market share, trendyol.com is the largest brand (Semrush, 2025; Ticaret Bakanlığı, 2025). The current study also found that trendyol.com is the most preferred site.

Despite the increased sales volume in e-retailing, many customers face certain obstacles in making ready-to-wear clothing purchases. Dawson and Kim (2010) reported that a customer decides whether to stay on a website within the first 30 seconds after opening it. Eun Young and Park (2008) stated that the rate of online purchases added to the cart but not completed was approximately 65%.

A literature review found few studies on the ready-to-wear sector and no studies on the impacts of perceived e-service quality, e-trust, and e-WOM on e-satisfaction in online shopping.

The present study was conducted to identify the impact of e-service quality and its components on e-satisfaction on e-commerce sites that sell ready-to-wear products online and the mediating role of e-WOM and e-trust in this impact.

The study's limitations include the fact that the sample comprised only university students, the data were collected within a certain time period, and regional differences were not revealed. However, the present study significantly contributes to the literature since limited research has been conducted on the ready-to-wear sector, it evaluates e-service quality holistically, and develops mediation models in the literature.

LITERATURE OVERVIEW

The theoretical framework for the e-service quality, e-satisfaction, e-WOM, and e-trust variables addressed in the study is presented below.

E-Service Quality

E-service refers to a process supported by technological infrastructure, ensuring two-way communication between the customer and the business, solving problems and performing transactions over the network (Çelik & Başaran, 2008; Li & Suomi, 2009).

E-service quality is the totality of features that ensure customers are satisfied with their online shopping experience before, during, and after the purchase (Parasuraman, Zeithaml, & Malhotra, 2005; Wolfinbarger & Gilly, 2003). In other words, e-service quality encompasses a broad range of factors, including ease of website use during online shopping, access to adequate product information, timely receipt of order information, protection of personal data, on-time product delivery, access to support when a problem is encountered, fulfillment of commitments, and customer-oriented return policies (Parasuraman, Zeithaml, & Malhotra, 2005). Therefore, it involves providing a set of components during customers' website visits that will satisfy them (Bressolles, Durrieu, & Senecal, 2014). Customers' evaluations and judgments regarding the delivery and quality of e-services determine e-service quality (Santos, 2003). In traditional service quality, customers usually perform quality evaluations as a result of their interactions with the service provider. However, in evaluating e-service quality, interaction occurs through a website. For this reason, many elements inevitably differ when comparing the components of e-service quality with traditional services.

Due to the widespread use of the internet and the rapidly growing volume of e-commerce, businesses entering this market quickly realized that they could not achieve success over their competitors merely through their products or prices. Measuring customers' perceptions of e-service quality is considered the most important tool for differentiating in the market, ensuring customer satisfaction, creating customer loyalty, and increasing market share and thus profits (Zeithaml, Parasuraman, & Malhotra, 2000).

Many scales in the literature were developed between 2000 and 2015 to measure e-service quality. A review of the early studies shows that they have initially focused on dimensions such as efficiency, reliability, and privacy (Zeithaml, Parasuraman, & Malhotra, 2000), whereas later website-oriented factors such as ease of use, aesthetic design, and information quality have come to the fore (Barnes & Vidgen, 2002; Yoo & Donthu, 2001). Wolfinbarger and Gilly (2003) and Bauer, Falk, and Hammerschmidt (2006) displayed a more holistic approach by adding process management, customer service, trust, and experiential elements to the scales. The E-S-QUAL and E-RecS-QUAL scales, developed by Parasuraman, Zeithaml, and Malhotra (2005), made significant contributions to the literature by examining service delivery and service recovery under separate dimensions. A review of recent studies shows that e-service quality is grouped into three dimensions: system quality, information quality, and service quality (Blut, 2016). Consequently, it can be stated that the scales initially proposed were technically focused, those developed afterward were process-based, and ultimately, there was a shift toward multidimensional and integrated models; however, there is no universally agreed-upon scale for the components of e-service quality. The mentioned difference can be attributed to the fact that studies address different sectors, different countries, and different consumption habits.

A review of studies conducted after 2015 demonstrates that no novel scale has been developed, and mostly updates or adaptations have been performed in mobile commerce, social commerce, and e-logistics (Blut, 2016; Erdoğan, 2022a; Erdoğmuş, Dirsehan, & Karakaya, 2017; Hassan, 2024).

Table 1 lists the research on e-service quality in the ready-to-wear sector and the studied variables.

Table 1. Research on Measuring E-Service Quality Perception in the Ready-to-Wear Sector

Years	Author(s)	Dependent Variables Studied
2004	Kim & Stoel	The impact of website quality on customer satisfaction
2008	Park & Kim	The impact of consumer characteristics on website quality, satisfaction, and purchase behavior
2009	Kim & Jackson	The impact of the e-SERVQUAL scale on e-service quality perception
2009	Kim & Niehm	The impact of website quality on perceived information quality, perceived value, and loyalty intentions
2010	Jones & Kim	Influences of retail brand trust, offline patronage, clothing involvement, and website quality on online apparel shopping intention
2015	Noorshella & Abdullah &, Nursalihah,	The effect of perceived risk and e-trust on consumers' online purchase intention in e-commerce
2019	Noor et al.	The impact of product quality and e-service quality attributes on customer satisfaction in online apparel purchases
2022a	Erdoğan	The impact of the e-service quality scale on perceived e-service quality in online apparel sites
2022b	Erdoğan	The impact of electronic service quality on loyalty (in clothing stores)
2022	Mahadevan & Joshi	The impact of e-service quality dimensions on customer satisfaction and the mediating role of customer loyalty
2024	Ramdani & Saad	The impact of e-service quality dimensions on customer satisfaction
2024	Bansal & Sharma	The impact of website quality dimensions on customer satisfaction
2024	Manandhar et al.,	The impact of service quality dimensions on customer satisfaction

Source: Developed by the author

A review of the studies in Table 1 demonstartes that the E-SERVQUAL and E-S-QUAL are the most commonly used scales, that the studies have mostly focused on measuring dimensions such as performance, security, information quality, usability, visual design, personalization, and response speed of e-services offered via mobile platforms or websites, and that the relationships between e-service quality and dependent variables such as customer satisfaction, repeat purchase intention, loyalty, and e WOM (word-of-mouth communication) have been usually investigated.

E-Satisfaction

E-satisfaction refers to the positive intuition, positive emotion, and emotional response that customers give regarding their online shopping experience before, during, and after purchasing on online shopping sites (Bozbay, Yaman, & Özkan, 2016; Malakmadze, Ünver, & Arıkan, 2017; Zhao, Lynch, & Chen, 2010). In other words, e-satisfaction expresses a consumer's satisfaction or dissatisfaction with the overall experience resulting from all interactions with online sellers throughout the process, including the search for, purchase of, and use of a product or service (Park, Bhatnagar, & Rao, 2010). Customers can be considered satisfied with their purchases if the benefits they receive from these platforms are equal to or exceed their expectations (Bayram & Şahbaz, 2017; Kaya et al., 2019; Sevim, 2018). Hence, these customers are more likely to make repeat e-purchases from online stores. A study found that 80% of customers satisfied with online shopping re-purchased within two months, and 90% recommended the e-store they shopped at to others (Cheung & Lee, 2004; Ke-

ment & Çavuşoğlu, 2017). Consequently, customer satisfaction plays an essential role in decision-making and repeat purchase behavior in online shopping (Gupta & Kim, 2010; Pappas et al., 2014).

Khalifa and Liu (2007) indicated that e-satisfaction consists of three stages: pre-purchase, purchase, and post-purchase. The pre-purchase stage covers activities carried out before placing an order, such as product search and product comparison. The purchase stage is related to the ordering and payment processes. Finally, the post-purchase stage encompasses online experiences such as customer support, returns, refunds, and online installation guides.

Parasuraman, Zeithaml, & Berry (1988) reported that service quality is a fundamental condition of customer satisfaction. Studies in the literature have reported that perceived service quality increases customer satisfaction (Akıskalı & Kitapçı, 2021; Akmal, Panjaitan, & Ginting, 2023; Erçetin & Arıkan, 2020; Özdemir & Çataltepe, 2022; Uysal, 2022; Yıldız & Kuyucu, 2021).

Based on the aforesaid studies, the following hypotheses were developed within the scope of the current study.

H1: *E-service quality has a positive and significant impact on e-satisfaction.*

$H1_a$: *The sub-components of the e-service quality process component have a positive and significant impact on e-satisfaction.*

$H1_b$: *The sub-components of the e-service quality outcome component have a positive and significant impact on e-satisfaction.*

$H1_c$: *The sub-components of the e-service quality recovery component have a positive and significant impact on e-satisfaction.*

H2: *The components of e-service quality together have a positive and significant effect on e-satisfaction.*

E-WOM

The degree to which the e-service offered to customers fulfills their expectations is positively associated with a higher level of perceived service quality. E-WOM (electronic word-of-mouth) is one of the most significant factors that impact customer expectations (Alnıaçık & Özbek, 2009). E-WOM expresses positive or negative comments from former, current, or potential customers about a product or business in online shopping (Hennig-Thurau, 2004). The benefits of e-WOM that can be listed as providing customers with access to reliable information they need, especially in decision-making processes, or creating a space where customers can share their experiences (Cantallops & Salvi, 2014; Joshi & Singh, 2017), enabling easy and quick access to information for everyone (Alboqami et al., 2015; Daugherty & Hoffman, 2014), decreasing information search costs (Erşen, Karabıyık Yerden, & Öztek, 2020), and increasing trust in reviews made by many people, thereby eliminating uncertainties about the business or product and successfully persuading potential customers (Mishra & Satish, 2016; Park, 2020; Zhang, Craciun, & Shin, 2010) have increased its importance in marketing literature.

Social media, discussion forums, shopping sites, blogs, and consumer review sites are reported to be the most suitable platforms for e-WOM (Akgün, 2019; Khwaja, Mahmood, & Zaman, 2020; Santosa & Wandebori, 2019). Customers can either contribute to businesses through their comments on these platforms or harm them.

This situation, called negative e-WOM, is an issue that should be prevented as much as possible since it damages business reputation and brand image (Kutlu & Ayyıldız, 2017) and adversely impacts customers' purchasing intentions (Gildin, 2022).

In a 1998 study, Anderson reported that the influence of a satisfied customer in word-of-mouth communication was 30%, whereas that of a dissatisfied customer was 70%. According to another study, 90% of customers trust people they know, while 70% trust online customer reviews (Kotler & Armstrong, 2018; Wolny & Mueller, 2013). Consequently, as also stated by Cheung and Lee (2012), e-WOM is more effective than traditional "WOM" because of its speed, permanence, reliability, accessibility, and measurability.

Some studies have investigated the impact of e-service quality on satisfaction and stated that e-WOM is an effective mediator variable (Hassan, 2024; Gounaris, Vassilikopoulou, & Chatzipanagiotou, 2010; Park & Kim, 2008). Hypothesis H3 below was developed accordingly.

H3: *E-WOM mediates the effect of e-service quality on e-satisfaction.*

E-Trust

E-trust represents customers' beliefs that a website, e-commerce platform, or e-seller they shop online from is ethical (Kim, Ferrin, & Rao, 2008; Pavlou & Fygenson, 2006).

Gefen, Benbasat, and Pavlou (2008) indicated that trust was an important concept for all customers. Customers' inability to contact sellers and products directly, the perceived risk in elements such as site reliability, payment security, confidentiality of personal information, and accuracy of the information provided, influence their satisfaction or purchase decisions (Gefen, Karahanna, & Straub, 2003; Kim, Ferrin, & Rao, 2008). Research has demonstrated that customers who feel trust have higher levels of satisfaction with the online shopping process (Chiou, 2004; Sevim, 2018; Pappas et al., 2014; Yıldız & Karadirek, 2014).

The above-mentioned satisfaction strengthens their loyalty to the online platform and their repurchase intentions (Kim & Niehm, 2009; Noorshella, Abdullah, & Nursalihah, 2015; Park & Kim, 2008). In this regard, e-trust is a necessary element for customer retention and a critical instrument for e-commerce sites to gain a competitive advantage and ensure their sustainable success. Hypotheses H4 and H5 were developed based on the importance of e-trust in practice and theory.

H4: *E-trust mediates the impact of e-service quality on e-satisfaction.*

H5: *E-WOM and e-trust play a joint mediating role in the impact of e-service quality on e-satisfaction.*

The present study also investigated whether the impact of e-service quality on e-satisfaction differed by consumers' demographic characteristics. The hypotheses below were formulated within this framework.

H6: *The impact of e-service quality on e-satisfaction differs by consumers' demographic characteristics.*

$H6_a$: *The impact of e-service quality on e-satisfaction differs by consumers' gender.*

$H6_b$: *The impact of e-service quality on e-satisfaction differs by consumers' age group.*

H6$_c$: *The impact of e-service quality on e-satisfaction differs by consumers' education level.*

METHODOLOGY

The current section describes the study's purpose and significance, main population and sample, method, and limitations.

Purpose and Significance of the Study

The purpose of the current study is to identify the impact of e-service quality and its components on e-satisfaction on e-commerce sites that sell ready-to-wear products online, accounting for the largest share of e-commerce volume in the Turkish economy, and the mediating role of e-WOM and e-trust in this impact.

Accordingly, we developed a model based on studies in the literature and applied this model particularly to young consumers, constituting a considerable proportion of the population.

A review of studies in the relevant literature shows that the relationships between two or three variables affecting purchase behavior in e-commerce have been mostly researched. The current study is important in that it presents a conceptual model with the addressed variables. Furthermore, very few studies have been conducted in the national and international literature on the ready-to-wear sector. It is thought that this study will contribute to the literature and practice, considering the increasing share of the ready-to-wear sector in the economy.

Conceptual Model of the Research

Figure 1 displays the conceptual model of the research.

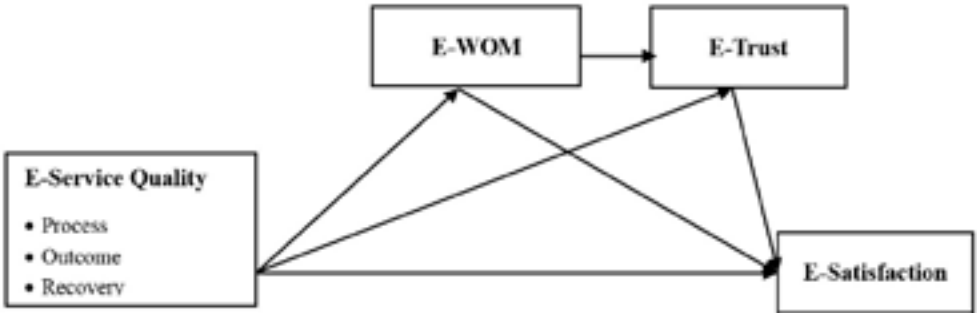

Figure 1. Research Model

Source: Developed by the author

The scales related to the variables included in the research model are given below:

E-Service Quality **:** (Collier & Bienstock, 2006)
E-Satisfaction **:** (Anderson & Srinivasan, 2003) (McKinney, Yoon, & Zahedi, 2002)
E-WOM **:** (Goyette et al., 2010)
E-Trust **:** (Kim, Ferrin, & Rao, 2008) (Kim, Jin, & Swinney, 2009)

Although numerous scales have been developed in the literature to measure e-service quality, this study employed the scale of Collier and Bienstock (2006). Collier and Bienstock (2006) addressed e-service quality within the framework of three components: process quality, outcome quality, and recovery quality. The sub-dimensions of process quality were expressed as ease of use, privacy, design, information accuracy, and functionality; the sub-dimensions of outcome quality included order condition, timeliness, and order accuracy; finally, the sub-dimensions of recovery quality included interactive fairness, outcome fairness, and procedural fairness.

Collier and Bienstock (2006) stand out with the e-Service Quality Scale, which they developed, which focuses on the service process, outcome quality, and recovery mechanisms in case of errors. In this respect, it is a holistic scale covering all aspects of the e-commerce experience, not just front-end features such as information quality, design, or usability of web pages.

The e-WOM scale used in the study consists of the sub-dimensions of WOM Intensity, Positive WOM, Negative WOM, and WOM Content.

Research Population and Sample

The research population comprises 44.092 students enrolled in the regular and evening programs of Muğla Sıtkı Koçman University who purchase ready-to-wear clothing online (https://www.mu.edu.tr).

When the number of individuals in the research population is known, the formula below is used to calculate the sample size representative of the population:

Formula 1. Sample Size Calculation Formula for a Known Population

$$n = \frac{N.t^2.p.q}{d^2.(N-1) + t^2.p.q}$$

N = Population size.
p = Frequency of occurrence of the event under investigation.
q = Frequency of non-occurrence of the event under investigation (1 - p).
t = Distribution value in the table for the confidence level.
d = Sampling error accepted according to the frequency of occurrence of the event.
n= Number of individuals to be selected for the sample.

Source: Krejcie & Morgan, 1970

The population size on which the research was conducted (N) was 44,092 individuals. Assuming that the population was not homogeneous, p=0.50 and q=0.50 were taken, and the d-value in the formula was taken as 0.05. At the alpha=0.05 level of significance, the theoretical t-value was taken as 1.96 and used accordingly. The values were substituted into the formula, and it was determined that the sample group, representative of the population of 44.092 individuals, consisted of approximately 381 individuals.

The target audience for the sample was selected from students at Yatağan Vocational School and the Faculty of Science using convenience sampling due to accessibility, and the surveys were administered face-to-face.

Research Method and Limitations

In the current study, face-to-face surveys were administered to 1000 students as the data collection method. After incomplete and erroneous surveys were eliminated, 755 usable surveys were identified. The first section of the survey included three demographic questions for customers (gender, age, and education level). This section also included an open-ended question about which e-commerce site customers most frequently used when purchasing ready-to-wear clothing online. The second section of the survey included 54 questions about e-service quality, 19 questions about e-WOM, 5 questions about e-satisfaction, and, finally, 3 questions about e-trust. A 5-point Likert scale (1: Strongly Disagree, 5: Strongly Agree) was employed for the questions about these variables. Questions about the negative e-WOM dimension were coded as 1: Strongly Agree, 5: Strongly Disagree. Consequently, the survey contained 85 questions, including demographic variables. Research analyses were conducted using SPSS 31, and mediation effects were determined using the Hayes Process v4.2 macro.

Ethics committee approval (Decision No: 55) was obtained from the relevant university before the implementation stage of the research began. The research was performed between February and March 2026. The most important limitation of the study is that it was conducted with students from a single university in Türkiye. Seven hundred fifty-five individuals participated in the study, and Table 2 contains their descriptive information. Of the respondents, 69.5% were female, and 89.1% were under 24 years of age. The majority of participants (98.4%) were associate and undergraduate students. Table 3 displays the distribution of the e-commerce sites most frequently used by respondents. Trendyol is the most frequently used shopping site (82.9%).

Table 2. Descriptive Information

	n	%
Gender		
Female	525	69.5
Male	230	30.5
Total	755	100.0
Age Groups		
≤24	673	89.1
25 - 40	59	7.9
41 - 56	23	3.0
Total	755	100.0
Education Level		
Associate's and Bachelor's Degree	743	98.4
Graduate	12	1.6
Total	755	100.0

Table 3. Most Used E-Commerce Sites

E-Commerce Sites	n	%
Trendyol	626	82.9
Zara	18	2.4
Hepsiburada	16	2.1
Amazon	11	1.5
Other	84	11.1
Total	755	100.0

Source: Created by the author

Exploratory Factor Analysis (EFA) was conducted to evaluate the construct validity of the e-service quality scale. A minimum factor loading of 0.50 was used as the threshold criterion for determining whether an item adequately represented its corresponding factor. Factor loading indicates the strength of the relationship between an observed variable and its underlying factor, with higher factor loadings indicating a stronger association between the item and the factor (Hair, Black, Babin, & Anderson, 2019). Accordingly, four items with factor loadings below 0.50 were eliminated due to their insufficient representation of the underlying factor. In addition, one item that loaded on a different factor than its theoretically designated dimension was excluded to preserve the conceptual distinctiveness and interpretability of the factor structure. Following the removal of these items, the EFA was re-administered, resulting in the final factor structure. The factor loadings of all remaining items exceeded the established threshold, indicating that the items adequately represented their respective factors.

The E-Service Quality variable comprises three main components: Process, Outcome, and Recovery. Since the said components also have sub-components, the analysis was conducted separately for each component. According to the results of the exploratory factor analysis for the Process component, the necessary conditions were fulfilled since the KMO value was 0.876, indicating the adequacy of the sample size, and the chi-squared significance value of Bartlett's test of sphericity was at the 1% level, indicating the suitability of the distribution to a multivariate normal distribution. Table 4 shows the five-factor structure. The total explained variance was 54.717%. One question item was removed from the structure since it was included in another factor, and four question items were removed since they had factor loadings below 0.50. The factors were as follows:

F1: Information Accuracy
F2: Functionality
F3: Privacy
F4: Ease of Use
F5: Design

Table 4: Exploratory Factor Analysis Results for the Process Component

	Factors				
	1	**2**	**3**	**4**	**5**
SPrEoU1				.637	
SPrEoU2				.518	
SPrEoU3				.553	
SPrEoU4				.709	
SPrEoU5				.567	
SPrPriv6			.776		
SPrPriv7			.582		
SPrPriv8			.868		
SPrPriv9			.812		
SPrDes10					.783
SPrDes11					.812
SPrDes12					.534
SPrIA16	.768				
SPrIA17	.517				
SPrIA18	.795				
SPrIA19	.712				
SPrFun21		.717			
SPrFun22		.722			
SPrFun23		.555			
SPrFun24		.506			

Source: Created by the author

According to the results of the exploratory factor analysis for the Outcome component, the necessary conditions were met because the KMO value, indicating the adequacy of the sample, was 0.707, and the chi-squared significance value of Bartlett's test of sphericity, showing the suitability of the distribution to a multivariate normal distribution, was at the 1% level. Table 5 displays the three-factor structure. The three factors explained 62.638% of the total variance. One question item was removed from the structure since its factor loading was below 0.50, and the factors were as follows:

F1: Order Condition

F2: Order Accuracy

F3: Timeliness

Table 5: Exploratory Factor Analysis Results for the Outcome Component

	Factors		
	1	**2**	**3**
SOOC26	.804		
SOOC27	.820		
SOTime29			.797
SOTime30			.807
SOTime31			.659
SOOA32		.894	

SOOA33	.878
SOOA34	.187

Source: Created by the author

In accordance with the results of the exploratory factor analysis for the Recovery component, the necessary conditions were fulfilled because the KMO value, showing the adequacy of the sample size, was 0.944 and the chi-squared significance value of Bartlett's test of sphericity, indicating the distribution's suitability to a multivariate normal distribution, was at the 1% level. Table 6 shows the three-factor structure. The three factors explained 54.097% of the total variance. Since the factor loading of one question item was below 0.50, it was removed from the structure, and the factors were as follows:

F1: Interactive Fairness
F2: Procedural Fairness
F3: Outcome Fairness

Table 6. Exploratory Factor Analysis Results for the Recovery Component

	Factors		
	1	2	3
SRecInter36	.710		
SRecInter37	.707		
SRecInter38	.547		
SRecInter39	.679		
SRecInter40	.654		
SRecInter41	.579		
SRecInter42	.599		
SRecInter43	.599		
SRecInter44			.659
SRecOut45			.640
SRecOut46			.778
SRecOut47			.600
SRecOut48			.582
SRecProc49		.635	
SRecProc50		.699	
SRecProc51		.671	
SRecProc52		.700	
SRecProc53		.665	
SRecProc54		.628	

Source: Created by the author

The e-WOM variable comprises four components, and Table 7 lists the results of the exploratory factor analysis for these components. The conditions were fulfilled because the KMO value was 0.899 and the chi-squared value of Bartlett's test of sphericity was at the significance level of 1%. In the resulting four-component structure, the factors explained 67.158% of the total variance. One question item was removed from

the structure because it was included in another factor, and the resulting factors were named in the following way:

F1: WOM Content
F2: Positive WOM
F3: Negative WOM
F4: WOM Intensity

Table 7: Exploratory Factor Analysis Results for the e-WOM Variable

	Factors			
	1	**2**	**3**	**4**
eWInt55				.873
eWInt56				.875
eWPos58		.799		
eWPos59		.803		
eWPos60		.731		
eWPos61		.751		
eWPos62		.710		
eWPos63		.604		
eWNeg64			.900	
eWNeg65			.887	
eWCon66	.707			
eWCon67	.775			
eWCon68	.795			
eWCon69	.833			
eWCon70	.813			
eWCon71	.782			
eWCon72	.721			
eWCon73	.689			

Source: Created by the author

Table 8 contains the results of the reliability analysis for the model variables. The reliability analysis for the conceptual model variables was conducted with Cronbach's alpha, and in the analysis performed on a component and variable basis, SPrDes12 and SOOA34 were removed from the scale structure to increase the reliability coefficient above 0.70.

Table 8. Reliability Analysis Results for the Conceptual Model Variables

Variables	**Number of Questions**	**Cronbach's Alpha**
E-SERVICE	**44**	**.928**
Process	**19**	**.845**
Information Accuracy	4	.744
Functionality	4	.679
Privacy	4	.826
Ease of Use	5	.663

Design	2	.741
Outcome	**7**	**.692**
Order Condition	2	.672
Order Accuracy	2	.813
Timeliness	3	.676
Recovery	**18**	**.917**
Interactive Fairness	8	.859
Procedural Fairness	6	.843
Outcome Fairness	4	.781
E-WOM	**18**	**.906**
Content	8	.920
Positive	6	.884
Negative	2	.793
Intensity	2	.784
E-TRUST	3	.795
E-SATISFACTION	5	.866

Source: Created by the author

EMPIRICAL EVIDENCE

Simple regression analysis tested the impact of e-service quality on e-satisfaction. The correlation coefficient (R=0.537), indicating the relationship between the two variables, revealed a moderate correlation, whereas the coefficient of determination (R2) demonstrated that e-service quality explained 28.8% of the variance in the e-satisfaction variable. In line with the results in Table 9, the impact was positive and significant, and the regression coefficient and the level of significance are given in Table 10. Hypothesis H1 was supported according to these results. This finding indicates that as consumers' perception of service quality experienced on an e-commerce platform increases, their overall level of satisfaction with the platform also increases.

Table 9. ANOVA Result for the Impact of E-Service Quality on E-Satisfaction

Model	Sum of Squares	sd	Mean Squares	F	p
Regression	90.724	1	90.724	304.486	<.001
Residual	224.362	753	.298		
Total	315.086	754			

Source: Created by the author

Table 10. Coefficients for the Impact of E-Service Quality on E-Satisfaction

	Non-Standardized Coefficients		Standardized Coefficients		
Model	**B**	**Standard Error**	**Beta**	**t**	**p**
Constant	1.175	.167		7.032	<.001
SQUAL	.753	.043	.537	17.450	<.001

SQUAL: E-Service Quality
Source: Created by the author

Multiple regression analysis tested the impacts of the e-service quality components on e-satisfaction. The multiple correlation coefficient (0.581) between the components and e-satisfaction indicates a moderate correlation, whereas the adjusted coefficient of determination shows that the three components jointly explained 33.5% of the variance in e-satisfaction. As seen in Table 11, the model was significant, and hypothesis H2 was supported. A review of the regression coefficients in Table 12 shows that the Outcome component has a level of significance above 5%. In other words, the combined effect of the three components is significant. However, the components that play a strong role in the impact at the 5% level are Process and Recovery. This scientifically demonstrates that consumer satisfaction perception in the digital ready-to-wear sector is not limited to the ultimate service outcome alone; rather, seamless user experience provided throughout the interaction with the platform, combined with recovery mechanisms activated during potential service failures, collectively shape customer satisfaction.

Table 11. ANOVA Results for the Impact of E-Service Quality Components on E-Satisfaction

Model	Sum of Squares	sd	Mean Squares	F	p
Regression	106.298	3	35.433	127.450	<.001
Residual	208.788	751	.298		
Total	315.086	754			

Source: Created by the author

Table 12. Coefficients for the Impact of E-Service Quality Components on E-Satisfaction

	Non-Standardized Coefficients		Standardized Coefficients		
Model	**B**	**Standard Error**	**Beta**	**t**	**p**
Constant	1.193	.167		7.121	<.001
SPr	.178	.052	.133	3.400	<.001
SO	.028	.039	.026	.724	<.469
SRec	.537	.045	.474	11.890	<.001

SPR: Process, SO: Outcome, SRec: Recovery
Source: Created by the author

The mediating role of e-WOM in the impact of e-service quality on e-satisfaction was tested using Process Hayes 4.2. As seen in Table 13, the mentioned impact was supported. In the analysis using the bootstrapping method, since there was no 0 between the BootLLCI and BootULCI values in the results indicating the indirect effect, the mediating role was accepted, and hypothesis H3 was supported. In the context of the online ready-to-wear sector, this result demonstrates that perceived e-service quality not only directly influences e-satisfaction, but also indirectly reinforces the e-satisfaction mechanism through positive reviews, ratings, and recommendations shared by users who experience superior service quality on the platform.

Table 13. Analysis Results for the Mediating Role of E-WOM in the Impact of E-Service Quality on E-Satisfaction

Model: 4					
Y: ESATIS					
X: SQUAL					
M: EWOM					
Sample size: 755					
Direct effect:					
Effect	se	t	p	LLCI	ULCI
.5927	.0473	12.5257	.0000	.4998	.6856
Indirect effect:					
	Effect	BootSE	BootLLCI	BootULCI	
EWOM	.1603	.0317	.1031	.2256	

ESATIS: E-Satisfaction, SQUAL: E-Service Quality, EWOM: E-WOM
Source: Created by the author

Likewise, the mediating role of e-trust in the impact of e-service quality on e-satisfaction was tested using Process Hayes 4.2. Table 14 shows that the effect in question was supported. Hypothesis H4 was supported according to the result above. When evaluated in the context of the online ready-to-wear sector, this finding reveals that perceived high e-service quality not only directly increases e-satisfaction, but also indirectly reinforces satisfaction through the sense of digital trust it builds in consumers. In other words, it can be stated that e-retailers can enhance customer satisfaction not merely by improving service processes, but also by incorporating elements that foster e-trust, such as SSL certificates, transparent privacy policies, secure payment infrastructures, and accurate product information.

The joint mediating roles of e-WOM and e-trust, whose mediating roles in the impact of e-service quality on e-satisfaction were tested separately, were tested using Process Hayes 4.2. Table 15 presents the results obtained. The mediating roles of both variables were confirmed upon examining the results concerning indirect effects. Hypothesis H5 was supported in line with this result. This result reveals that in the online ready-to-wear sector, e-service quality indirectly feeds e-satisfaction through the variables of e-WOM and e-trust. In other words, the accepted H5 hypothesis implies that both establishing e-trust by offering a transparent and secure platform infrastructure and encouraging e-WOM mechanisms where satisfied customers share their experiences accelerate the transformation of service quality into e-satisfaction.

Table 14. Analysis Results for the Mediating Role of E-Trust in the Impact of E-Service Quality on E-Satisfaction

Model: 4
Y: ESATIS
X: SQUAL
M: ETRUST

Sample size: 755					
Direct effect:					
Effect	se	t	p	LLCI	ULCI
.4622	.0462	10.0145	.0000	.3716	.5528
Indirect effect:					
	Effect	BootSE	BootLLCI	BootULCI	
ETRUST	.2908	.0338	.2251	.3573	

ESATIS: E-Satisfaction, SQUAL: E-Service Quality, EWOM: E-WOM
Source: Created by the author

Table 15. Analysis Results for the Joint Mediating Role of E-WOM and E-Trust in the Impact of E-Service Quality on E-Satisfaction

Model:6					
Y: ESATIS					
X: SQUAL					
M1: EWOM M2:ETRUST					
Sample size: 755					
Direct effect:					
Effect	se	t	p	LLCI	ULCI
.3834	.0481	7.9777	.0000	.2890	.4777
Indirect effect:					
	Effect	BootSE	BootLLCI	BootULCI	
Total	.3696	.0415	.2916	.4541	
Ind1	.1069	.0278	.0555	.1639	
Ind2	.2093	.0289	.1552	.2687	
Ind3	.0534	.0132	.0297	.0809	
Ind1: SQUAL → EWOM → ESATIS Ind2: SQUAL → ETRUST → ESATIS Ind3: SQUAL → EWOM → ETRUST → ESATIS					

ESATIS: E-Satisfaction, SQUAL: E-Service Quality, EWOM: E-WOM, ETRUST: E-Trust
Source: Created by the author

Simple regression analysis was conducted to test the main hypothesis, which posits that the impact of e-service quality on e-satisfaction varies by respondents' demographic characteristics, and the results are presented in Table 16. The difference between the regression coefficients obtained by gender was computed, considering the standard errors, as suggested by Paternoster et al. (1998). Considering the criterion of Z=±1.96 at the 5% significance level, and since Z = -0.655 was obtained, the difference between the two regression coefficients was not statistically significant at the 5% significance level. In other words, the impact of e-service quality on e-satisfaction does not differ by gender. Thus, hypothesis H6a was not supported.

An examination of the test for differences in the effect across age groups showed that the difference between the regression coefficients of the group aged 24 years and

below and the 25–40 age group was significant (Z = -3.536), as was the difference between the group aged 24 years and below and the 41-56 age group (Z = -2.028) at the 5% significance level. However, for the difference between the regression coefficients of the 25-40 age group and the 41-56 age group, the value of Z = 0.592 indicated that the difference was not statistically significant. Hence, hypothesis H6b was supported.

It was examined whether the effect differed by respondents' education level, and the results in Table 16 showed that the effect was not statistically significant at the 5% significance level among graduate students. However, the effect was statistically significant among associate and undergraduate students, indicating a difference between these two groups, and hypothesis H6c was accepted.

In conclusion, based on the analyses conducted to determine whether the effect of e-service quality on e-satisfaction differs according to consumers' demographic characteristics, it can be stated that the impact of e-service quality on e-satisfaction remains at a similar level between female and male consumers, indicating that gender is not a discriminating factor in the digital ready-to-wear sector; that the importance attached to e-service quality by young consumers (aged 24 and under) differs significantly compared to older age groups; and that as the education level increases, consumers' expectation levels regarding e-service quality change accordingly.

Table 16. Results of the Gender Difference Test for the Impact of E-Service Quality on E-Satisfaction

Gender	F	p	Regression Coefficient	p	SE
Female	218.812	<.001	0.735	<.001	0.050
Male	90.431	<.001	0.799	<.001	0.084
Age Groups					
≤ 24	224.201	<.001	0.695	<.001	0.046
25-40	83.439	<.001	1.176	<.001	0.129
41-56	38.721	<.001	0.126	<.001	0.169
Education Level					
Associate's and Bachelor's Degree	299.127	<.001	0.753	<.001	0.044
Graduate	4.414	0.062	0.756	0.062	0.360

Source: Created by the author

RESULTS AND DISCUSSION

As a result of the current study, the hypothesis stating that e-service quality has a positive and significant impact on e-satisfaction was accepted. Furthermore, it can be said that studies conducted in the ready-to-wear sector in the literature have yielded similar results (Bansal & Sharma, 2024; Erdoğan, 2022a; Erdoğan, 2022b; Manandhar et al., 2024).

All three components of e-service quality—process, outcome, and recovery—had a significant effect on e-satisfaction, and this impact was mainly observed in the sub-dimensions of order accuracy and timeliness, and procedural fairness and outcome fairness. Hence, the effect was significant in the three-component model, with the process and recovery components having weight in the impact. The said finding is simi-

lar to other studies in the literature. In their study on the online ready-to-wear sector, Bansal and Sharma (2024) found that the information and system quality dimensions created stronger effects on e-satisfaction. Erdoğan (2022a; 2022b) determined that the reliability and system performance dimensions were especially decisive among the e-service quality dimensions. Additionally, Manandhar et al. (2024) revealed that the reliability and responsiveness dimensions of e-service quality had a weighted impact. Hence, the weighted impact of the process and recovery components revealed in the current research coincides with the dimensions stressed in the literature, such as service effectiveness, reliability, and system quality. In other words, all components of e-service quality have a significant effect on e-satisfaction; however, some dimensions have more weighted impacts.

However, previous research has focused more on system-based dimensions of e-service quality, such as technical aspects, ease of use, and reliability. However, the fact that the recovery component, covering the procedural and outcome fairness dimensions, came to the fore in the present study demonstrates that customers attach great importance not only to the service delivery process but also to problem-solving processes. Additionally, most studies in the literature have mentioned the weighted impact of a single quality dimension. On the contrary, the fact that the process and recovery components came to the fore together in this study indicates that e-service quality should be assessed holistically. It can be said that our study contributes to the literature in this respect.

Another finding of the current research is that e-WOM and e-trust play separate and joined mediating roles in the impact of e-service quality on e-satisfaction. Studies in the literature have obtained similar results (Bansal & Sharma, 2024; Erdoğan, 2022a; Erdoğan, 2022b; Mahadevan & Joshi, 2022; Noor et al., 2019; Noorshella, Abdullah, & Nursalihah, 2015; Ramdani & Saad, 2024; Manandhar et al., 2024).

However, previous studies have addressed e-trust as a mediator variable alone. The present study included e-trust in the model along with e-WOM, and the research hypotheses were accepted. Therefore, customers' satisfaction with online shopping is formed by trust and sharing their experiences in online environments. This once again demonstrates the need to address e-service quality as a multidimensional construct, and the study also contributes to the literature by developing mediation models.

The results of the present study were obtained from data collected from 755 university students. The fact that the sample comprised solely students limits the generalization of the findings to different age groups and consumer segments. Moreover, having collected the research data within a specific time period prevents the observation of changes over time. Finally, this study does not reveal cultural or regional differences since it was limited to a single university. Although it is impossible to generalize the data due to the aforesaid limitations, the following recommendations can be made for practice based on the research results:

- Based on the weight of the process and recovery components in the impact of e-service quality on satisfaction, businesses should prioritize issues such as order accuracy, facilitating return and exchange processes, implementing compensation mechanisms effectively, timely delivery, and resolving customer complaints in a quick and fair manner,
- Based on the mediating role of e-trust, businesses should focus on strate-

gies that will create and increase trust, use secure payment systems, protect personal data, share accurate and complete information about products and services, and build brand trust,
- Based on the mediating role of e-WOM, businesses should develop systems encouraging customers to make comments, respond quickly to user reviews, increase the visibility of positive experiences, and address negative comments constructively.

For future academic research, the following can be recommended:
- The findings should be compared by applying the model used in the current research to different sectors and countries,
- Diverse variables, such as e-loyalty, perceived value, brand image, customer experience, and complaint management, should be included in the model,
- The model employed in the study should be tested using qualitative or mixed methods,
- The model should be tested or compared using different scales for e-service quality (E-S-QUAL or eTailQ).

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https://doi.org/10.7251/EMC2603946C
UDK: 316.77:27-23/-27]:929 Rupnik M.
Datum prijema rada: 28. april 2026.
Submission Date: April 28, 2026
Datum prihvatanja rada: 7. septembar 2026.
Acceptance Date: September 7, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 946-961

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

WHEN CANCEL CULTURE ENTERS THE CHURCH: INSTITUTIONAL RESPONSE TO THE RUPNIK AND CENTRO ALETTI CASE

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***Abstract**: This article examines how discourses of cancel culture emerged and developed around the case of Marko Rupnik, a Jesuit priest and artist against whom multiple women have filed allegations of abuse spanning several decades, and how calls for the removal or preservation of his artworks extended cancel culture logic beyond the individual to the symbolic objects and spaces associated with him, with particular attention to Centro Aletti, the Catholic artistic centre he founded in Rome in 1991. Drawing on a document analysis of selected media reports and ecclesial documents, the study addresses the following research question: in what ways does the Rupnik affair illustrate how cancel culture operates at both individual and institutional levels within a religious context? The analysis yields three principal findings. First, the cancel culture framing was a discursive strategy introduced by Centro Aletti itself as a defensive communicative response to mounting public pressure. Second, cancel culture logic produced a ripple effect of accountability demands that extended from the individual to the symbolic objects associated with him, generating a spectrum of institutional responses. Third, religious institutional contexts generate specific forms of resistance to cancellation dynamics, grounded in canonical procedure, theological authority, and the spiritual function of sacred art, that distinguish them from secular corporate contexts. The article contributes to the emerging literature on cancel culture by extending its analytical scope to religious institutional communication.*

***Keywords**: Cancel Culture, Marko Ivan Rupnik, Centro Aletti, reputational sanctioning, media discourse*

***JEL classification:** D83, L82, Z12*

INTRODUCTION

In contemporary media environment, public figures, brands, and institutions operate within dense reputational economies in which their perceived credibility and moral acceptability directly shape access to attention, resources, and support (Bromley, 1993; Fombrun & Van Riel, 1997). Practices such as cancel culture intervene in these reputational economies by mobilizing publics to withdraw symbolic and economic support from targeted individuals and institutions, thereby reshaping who is seen as legitimate in the marketplace and public sphere (Dias et al., 2022; Norris, 2023). In some cases, such dynamics do not remain confined to primary targets: when a transgressor is embedded within an institutional network, cancel culture logic extends to affiliated organisations, cultural spaces, and bodies perceived as complicit in, or insufficiently distanced from, the original transgression. Religious organizations are not exempt from these dynamics, as their authority likewise depends on public perceptions of moral integrity and institutional trustworthiness (Casanova, 1994; Demerath & Williams, 1992). The Catholic Church's reputation has been significantly compromised by intensifying media coverage of sexual abuse scandals, resulting in disillusionment among its adherents and diminished conversion rates (Navas, 2026). The scandal surrounding abuse allegations against Jesuit priest and artist Marko Rupnik has raised questions not only about individual responsibility, but also about the credibility of the Catholic Church and affiliated institutions that protected him or continued to display his work, making it a paradigmatic case for analysing how cancel culture operates across both individual and institutional levels in a religious field. Building on this, the aim of the article is to examine how discourses of cancel culture emerge and develop around the Rupnik case, and how calls for the removal, preservation, or reinterpretation of his artworks extend cancel culture logic beyond the individual to the symbolic objects and spaces associated with him, with particular attention to Centro Aletti, a Catholic cultural and artistic centre he founded in Rome in 1991 (Drozdziak, 2024).

The research problem addressed in this paper can be formulated as follows: in what ways does the Rupnik affair illustrate how cancel culture operates at both individual and institutional levels within a religious context? To investigate this, the study conducts a document analysis of selected media reports and ecclesial documents related to the Rupnik and Centro Aletti controversy. In doing so, the article contributes to the emerging literature on cancel culture by extending its analytical scope to religious institutional contexts.

The article is organised into four sections and a conclusion. The first section reviews relevant literature on cancel culture, tracing its individual, corporate, and institutional dimensions. The second section offers a chronological case study of the Rupnik affair and Centro Aletti, covering the canonical and institutional proceedings against Rupnik, the history and responses of Centro Aletti, and the debate over the fate of his artworks. The third section analyses how cancel culture discourses and their institutional extensions are articulated in selected media reports and official Church documents. The conclusion discusses the implications of these findings for understanding cancel culture in religious contexts and suggests directions for further research.

LITERATURE REVIEW

Cancel culture: definitions and dynamics

Cancel culture is a relatively recent and contested term for practices where publics collectively withdraw support from individuals or institutions perceived to have violated social norms (Scalcău, 2023). According to Merriam Webster, the first known use of "cancel culture" dates to 2017, but public debate intensified in 2020 with the publication of "A Letter on Justice and Open Debate" in Harper's Magazine, in which 153 public intellectuals warned that rising intolerance of opposing views and public shaming threaten open debate and democratic participation (Harper's Magazine, 2020). Scholars offer multiple, partly competing definitions. Many describe "canceling" as the public withdrawal of support for artists, celebrities or public figures, typically through boycotts and reputational sanctions (Eaves, 2021; Scalcău, 2023). Others conceptualise cancel culture more broadly as a collective strategy of cultural ostracism and public shunning directed at individuals or institutions accused of objectionable behaviour, enacted through social and institutional channels (Dudenhoefer, 2020; Mujtaba & Cavico, 2020; Norris, 2023; Berghel, 2021).

The positive dimension of cancel culture lies in its capacity to function as a mechanism of social transformation. Empirical and discourse-analytic studies show that cancellation episodes can validate the grievances of marginalised communities, draw symbolic boundaries, shape collective identities and mobilise pressure on institutions to sanction powerful offenders (Altungy et al., 2025; Traversa et al., 2023; Butyrina et al., 2024). From this perspective, cancellation appears as a grassroots tool for exposing systemic inequalities and holding influential individuals and institutions morally accountable where formal politics and legal mechanisms fall short (Hudlay in Romano, 2020; Velasco, 2020). Despite these emancipatory potentials, cancel culture also presents serious risks. Critics argue that social media have intensified dynamics of public shaming and "speech privilege", creating hierarchies of visibility that marginalise dissenting viewpoints and conflict with norms of pluralism and open dialogue (Coleman, 2022; Custer, 2024). Emotional amplification and outrage can transform legitimate accountability into moral panics or "witch hunts", undermining due process and enabling mob mentality (Janssens & Spreeuwenberg, 2022; Paliy, 2024). Fear of becoming a target encourages self-censorship that may stifle free speech and critical debate (Adeyemi, 2025).

Corporate and institutional cancel culture

In corporate contexts, cancel culture is commonly defined as the collective withdrawal of consumer support from individuals or brands in positions of power, enacted through public pressure and reputational sanctions in order to influence corporate policies and practices (Saldanha et al., 2023; Scheinbaum & Poehlman, 2025). This reflects a broader shift in power relations, as consumers increasingly hold organisations accountable in the public sphere. Early high-profile cases illustrate the entanglement of individual and corporate reputations. In 2018, Roseanne Barr faced extensive backlash for a racist tweet, leading to the cancellation of her television show and prompting the sleeping-pill brand Ambien to publicly distance itself, signalling how corporate actors seek to manage reputational spillovers from individual controversies (Scheinbaum & Poehlman, 2025). Campaigns such as #BoikotScarlett and recurring boycotts of companies like Starbucks show how perceived misalignments between corporate actions

and dominant social or political values can generate sustained economic and symbolic consequences (Ardiningrum & Liwoso, 2025; Parker et al., 2024). Unlike individuals, corporations often possess resources for reputational recovery, crisis communication, policy reforms and rebranding, yet individual cancellations can still have significant corporate consequences when reputational damage spills over to affiliated organisations and partners (Abbasi et al., 2022). Jeffree Star's personal controversies, for instance, led to the termination of brand partnerships with companies such as Morphe, illustrating how closely associated corporate actors can be drawn into the orbit of an individual's cancellation regardless of their own conduct (Eaves, 2021). As Roos (2020, p. 13) summarises, the goal of cancel culture is ultimately "to squash the influence of these individuals or companies and eventually make them powerless by boycotting them financially, politically, or professionally".

The reach of cancel culture extends beyond the corporate sphere. When a transgressor occupies a position within a religious, cultural or civic institution, cancellation demands frequently target not only the individual but also the institution itself, its leadership, symbols, physical spaces and affiliated bodies, especially in religious contexts where institutional authority rests on claims to moral integrity and spiritual trustworthiness (Casanova, 1994; Demerath & Williams, 1992). When that moral foundation is publicly challenged, the institution as a whole becomes subject to cancellation pressures, irrespective of its direct involvement in the original transgression. The Catholic Church is therefore not exempt from these dynamics: scandals involving individual clergy can trigger broader demands for institutional accountability and sanctions, as in the case of Jesuit Marko Ivan Rupnik.

CASE STUDY: THE RUPNIK AFFAIR AND CENTRO ALETTI

Chronology of the Marko Rupnik Case

Understanding the unfolding of the Rupnik case is essential for analysing how cancel culture discourses emerged and developed in response to both individual misconduct and institutional failure. The case of the Slovenian Jesuit Marko Rupnik concerns allegations of sexual, psychological and spiritual abuse of adult women, mostly nuns from the Loyola community that he himself founded. Although the allegations date back to the 1980s and 1990s, the wider public only became aware of them in 2022. For greater clarity, the development of the case can be divided into several phases.

Initial period and first allegations (1980s – 1993)

In the 1980s and early 1990s, Rupnik, together with Sister Ivanka Hosta, founded the Loyola community in Mengeš, Slovenia. It was precisely in this period that the first allegations of various forms of abuse (sexual, psychological and spiritual) emerged. Among the claims mentioned are group sexual relations, coercion to watch pornographic content and manipulation through spiritual authority. The first known complaint was filed in 1993; however, according to media reporting (Giangravé, 2025), no formal canonical or administrative proceedings were initiated by ecclesial authorities at that time. Already in 1993, Rupnik left the Loyola community following internal complaints from the sisters. Media accounts further report that a sister who submitted a complaint left the community around the same period, with no public institutional explanation provided (Giangravé, 2025).

First official investigations and sanctions (2018 – 2020)

After a long-time gap, the case came back into focus in 2018, when the Jesuit superior received allegations against Rupnik of sexual abuse as well as the specific canonical offence of absolving an accomplice in a sin against the sixth commandment. A preliminary investigation was launched within the Society of Jesus (Verschueren, 2022). In 2019 the allegations were deemed credible and the case was forwarded to the Dicastery for the Doctrine of the Faith. At the beginning of 2020, canonical investigations concluded that the administrative criteria for the alleged offense of absolution of an accomplice had been met. In May 2020, the Dicastery for the Doctrine of the Faith formally declared that Rupnik had incurred automatic excommunication (*latae sententiae*), which was subsequently remitted by decree shortly thereafter (Verschueren, 2022).

New allegations and restrictions (2021 – October 2022)

During 2021, in the framework of the apostolic visitation of the Loyola community, Bishop Daniele Libanori received accusations from at least nine women against Rupnik, who had served as the community's confessor and spiritual director for a number of years (Brockhaus, 2022; Pentin, 2022). These complaints were subsequently forwarded to the Dicastery for the Doctrine of the Faith. In response, the existing restrictions on Rupnik's public activity were further tightened, with the aim of avoiding scandal and preventing further traumatisation of the victims (Pentin, 2022). Nevertheless, Rupnik was still permitted to engage in artistic work and limited liturgical activity within his own community (Brockhaus, 2022). In October 2022, the Vatican declined to initiate a canonical procedure, ruling that the allegations fell outside the canonical statute of limitations, although the statute of limitations had previously been waived in other cases (Brockhaus, 2022; Pentin, 2022).

Public disclosure and escalation (December 2022 – February 2023)

Only at the end of 2022 did the case gain wider public visibility. The Society of Jesus published a detailed chronology of the investigations into Rupnik, covering the period from the 2018 allegations through excommunication to the 2022 restrictions, affirming the credibility of the allegations and inviting victims to contact the order through a dedicated support team (Verschueren, 2022; Vatican News, 2022). The statement expressed empathy towards those affected and outlined the establishment of a reporting and support system for survivors. The Slovenian Bishops' Conference expressed sorrow over the abuse, characterised it as unacceptable, and voiced support for the victims, while expressing regret over the delayed institutional response. The statement called for greater transparency and assistance to victims, and explicitly distinguished Rupnik's personal conduct from his artistic work (Slovenian Bishops' Conference, 2022). At the beginning of 2023, following the receipt of fifteen additional credible reports of abuse, further measures were imposed: Rupnik was prohibited from travelling outside Rome and from engaging in any public artistic activity (Eternal Word Television Network, 2023; Brockhaus, 2023). The Slovenian Jesuits issued a formal apology to the victims, acknowledging the credibility of their allegations and their distress, reaffirming the order's commitment to justice, and expressing regret for the suffering endured (Jesuits in Slovenia, 2023).

Key institutional decisions (June 2023 – October 2023)

In June 2023, the Society of Jesus published a decree formally dismissing Rupnik from the order on the grounds of his repeated refusal to comply with the imposed restrictions. The decree clarified that the administrative measure of dismissal was based on canonical disobedience—specifically his refusal to abide by imposed restrictions—rather than a definitive judicial finding on the abuse allegations, noting that Rupnik retained the status of a diocesan priest pending further canonical review (Brockhaus, 2023b). In October Pope Francis lifted the statute of limitations for this case, thereby opening the possibility of initiating a canonical procedure (Da Silva 2023). The Vatican announced that Pope Francis, following a report from the Pontifical Commission for the Protection of Minors on problems in handling the case and the lack of support for victims, had requested a review by the Dicastery for the Doctrine of the Faith and had lifted the statute of limitations so that the procedure could begin. The statement emphasises the Pope's conviction of the need to listen to victims with compassion, inspired by the Synod. This enables a formal trial (Holy See Press Office 2023). The case thus remains open in 2025/2026, and its final outcome also depends on the outcome of the canonical process. Namely, in 2025 the Dicastery for the Doctrine of the Faith appointed five judges who will conduct the procedure, with emphasis on their independence (Holy See Press Office 2025). Pope Leo XIV confirmed that the process had begun and called for patience and respect for the rights of all involved (Wooden 2025). While the canonical process against Rupnik remains ongoing, the scandal has not remained confined to his person alone. The allegations and the institutional responses they generated have progressively drawn Centro Aletti, the art centre Rupnik founded in Rome in 1991 and which served for decades as the primary hub of his artistic activity (Allen, 2024; Christian, 2024) into the public controversy. Questions about the centre's role in Rupnik's work, its institutional responses to the allegations, and the fate of the artworks produced under its umbrella have opened a parallel public debate that merits separate examination.

CENTRO ALETTI: A CHRONOLOGY

Centro Aletti is a centre for spiritual art and theology founded in Rome in 1991 by Marko Ivan Rupnik, initially established with the aim of fostering dialogue between Eastern and Western Christian traditions and providing a space for theological and artistic research (Drozdziak, 2024). Over the following decades, the centre became specialised in the production of large-scale mosaics for churches and shrines worldwide, functioning as the primary hub of Rupnik's artistic activity (Allen, 2024; Christian, 2024). Rupnik served as the centre's director until May 2020, when, coinciding with the imposition of administrative restrictions, he formally ceased to hold that role (Verschueren, 2022).

Following Rupnik's dismissal from the Society of Jesus in June 2023, Centro Aletti's director Maria Campatelli issued a public statement in which she described the dismissal as the result of a "lynching" stemming from what she characterised as defamatory allegations and contested the Jesuits' account of the grounds for dismissal (Winfield, 2023; Centro Aletti, 2023).

In September 2023, the Vicariate of the Diocese of Rome published the conclusions of a canonical visitation to Centro Aletti, ordered by Cardinal Vicar Angelo

De Donatis, which concluded that the centre maintained "a healthy community life free of particular critical issues". Based on the final report, the Vicar Cardinal, after confirming that there were no reasons to take further measures within his jurisdiction, decreed the closure of the Canonical Visit (Zenit, 2023; EWTN Vatican, 2023). In July 2024, Campatelli issued a further public statement opposing calls for the removal of Rupnik's artworks, describing such pressure as a manifestation of "cancel culture" and "the criminalisation of art." She argued that the mosaics are not the work of a single author but a collective effort of dozens of artists and theologians, and that their removal would cause unjust harm to innocent collaborators and to members of the faithful (OSV News, 2024). Despite the ongoing canonical process, Centro Aletti continued to promote Rupnik's artistic and spiritual work, including his mosaics at the Sanctuary of Our Lady of Aparecida in Brazil and a new e-book of his spiritual writings published in April 2025 (Esteves, 2025b)

The debate over rupnik's artworks

At the beginning of 2024, several alleged victims, including Gloria Branciani and Mirjam Kovač, publicly testified for the first time about their experiences of spiritual, psychological, and sexual abuse, explicitly linking these experiences to the context of Rupnik's artistic activity (Pullella, 2024; America Magazine, 2024). Their accounts emphasised that the mosaics and other artworks produced in this context function as a reminder of the abuse and can be experienced as retraumatising for both survivors and members of the faithful who encounter them in liturgical spaces (OSV News, 2024). In published accounts, a complainant identified under the pseudonym Sister Samuelle alleged that abuse occurred during the installation of a mosaic, and explicitly called for the removal of his works (Esteves, 2025b). On 28 June 2024, five women alleging abuse sent letters to bishops worldwide, arguing that the continued display of Rupnik's works in churches and shrines is inappropriate and harmful to victims, and proposing their removal as a visible sign of institutional commitment to change (Christian, 2024; Winfield, 2024).

These demands led to concrete institutional reactions throughout the Church.

In June 2025 Vatican News removed all of Rupnik's mosaics and illustrations from its website, replacing them with blank spaces or other images (Milinare 2025; Guzik, 2025).

The Shrine of Lourdes in France covered Rupnik's mosaics on the side doors of the Basilica of Our Lady of the Rosary with aluminium panels already on 31 March 2025, and soon afterwards on the central doors as well. Bishop Jean-Marc Micas explained that the aim was to facilitate access for those who feel traumatised by the mosaics and unable to cross the threshold of the basilica. Complete removal has not yet been carried out; the focus is on a symbolic and pastoral step in the context of the Jubilee Year (Vatican News 2025).

The Knights of Columbus covered the mosaics in the Chapel of St John Paul II in Washington and in the Chapel of the Holy Family at their headquarters in New Haven with fabric (decision announced on 11 July 2024). The fabric will remain until the Dicastery for the Doctrine of the Faith issues a final decision on the case, and permanent covering with plaster is also possible. Supreme Knight Patrick Kelly emphasised that the first concern is the protection of victims and that shrines must not cause additional suffering (Christian, 2024; Winfield, 2024).

The Shrine of Fatima in Portugal decided on 3 April 2025 not to remove the mosaic in the Basilica of the Most Holy Trinity, but to ban any promotional use of the work (images, reproductions, promotional materials). The wall surface of the largest and most modern prayer space in the shrine, the Basilica of the Most Holy Trinity, is covered by a huge golden mosaic stretching from floor to ceiling. The work was created in 2007 by Father Rupnik and his collaborators from the Aletti Centre. The mosaic, approximately 10 x 50 metres in size, depicts the Paschal Lamb in the centre, surrounded by saints and angels. The shrine stated that it condemns the acts committed by Father Rupnik and expressed its solidarity with the victims (Esteves 2025a).

On the other side, many churches and shrines, like ones in Poland, Slovenia, Italy, and Spain have so far refused complete removal, awaiting the final decision of the Dicastery for the Doctrine of the Faith. Jesuit representatives in Spain acknowledged that there is currently no clear policy on what to do with Rupnik's mosaics (Brockhaus & Martínez-Bordiú, 2025)

ANALYSIS

The study is based on a document analysis of selected media reports and institutional documents concerning the Rupnik affair. The search covered the period from December 2022 (when the allegations first gained widespread public visibility) to late 2025. Relevant news coverage and official materials were identified through web searches using targeted search queries (such as "Marko Ivan Rupnik", "Centro Aletti", and "Rupnik cancel culture") in Google and relevant news databases. The examined corpus includes two main categories of sources: (1) ecclesial and institutional documents, comprising official press releases, decrees, and statements issued by the Holy See Press Office, the Society of Jesus, the Vicariate of the Diocese of Rome, the Slovenian Bishops Conference, Centro Aletti, and administration of major shrines and organizations (e.g. Lourdes, Fatima, Knights of Columbus); and (2) media coverage, encompassing both specialized Catholic news agencies (e.g. Catholic News Agency, OSV News, National Catholic Reporter, Crux, EWTN, Vatican News) and major secular international news outlets (e.g. Reuters, Associated Press). Documents were selected based on three key relevance criteria: (a) direct focus on the canonical or institutional proceedings concerning Marko Rupnik and Centro Aletti; (b) explicit articulation of discourses surrounding cancel culture, boycott, or reputational sanctioning; and (c) coverage of concrete institutional decisions, policy statements, or debates regarding the removal, covering, or preservation of Rupnik's artworks in physical and digital spaces.

The Construction of the Rupnik Affair as Cancel Culture

The analysis of selected media reports and institutional documents reveals that, within the examined corpus, the explicit mention of cancel culture originated from a specific institutional actor, Centro Aletti itself, as a deliberate discursive strategy. In a statement published on 24 July 2024, director Maria Campatelli explicitly invoked the concept to characterise calls for the removal of Rupnik's artworks, describing such pressure as "the widespread diffusion of the so-called 'cancel culture'" and as a form of "criminalisation of art" (OSV News, 2024; Centro Aletti, 2024). By positioning survivors' demands within the discourse of cancel culture, Campatelli reframed the debate

from one about institutional accountability to one about artistic freedom and collective injustice toward innocent collaborators. This rhetorical move was not without precedent. As early as June 2023, Campatelli had characterised the allegations as "defamatory and unproven" and described media coverage as a form of "lynching" directed at both Rupnik and the centre (Winfield, 2023), indicating that the July 2024 statement represented an escalation of a defensive narrative that had been developing since the scandal became public. This pattern reflects the contested nature of cancel culture as a discursive category that, as the literature review has shown, functions simultaneously as a tool of accountability and as a rhetorical defence against legitimate demands for reform (Norris, 2023; Scalcău, 2023).

Cancel Culture at the Institutional Level

The analysis of institutional responses to the Rupnik affair reveals the progressive extension of cancel culture logic from the individual transgressor to the symbolic objects associated with him. This institutional dimension of cancel culture operates through the collective withdrawal of symbolic support from a primary target (Norris, 2023; Saldanha et al., 2023), a logic that, as the examined cases illustrate, can extend beyond the individual to encompass the spaces and objects through which his legacy remains publicly visible.

Survivors' demands did not target Rupnik alone, but extended to the symbolic objects associated with him, calling for the removal of his artworks from the spaces where they remain publicly visible (Christian, 2024; Winfield, 2024). In this configuration, the mosaics functioned not merely as aesthetic objects but as institutional symbols of continued association with a sanctioned individual. The call for their removal can be interpreted as a call for institutional distancing, a demand that churches and shrines perform their rejection of Rupnik's legacy in a publicly visible and symbolic manner.

Table 1: Institutional Responses to Calls for the Removal of Rupnik's Artworks

Institution / site	Country	Type
Vatican News (Holy See news portal)	Vatican	Digital illustrations of Rupnik's mosaics removed
Shrine of Our Lady of Fatima (Basilica of the Most Holy Trinity)	Portugal	Mosaics physically kept, but promotional use suspended.
Sanctuary of Our Lady of Lourdes (Basilica of Our Lady of the Rosary)	France	Mosaics covered
The Knights of Columbus (St. John Paul II Shrine)	USA	Mosaics covered

Source: Data collected by the authors based on Christian (2024), Esteves (2025a), Vatican News (2025), Guzik (2025), and Milinare (2025)

The responses of major Catholic institutions can be understood as varying positions along a spectrum of institutional distancing. At one end, the Knights of Columbus and the Shrine of Lourdes opted for visible and immediate symbolic action, covering the mosaics with fabric and aluminium panels respectively, explicitly framing these gestures as expressions of solidarity with survivors (Christian, 2024; Vatican News, 2025). Vatican News' removal of Rupnik's illustrations from its website extended the

logic of cancellation into the digital sphere (Millinare, 2025; Guzik, 2025). These actions collectively constitute what the cancel culture literature describes as the withdrawal of support (Dias et al., 2022). In this case, the withdrawal of institutional visibility and endorsement from an artist whose personal conduct had been publicly condemned. At the other end of the spectrum, the Shrine of Fatima suspended promotional use of Rupnik's images while retaining the physical mosaic, and numerous churches and shrines in Poland, Slovenia, Italy, and Spain declined any immediate action, awaiting the outcome of the canonical process (Esteves, 2025a; Brockhaus & Martínez-Bordiú, 2025). This reluctance reflects a tension specific to religious institutional contexts: the canonical process functions as a brake on the speed and totality of cancellation that public pressure demands, illustrating the coexistence of public cancellation pressure with institutional procedural frameworks that resist or slow its logic.

Centro Aletti occupies a particularly significant position within this landscape. Unlike the institutions that introduced at least partial measures of distancing, Centro Aletti explicitly refused such distancing and continued to promote Rupnik's artistic and spiritual work throughout 2024 and 2025 (Esteves, 2025b). This refusal, combined with Campatelli's active reframing of accountability demands as cancel culture, positioned Centro Aletti as the primary institutional site of resistance among the institutions examined in this study.

This dynamic illustrates how cancel culture, when it encounters an embedded institutional network, produces a ripple effect of accountability demands that moves from the individual to his symbolic output as process shaped by the perceived inseparability of Rupnik's person, his artistic legacy, and the institution he founded.

Resistance and Contestation: The Limits of Cancel Culture in a Religious Context

The Rupnik case is instructive precisely because it does not follow the pattern of rapid and total cancellation that characterises many high-profile cases in secular cases, where institutional ties are severed within days of a scandal (Zeitchik & Heil, 2018; The Associated Press, 2017). Instead, it reveals a set of structural, theological, and communicative factors specific to religious institutions that slow the cancellation dynamic.

The most significant structural factor is the canonical process itself. Several institutions explicitly cited the pending canonical procedure as the reason for deferring any definitive action on Rupnik's artworks, framing their inaction not as indifference to survivors but as procedural prudence (Brockhaus & Martínez-Bordiú, 2025; Holy See Press Office, 2025). This appeal to canonical procedure allowed institutions to resist cancellation demands while maintaining institutional legitimacy which is a strategy unavailable to secular institutions facing comparable pressure.

A second form of resistance is theological and aesthetic in character. Campatelli's argument that the mosaics represent "a collective effort of dozens of artists and theologians" and that their removal "ought never to be thought of as a punishment or a cure" invoked a theological understanding of sacred art as a communal object that exceeds the moral status of any individual contributor (OSV News, 2024). This draws on a longstanding theological tradition distinguishing between the moral character of an artist and the spiritual value of their work (Ramos, 2026). In the religious context,

this distinction carries additional theological weight, as sacred art is understood to belong to the community of the faithful rather than to its creator (Office of Liturgy of the Archdiocese of New York, 2016). The Shrine of Fatima's decision to retain the mosaic while suspending its promotional use (Esteves, 2025a) reflects a similar logic, acknowledging the moral problem while preserving the theological function of the artwork.

A third form of resistance is institutional in character. The Diocese of Rome's canonical visitation of Centro Aletti, concluding in September 2023 with a finding of "healthy community life free of particular critical issues," (EWTN Vatican, 2023; Zenit, 2023) provided the centre with a formal institutional endorsement that functioned as a buffer against cancellation pressure, though survivors contested these conclusions (Mares, 2023).

These forms of resistance reveal the limits of cancel culture as an analytical and social mechanism in religious contexts. Cancel culture, as theorised in the literature, derives its power from the ability of mobilised publics to withdraw symbolic and economic support from a target and its associates, thereby making continued association reputationally and financially untenable (Norris, 2023; Roos, 2020). In secular contexts, particularly in the corporate and entertainment industries, this mechanism tends to operate rapidly and decisively, as the reputational and economic costs of association with a cancelled figure quickly outweigh the costs of distancing (Zeitchik & Heil, 2018; The Associated Press, 2017; Saldanha et al., 2023). In religious contexts, however, the calculus is more complex. Institutions such as churches and shrines derive their legitimacy not primarily from public opinion but from theological authority, canonical procedure, and the spiritual needs of their communities. This means that the reputational costs of continued association with a sanctioned individual are partially offset by the theological costs of removing sacred art, disrupting community life, or acting in ways perceived as capitulating to secular pressure. The result is a slower, more contested, and more ambiguous cancellation dynamic, one in which resistance is not simply denial or cover-up, but a genuinely complex negotiation between competing institutional, theological, and reputational imperatives.

CONCLUSION

This article has examined how discourses of cancel culture emerged and developed around the Rupnik affair, and how calls for the removal or preservation of his artworks generated institutional cancellation pressures that extended beyond the primary target to the spaces and symbolic objects associated with him. Drawing on a case analysis of selected media reports and ecclesial documents, the study has addressed the following research question: in what ways does the Rupnik affair illustrate how cancel culture operates at both individual and institutional levels within a religious context?

The analysis yields three principal findings. Given the single case-study design of this qualitative research, these findings should be understood as exploratory insights grounded in this specific controversy, rather than broadly generalizable patterns across all religious or organizational settings. First, the cancel culture framing of the affair was not a spontaneous product of public discourse, but a deliberate discursive strategy introduced by Centro Aletti as a defensive communicative response to mounting public pressure. Second, cancel culture logic, when it encounters an embedded institutional

network, produces a ripple effect of accountability demands that extends from the individual to his symbolic outputs, generating a spectrum of institutional responses that reflect varying reputational, theological, and communicative strategies. Third, religious institutional contexts generate specific forms of resistance to cancellation dynamics, grounded in canonical procedure, theological authority, and the spiritual function of sacred art, that distinguish them qualitatively from secular corporate contexts, resulting in a slower, more contested, and more ambiguous cancellation dynamic.

While the case-specific nature of this study inherently limits the direct generalizability of these conclusions, these exploratory findings carry significant theoretical implications for communication research. Existing theoretical frameworks, developed largely in relation to secular corporate and media contexts, require adaptation when applied to religious institutions, whose logic of legitimacy and public communication differs fundamentally from that of corporations or public figures. At the same time, the Rupnik case suggests that cancel culture, despite its risks of excessive or premature symbolic sanctioning, can function as a mechanism of public pressure on institutions that have historically been slow to protect survivors - a dynamic that needs further scholarly attention.

Several limitations of this study should be acknowledged. The corpus was assembled through purposive web searches rather than systematic sampling, which means the findings cannot be generalised beyond the examined documents. The study does not include a systematic analysis of broader media framing of the Rupnik affair, nor does it examine audience reception or the perspectives of all institutional actors involved. Future research might address these gaps by conducting systematic media content analysis, exploring comparable cases in other religious traditions, or investigating the long-term reputational consequences for institutions that resist cancellation pressure in the face of credible abuse allegations.

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https://doi.org/10.7251/EMC2603962R
UDK: 351.824.11:368.2.026.4(4-672EU)
Datum prijema rada: 12. mart 2026.
Submission Date: March 12, 2026
Datum prihvatanja rada: 7. septembar 2026.
Acceptance Date: September 7, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 962-978

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

CYBERSECURITY IN THE MARITIME INDUSTRY: CREW PREPAREDNESS, ORGANISATIONAL COMMUNICATION, AND ECONOMIC IMPLICATIONS

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***Abstract**: The maritime industry is increasingly exposed to cyber threats due to its strong reliance on information and communication technologies and automated systems. While digitalisation enhances the efficiency of maritime operations, it simultaneously creates new security challenges related to information management, the exchange of security-related data, and coordination within shipboard systems. In this context, cybersecurity is not solely a technical issue but an organisational and managerial one in which the crew plays a central role.*

This preliminary exploratory and descriptive study examines respondents' reported experiences and perceptions of maritime crew awareness, preparedness, and communication concerning cyber threats. The analysis addresses crew training, respondents' familiarity with security protocols, threat information sharing, perceived communication effectiveness among crew members, access control to information systems, and awareness of recovery plans and business continuity procedures in the event of a cyber incident.

The results indicate that respondents frequently reported basic technical security measures on board, while training was often reported as a one-time experience, participation in regular simulations was limited, and awareness of information-sharing practices and protocols was inconsistent. Respondents also frequently perceived cyber incidents as potentially having operational and economic consequences, including disruptions and negative effects on the financial stability and competitiveness of shipping companies. Based on these findings, this paper proposes preliminary recommendations for improving crew cyber preparedness, considering their potential operational and economic implications for maritime operations and shipping companies. This paper builds upon previous research on cyber challenges in the Croatian maritime industry published in 2022 by Springer.

The findings are based on a convenience sample of 77 male seafarers attending a Special Education Programme at a single Croatian institution. They represent respondents' self-reported perceptions rather than verified onboard practices or demonstrated economic effects and should not be generalised to the maritime industry as a whole.

***Keywords**: cybersecurity, maritime industry, cyber risk management, organisational communication, economic implications*

***JEL classification**: M15, D81, L92, J24*

INTRODUCTION

The contemporary maritime industry is facing increasingly complex cybersecurity challenges, primarily due to its growing reliance on digital technologies and automated systems. The integration of information and operational technologies into shipboard operations—including navigation, communication, cargo handling, and engine room management—significantly contributes to operational efficiency, while simultaneously introducing a range of new vulnerabilities to cyber threats (Car et al., 2014; Standard Club, 2020). Cyber-attacks in the maritime domain no longer represent solely a technical challenge but entail potential consequences for human safety, environmental protection, and the economic sustainability of the entire logistics system.

One of the key challenges lies in the quantification of the economic consequences of cyber incidents, including operational disruptions, revenue losses, increased insurance premiums, system recovery costs, and reputational damage. Industry examples, such as the attack on Maersk in 2017, have demonstrated that costs may reach hundreds of millions of dollars, while even smaller incidents can result in substantial losses if they interrupt vessel operations or compromise the integrity of supply chains. Cybersecurity management is therefore increasingly viewed as an integral component of financial planning and strategic decision-making, with investments in security measures and crew training more frequently justified through return-on-security-investment (ROSI) models.

Cyber risk management has evolved from traditional information security, with a key transition towards an integrated approach emerging in the early 2000s, when security began to be perceived as a business risk rather than exclusively a technical problem (Blakley et al., 2001; Gordon et al., 2003; Eling et al., 2021). This shift in perspective created space for the incorporation of organisational, managerial, and human factors into cybersecurity systems, which was soon reflected in industrial practice through standards such as ISO/IEC 27005:2008 and frameworks developed by national agencies such as NIST (NIST, 2024).

In the maritime sector, these concepts began to be applied more systematically only after 2014, when the International Maritime Organization (IMO) initiated the development of guidelines for cyber risk management (IMO, 2017a; IMO, 2017b). Industry stakeholders, led by BIMCO and partner organisations, developed *The guidelines on cyber security onboard ships*, which were subsequently integrated into safety management requirements through IMO Resolution MSC.428(98) (DNV, 2020). In this way, cybersecurity was formally embedded into existing Safety Management Sys-

tems (SMS); however, its operational implementation has remained largely dependent on the human factor.

Effective cybersecurity management requires a comprehensive approach that includes threat identification, vulnerability assessment, the definition of preventive measures, and the development of response and recovery plans. Within this framework, the human factor represents the central link between technical systems and organisational procedures, with the ship's crew often constituting the first line of defence against cyber threats. Nevertheless, existing research indicates a low level of crew awareness and preparedness, accompanied by a lack of formal education and simulation-based exercises (Safety4Sea, 2017; Chupkemi & Mersinas, 2024).

Multicultural and technically heterogeneous crews, frequent crew rotation, and limited shipboard connectivity further complicate the implementation of unified and effective training programmes (Chupkemi & Mersinas, 2024). Under such conditions, communication regarding cyber threats gains particular importance as an organisational mechanism for coordination and the transfer of security-relevant information.

For these reasons, more recent guidelines, as well as classification recommendations such as DNVGL-RP-0496 (DNV, 2016), increasingly emphasise the need to develop so-called *cyber hygiene*, regular training, and the implementation of simulations in order to strengthen the resilience of the human factor. In this paper, communication regarding cyber threats is viewed as an organisational function of safety management, as it directly affects crew coordination, the implementation of security procedures, and the effectiveness of responses to cyber incidents.

Accordingly, this study adopts a preliminary exploratory and descriptive approach to examine the reported experiences and perceptions of seafarers concerning onboard cybersecurity. It focuses on the security measures and procedures encountered by respondents, their participation in training and simulations, their perceptions of crew preparedness and communication, and their views regarding the potential operational and economic consequences of cyber incidents.

The study addresses the following research questions: RQ1: What cybersecurity measures, procedures, and training practices do respondents report encountering on board their vessels? RQ2: How do respondents perceive crew preparedness, communication, and information-sharing practices concerning cyber threats? RQ3: How do respondents perceive the potential operational and economic consequences of cyber incidents, and what improvements do they recommend? The research questions are descriptive rather than hypothesis-testing. Accordingly, no hypotheses were formulated, and the study does not test causal relationships.

Data were collected through a structured questionnaire containing closed-ended items and one optional open-ended item. The questionnaire enabled a descriptive examination of respondents' reported experiences and perceptions, the identification of perceived challenges, and the formulation of preliminary recommendations. This research builds upon a previous analysis of seafarers' awareness of cyber threats (Pavlinović et al., 2022) and extends the focus to security protocols, cyber risk management procedures, crew operational preparedness, and the financial implications for shipping companies and the wider supply chain.

The structure of the paper is as follows. The next section reviews relevant literature on maritime cybersecurity, focusing on cyber risk management, the human fac-

tor, and organisational communication in the maritime environment. The methodology section outlines the research design and data collection conducted among seafarers. This is followed by the presentation and discussion of empirical findings related to crew preparedness, training, communication practices, and the economic implications of cyber incidents. The final section summarises the main conclusions and provides recommendations for improving cybersecurity preparedness and resilience in the maritime industry.

LITERATURE REVIEW

Cyber risk management has evolved from traditional information security, with a key transition towards an integrated approach emerging in the early 2000s, when security began to be perceived as a business risk rather than exclusively a technical problem (Blakley et al., 2001; Gordon et al., 2003). This concept was soon recognised in industry through standards such as ISO/IEC 27005:2008 and national frameworks such as the NIST Risk Management Framework, thereby establishing the foundations for systematic cyber risk management across various sectors, including maritime transport (NIST, 2024). This paradigm shift enabled a stronger integration of security considerations into strategic and financial planning processes. Today, cybersecurity is increasingly viewed as an integral component of overall business resilience, with losses caused by cyber-attacks—such as operational disruptions, contract losses, reputational damage, and increased insurance premiums—being quantified and incorporated into risk assessments (Eling et al., 2021; ENISA, 2022; Woods & Wolff, 2025).

The maritime industry recognised the seriousness of cyber threats relatively late; however, the past decade has seen accelerated development of regulatory and industry frameworks. A significant regulatory milestone occurred in 2017, when the International Maritime Organization (IMO) issued the *Guidelines on Maritime Cyber Risk Management* (MSC-FAL.1/Circ.3), emphasising the need to integrate cybersecurity into existing safety management systems (IMO, 2017a; IMO, 2017b), including clearly defined communication protocols and information exchange between shipboard crews and organisations. At the same time, industry guidelines jointly developed by BIMCO, ICS, INTERCARGO, and other organisations established the foundations for the operational implementation of protective measures at the ship level (BIMCO et al., 2020). In the context of technological transformation, organisational investments in digital technologies represent a key prerequisite for sustainable development, while the lack of such investments may limit a system's ability to respond to emerging security challenges (Spasojević & Đukić, 2025). These documents, incorporated into IMO Resolution MSC.428(98), require shipping companies to implement cyber risk management within their safety management systems by 2021 (DNV, 2020).

Although the regulatory and institutional framework has been significantly strengthened over the past decade, numerous studies indicate that the human factor remains one of the weakest links in maritime cybersecurity systems. A survey conducted among seafarers in 2017 revealed that as many as 84% of respondents had received no or only minimal cybersecurity training, while 64% believed they were responsible for the security of IT systems but did not know how to act in practice (Safety4Sea, 2017). These findings point to a substantial gap between technical expectations and the actual level of crew awareness and preparedness.

Contemporary approaches to cyber risk management increasingly emphasise the development of so-called *cyber hygiene*—a set of basic security habits and behaviours that every crew member must understand and apply in daily operations. In its recommendations on ship resilience to cyber threats, DNV (2016) highlights the importance of conducting simulation exercises, regular training, and developing simple and comprehensible incident response procedures. However, the implementation of such activities in practice encounters numerous obstacles, including limited shipboard internet connectivity, frequent crew rotation, language barriers, and differences in digital literacy levels (Chupkemi & Mersinas, 2024). Under conditions of limited onboard internet connectivity, the effective implementation of cyber measures requires a secure data-processing environment, with local processing of sensitive information representing a practical solution that supports both protection and analytical processing (Milojković et al., 2025). This suggests that individual crew awareness and motivation are not sufficient without systematic organisational support and an adequate regulatory and educational framework, highlighting the importance of closing the gap between individual preparedness and institutional support (Grujić & Novaković, 2025).

Recent research by Chupkemi and Mersinas (2024) identified 17 specific challenges in the implementation of cyber training in the maritime sector, with particular emphasis on the lack of time available for training during voyages, resistance to change, and the absence of standardised curricula. The authors also highlight the need to introduce a risk-based approach to training, whereby crew members are trained primarily to address threats that are most likely within their operational environment, including phishing attacks, the use of unauthorised USB devices, and responses to suspicious system changes.

Industry recommendations further stress the importance of continuous awareness enhancement through campaigns such as *Be Cyber Aware at Sea*, as well as the integration of cybersecurity elements into formal maritime education programmes (Safety4Sea, 2017). Some shipping companies have already introduced roles such as the Cyber Security Officer (CySO), both onboard and ashore, whose responsibilities include coordinating training activities, conducting preparedness assessments, and facilitating functional communication between technical staff and crew members (Moen et al., 2024).

In addition to international organisations such as the IMO and industry associations, the European Union Agency for Cybersecurity (ENISA) plays a significant role in shaping approaches to cyber risk management within the European context. In its *Guidelines for Cybersecurity in the Maritime Sector*, ENISA (2022) emphasises the importance of involving all stakeholders—from shipping companies and port authorities to IT service providers—in a comprehensive risk management process. Particular emphasis is placed on cyber risk management in ports, which represent critical nodes within the maritime logistics chain and are often interconnected with numerous vulnerable systems. ENISA recommends the establishment of unified security policies, the regular conduct of risk assessments, and the development of coordinated incident response mechanisms, in line with European regulatory frameworks such as the NIS Directive.

Despite these challenges, recent trends indicate a gradual institutionalisation of security culture within the maritime sector, whereby the crew is no longer viewed sole-

ly as a risk but rather as a key line of defence. Systematic investment in training and the raising of seafarers' awareness is increasingly recognised as a fundamental prerequisite for effective cyber risk management and for ensuring the resilience of maritime operations in the digital era.

Nevertheless, despite the development of regulatory and industry frameworks, the literature review reveals that a relatively small number of empirical studies focus on the operational preparedness of shipboard crews, particularly in the context of communication practices and perceptions of the economic consequences of cyber incidents. Most existing studies primarily address technical security aspects or regulatory requirements, while organisational and human factors are often examined in a fragmented manner. This paper seeks to contribute to closing this research gap through an empirical analysis of crew awareness, training, communication, and perceptions of the economic implications of cyber threats in the maritime sector.

METHODOLOGY

The study employed a cross-sectional, exploratory and descriptive survey design. Its purpose was to describe respondents' reported experiences and perceptions rather than to test hypotheses or causal relationships. Accordingly, the quantitative analysis was limited to descriptive statistics, including frequencies and percentages. Complete response distributions are reported for all closed-ended items as frequencies (n) and percentages (%), calculated using N = 77 as the denominator and presented to two decimal places. No inferential statistical tests were conducted. The units of analysis were the individual respondents and their self-reported answers. Questions concerning crew preparedness, communication effectiveness, company procedures, and onboard security measures were therefore interpreted as respondents' perceptions or reported experiences. They were not treated as objective verification of crew competence, company-level practices, or the actual implementation and effectiveness of cybersecurity controls on board.

The sampling frame consisted of active seafarers attending the Special Education Programme (SEP) at the Faculty of Maritime Studies, University of Split, during the 2023/24 and 2024/25 academic years. Convenience sampling was used, and all SEP attendees present when the questionnaire was administered were invited to participate voluntarily. Questionnaires were distributed and collected in paper form during the programme sessions. A total of 86 questionnaires were returned. Nine questionnaires were excluded because they contained incomplete responses that prevented their consistent inclusion in the analysis, resulting in a final analytical sample of 77 respondents. Thus, 89.5% of the returned questionnaires were retained for analysis. The number of attendees present and invited was not recorded separately from the number of returned questionnaires; consequently, a formal response rate cannot be calculated.

To reduce the possibility of repeated participation, the questionnaire was administered once within each programme group, and participants were instructed to complete it only once. However, because no personal identifiers were collected, possible participation by the same individual in both academic years could not be independently verified. Nationality, employer, vessel name, and exact collection dates were not recorded, as these variables were not required for the planned descriptive analysis. The respondents reported their professional position, work experience, and general vessel

type. The absence of nationality and employer information limits the possibility of assessing the organisational and national diversity of the sample.

SEP attendees were considered a relevant accessible group because they were active or professionally experienced seafarers undertaking continuing education aligned with the STCW Convention and could report on their recent shipboard experiences. Nevertheless, SEP attendees represent a specific subgroup of seafarers with access to continuing education and should not be considered representative of the maritime industry as a whole.

In line with the research goal and the themes identified in the literature review, the questionnaire consisted of a total of 25 questions, grouped into five thematic sections corresponding to the phases of risk management in the maritime environment:

- Demographic data (Q1–Q5): gender, age, work experience, position, type of vessel
- Technical and procedural measures (Q6–Q12): security measures, frequency of checks, recovery plans, threat detection
- Communication and awareness (Q13–Q17): training, simulations, information sharing, communication effectiveness, preparedness
- Monitoring, evaluation, and accountability (Q18–Q22): monitoring of measures, plan updates, incident analysis, recommendations
- Economic implications (Q23–Q25): perception of financial losses and operational disruptions, cost-effectiveness of investments in training, and assessment of the impact of cyber incidents on the financial stability and competitiveness of shipping companies.

The questionnaire primarily consisted of closed-ended questions with categorical response options. Selected attitude and perception items used Likert-type response scales, while Q22 was an open-ended question that allowed respondents to provide recommendations in their own words. The questionnaire was designed in the Croatian language. The English-language version presented in the paper was prepared by the authors for publication. The questionnaire assessed respondents' self-reported experiences, awareness, and perceptions of onboard cybersecurity. Q13 and Q16 assessed individual participation in simulations and training. Q15 and Q17 assessed perceived communication effectiveness and crew preparedness. Q6–Q12 and Q18–Q21 assessed respondents' awareness and perceptions of vessel- or company-level cybersecurity practices. Q23–Q25 assessed perceptions of potential operational and economic consequences. Accordingly, the questionnaire assessed how respondents experienced and understood cybersecurity practices rather than objectively testing their cybersecurity knowledge or independently verifying onboard controls and company-level practices.

The questionnaire consisted of standalone items addressing different topics and using different response formats. The items were analysed separately and were not combined into composite scores. A comparable literature-informed questionnaire containing different question formats and addressing several dimensions of maritime cybersecurity awareness was used by Moen et al. (2024). Questions Q1–Q5 were author-developed items used to collect respondents' demographic and professional characteristics. Questions Q6–Q12 were informed by the IMO Guidelines on Maritime Cyber Risk Management (IMO, 2017b), *The Guidelines on Cyber Security Onboard Ships* (BIMCO et al., 2020), and DNVGL-RP-0496 (DNV, 2016). Questions Q13–

Q17 were informed by BIMCO et al. (2020) and DNV (2016), while Q15 and Q17 were author-developed items measuring respondents' perceptions of communication effectiveness and crew preparedness, respectively. Questions Q18–Q21 were informed by IMO Resolution MSC.428(98) (IMO, 2017a), the IMO Guidelines on Maritime Cyber Risk Management (IMO, 2017b), BIMCO et al. (2020), and DNV (2016). Q22 was an optional open-ended item that allowed respondents to provide supplementary recommendations. The responses were used only to contextualise the descriptive findings and were not subjected to formal thematic coding, following a comparable treatment of supplementary open-text responses in maritime cybersecurity research (see Kurt et al., 2026). Questions Q23–Q25 were author-developed perception items informed by BIMCO et al. (2020), Gordon et al. (2003), and ENISA (2022).

Before administration, the draft questionnaire was informally reviewed by academic colleagues familiar with maritime education and cybersecurity-related topics. They considered the relevance, clarity, and comprehensibility of the questions. The questionnaire and response options were also informally checked with individuals comparable to the intended respondents, who confirmed that they were understandable. This informal review was used to improve the clarity and content relevance of the questionnaire.

Participation in the survey was voluntary and anonymous, and no personal identifying data were collected. The study adhered to the ethical principles of academic research.

RESULTS

The results are presented in accordance with the three descriptive research questions. All findings refer exclusively to the answers provided by the respondents included in the study. References to onboard measures, procedures, communication, preparedness, and economic consequences therefore describe respondents' reported experiences and perceptions and should not be interpreted as independently verified conditions. There were no missing responses to the closed-ended items in the final analytical sample. According to the gender structure, all respondents (100%) were male. The sample included an almost equal proportion of respondents aged 31–40 years (31.17%) and 18–30 years (38.96%), while respondents aged 41–50 years accounted for 29.87% of the sample. With regard to maritime work experience, the largest proportion of respondents had up to 5 years of experience (38.96%), followed by those with 6–10 years (31.17%) and 11–20 years of experience (29.87%).

The most frequently reported position on board was deck officer (44.16%), followed by engine officer (33.77%) and crew member (20.78%), while only one respondent indicated that they currently held the position of captain. In terms of the type of vessel on which respondents were currently employed, the largest proportion worked on tankers (38.96%), followed by cargo ships (31.17%) and passenger vessels (28.57%), while one respondent reported another type of vessel.

Table 1. Demographic characteristics of respondents (N = 77)

Demographic characteristics	Category	Frequency	%
Gender	Male	77	100.00
	Female	0	0.00
Age	18–30	30	38.96
	31–40	24	31.17
	41–50	23	29.87
Experience	0–5	30	38.96
	6–10	24	31.17
	11–20	23	29.87
Position	Deck officer	34	44.16
	Engine officer	26	33.77
	Crew member	16	20.78
	Captain	1	1.30
Type of vessel	Cargo ship	24	31.17
	Passenger ship	22	28.57
	Tanker	30	38.96
	Other:_____	1	1.30

Source: Authors

After examining the demographic characteristics of the sample, Table 2 presents respondents' reports of technical and procedural cybersecurity measures on the vessels to which their answers referred. Antivirus protection was the most frequently reported measure, while respondents most commonly reported that system security checks were conducted every few months. Forty-four respondents (57.14%) reported that incident-reporting procedures were available to all crew members, whereas 33 respondents (42.86%) reported that threat-detection systems were not used. Furthermore, 43 respondents (55.84%) reported that the most recent cyber-risk assessment had been conducted within the previous six months. However, 53 respondents (68.83%) did not know whether a cyber-incident recovery plan existed. This indicates uncertainty or limited respondent awareness and should not be interpreted as evidence that recovery plans were absent.

Table 2. Technical and procedural cybersecurity measures (Q6-Q12; N = 77)

Question (code)	Short question	Response category	n	%
Q6	Implemented security measures	Antivirus	75	97.40
		Firewall	48	62.34
		Access control	37	48.05
		Data backup	29	37.66
		Encryption	18	23.38
		Other security measures	5	6.49
		None	1	1.30

Q7	Frequency of system security checks	Weekly or more frequently	9	11.69
		Monthly	18	23.38
		Every few months	41	53.25
		Once a year or less frequently	6	7.79
		Never	3	3.90
Q8	Existence of incident-reporting procedures	Yes, for all crew members	44	57.14
		Yes, but only for designated personnel	18	23.38
		No	9	11.69
		I do not know	6	7.79
Q9	Use of threat-detection systems	Yes	25	32.47
		No	33	42.86
		I do not know	19	24.68
Q10	Perceived level of cyberattack risk	Very high	8	10.39
		High	30	38.96
		Moderate	27	35.06
		Low	10	12.99
		Very low	2	2.60
Q11	Timing of the most recent cyber-risk assessment	Within the past six months	43	55.84
		Between six and twelve months ago	15	19.48
		More than one year ago	8	10.39
		No assessment has been conducted	4	5.19
		I do not know	7	9.09
Q12	Existence of a cyber-incident recovery plan	Yes	15	19.48
		No	9	11.69
		I do not know	53	68.83

Source: Authors (note: Q6 was a multiple-response item; therefore, its percentages may sum to more than 100%.)

As effective cybersecurity management does not rely solely on technical solutions, Table 3 presents respondents' reports related to crew communication and training, including simulations, information sharing, and perceived preparedness. Thirty-two respondents (41.56%) reported never having participated in cyber-incident recovery simulations; however, this finding should not by itself be interpreted as evidence of limited practical crew preparedness. Official notices were the most frequently reported method of sharing threat-related information (n = 32; 41.56%), while 42 respondents (54.55%) perceived threat-related communication as effective. A total of 61 respondents (79.22%) reported having participated in formal cybersecurity training at least once. Furthermore, 46 respondents (59.74%) perceived the crew as only partially prepared to address cyber threats.

Table 3. Communication practices and cybersecurity training (Q13-Q17; N = 77)

Question (code)	Short question	Response category	n	%
Q13	Participation in recovery simulations	No, never	32	41.56
		Yes, once	27	35.06
		Yes, more than once	18	23.38
Q14	Method of sharing threat-related information	Through official notices	32	41.56
		During organised meetings or briefings	18	23.38
		By email or another digital platform	15	19.48
		Through informal communication	8	10.39
		Information is not regularly shared	4	5.19
Q15	Effectiveness of threat-related communication	Very effective	12	15.58
		Effective	42	54.55
		Neither effective nor ineffective	13	16.88
		Ineffective	8	10.39
		Very ineffective	2	2.60
Q16	Participation in formal cybersecurity training	Yes, once	40	51.95
		Yes, more than once	21	27.27
		No, never	16	20.78
Q17	Perceived crew preparedness for cyber threats	Fully prepared	15	19.48
		Partially prepared	46	59.74
		Not prepared	13	16.88
		I do not know	3	3.90

Source: Authors

Table 4 presents respondents' reports concerning the monitoring of cybersecurity measures, incident analyses, security-plan updates, and responsibility for the security plan. Periodic checks were the most frequently reported method of monitoring security measures, while 30 respondents (38.96%) identified an IT specialist as the person responsible for the security plan.

Table 4. Monitoring, updating, and accountability in cybersecurity implementation (Q18-Q21; N = 77)

Question (code)	Short question	Response category	n	%
Q18	Monitoring the effectiveness of security measures	Periodic checks	34	44.16
		Continuous monitoring	20	25.97
		Checks following an incident	13	16.88
		No monitoring	6	7.79
		I do not know	4	5.19
Q19	Frequency of incident analysis	After every incident	22	28.57
		Every three months	9	11.69

		Every six months	28	36.36
		Once a year	13	16.88
		Never/I do not know	5	6.49
Q20	Frequency of security-plan updates	After a cybersecurity incident	8	10.39
		Every three months	27	35.06
		Every six months	23	29.87
		Once a year	14	18.18
		Never/I do not know	5	6.49
Q21	Person responsible for the security plan	IT specialist	30	38.96
		Captain	18	23.38
		Company cybersecurity officer	14	18.18
		Designated crew member	9	11.69
		Shore-based manager	4	5.19
		I do not know	2	2.60

Source: Authors

Respondents were given an opportunity to provide additional recommendations in an optional open-text format (Q22). Their comments referred to clearer cybersecurity protocols, improved information sharing, more frequent security checks and incident simulations, additional crew training, and clearer allocation of responsibilities. For example, one respondent recommended clearer procedures, regular crew training, and more frequent onboard security checks. These comments are presented as supplementary contextual observations rather than formally coded qualitative findings, following the approach used by Kurt et al. (2026).

Table 5. Respondents' perceptions of the economic implications of cybersecurity (Q23-Q25; N = 77)

Question (code)	Short question	Response category	n	%
Q23	Financial losses and operational disruptions for the shipping company	Strongly agree	40	51.95
		Agree	24	31.17
		Neither agree nor disagree	8	10.39
		Disagree	4	5.19
		Strongly disagree	1	1.30
Q24	Cost-effectiveness of investments in crew training	Yes	65	84.42
		No	8	10.39
		I do not know	4	5.19
Q25	Long-term impact on financial stability and competitiveness	Poses a significant threat to financial stability and competitiveness	44	57.14
		Poses a moderate threat	22	28.57
		Poses a limited threat	7	9.09
		Has no significant impact	2	2.60
		I do not know	2	2.60

Source: Authors

Table 5 presents respondents' perceptions of the potential economic implications of cyber incidents. Forty respondents (51.95%) strongly agreed that insufficient crew preparedness and inadequate protective measures could result in financial losses and operational disruptions. Sixty-five respondents (84.42%) perceived investment in crew training as cost-effective, while 44 respondents (57.14%) perceived a cyber incident as a significant long-term threat to a company's financial stability and competitiveness. These findings describe respondents' perceptions and do not demonstrate actual financial losses or the cost-effectiveness of cybersecurity investments.

DISCUSSION

The responses obtained from 77 seafarers suggest possible gaps in respondents' awareness of and exposure to certain onboard cybersecurity procedures, despite the existence of formal IMO and industry guidelines (IMO, 2017a; IMO, 2017b; DNV, 2020). For example, 75 respondents (97.40%) reported that antivirus protection was used on the vessels to which their responses referred, indicating that this was the most commonly reported basic technical measure (Table 2). However, 53 respondents (68.83%) selected "I do not know" when asked whether a recovery plan existed (Q12), while 33 respondents (42.86%) reported that threat-detection systems were not used (Q9). The responses to Q12 indicate uncertainty or limited awareness and should not be interpreted as evidence that recovery plans were absent.

Similar findings have been reported in previous studies, which identify a gap between the existence of technical measures and their operational effectiveness, particularly with regard to crew awareness and training (Safety4Sea, 2017; Chupkemi & Mersinas, 2024). For instance, although 61 respondents (79.22%) reported having participated in formal cybersecurity training at least once (Q16), 46 respondents (59.74%) perceived the crew as only partially prepared (Q17). This is consistent with DNV's (2016) emphasis on continuous practical application, simulations, and exercises as important components of shipboard cyber resilience.

Thirty-two respondents (41.56%) reported never having participated in recovery simulations (Q13), which contrasts with industry recommendations that identify simulation-based exercises as an important component of cyber hygiene (DNV, 2016; BIMCO et al., 2020). Furthermore, 44 respondents (57.14%) reported that incident-reporting procedures were available to all crew members (Q8), while 28 respondents (36.36%) reported that incident analyses were conducted every six months (Q19). These responses may indicate uneven respondent awareness of and exposure to operational cybersecurity procedures but do not verify their actual implementation or effectiveness on board.

The supplementary comments to Q22 referred to clearer protocols, more frequent checks, improved communication, and additional training, which is consistent with ENISA's recommendations (2022). Because the responses were not formally coded, the prevalence of these recommendations within the sample cannot be established. At the same time, 30 respondents (38.96%) identified an IT specialist as the person responsible for the security plan, which may reflect a perceived emphasis on technical responsibility for cybersecurity.

An additional dimension concerns respondents' perceptions of the potential economic implications of insufficient cybersecurity preparedness. Forty respondents

(51.95%) strongly agreed that insufficient awareness and training could result in financial losses and operational disruptions. Sixty-five respondents (84.42%) perceived investments in crew training as economically justified, while 44 respondents (57.14%) perceived a successful cyberattack as a significant long-term threat to a shipping company's financial stability and competitiveness. These findings indicate that respondents perceived cybersecurity as both a technical concern and a potential business risk.

Recent research increasingly highlights the need to apply a risk-based approach to training, whereby education should be focused on the most likely scenarios, such as phishing attacks, unauthorised use of devices, or responses to suspicious system changes (Chupkemi & Mersinas, 2024). Within the present sample, 32 respondents (41.56%) reported official notices as the method of communicating information about cyber threats, while 42 respondents (54.55%) perceived threat-related communication as effective. These responses describe respondents' reported experiences and do not verify the consistency or effectiveness of company-level information-sharing practices.

Given that the study sample is entirely male, the findings do not capture potentially different experiences and perceptions among women seafarers, which provides scope for future research on the gender dimension of cybersecurity in the maritime sector. In addition, most respondents are between 18 and 40 years of age, while most reported less than 10 years of maritime experience (Table 1). This age and experience profile limits the applicability of the findings to older and more experienced seafarers. Previous research has identified professional experience and individual characteristics as potentially relevant to cybersecurity awareness and preparedness (Chupkemi & Mersinas, 2024; Moen et al., 2024), however, their relationship with respondents' answers was not tested in the present study.

When interpreting these findings, certain methodological limitations of the study should also be taken into account. The study used a convenience sample of SEP attendees recruited from a single Croatian institution. Participation in continuing education may be associated with motivation, career stage, certification requirements, employer support, or access to training, creating a risk of selection and self-selection bias. Nationality and employer information were not collected, a formal response rate could not be calculated, and possible repeated participation across the two academic years could not be independently verified because the questionnaires were anonymous. Consequently, the results provide preliminary insight into the reported experiences and perceptions of the surveyed respondents but should not be generalised to the Croatian or international maritime industry.

Overall, respondents frequently reported encountering basic elements of cybersecurity protection, while their answers suggest possible gaps in awareness of and exposure to training, operational procedures, and the allocation of cybersecurity responsibilities. These findings reflect the perceptions and reported experiences of the surveyed sample rather than verified conditions across the maritime sector. As emphasised by ENISA (2022), strengthening resilience requires not only technical measures but also the development of a security culture at all levels in which the crew is recognised as an important component of cybersecurity resilience.

CONCLUSION

This research highlights respondents' perceptions of the importance of the human factor as a key element of cybersecurity management systems in the maritime industry, particularly in the context of shipboard crew preparedness for cyber threats. Despite formal regulatory requirements and industry guidelines, the results suggest possible gaps in respondents' awareness of and exposure to their operational implementation at the ship level, particularly in the areas of continuous training, the conduct of simulations, and the practical application of security procedures. Empirical data obtained through the survey show that respondents frequently reported encountering basic technical security measures on-board, while their responses indicate less consistent awareness of or exposure to more advanced elements of cyber resilience, such as recovery plans, threat detection systems, and regular incident simulations. These findings suggest a perceived need for stronger institutional and organisational support in building a security culture, in which education and digital literacy should be integrated into everyday shipboard operations rather than limited to occasional or purely formal forms of training. The findings further suggest that respondents perceive cybersecurity as both a technical and an economic concern. The majority of respondents perceive an association between the level of cybersecurity protection, operational stability, and the financial health of shipping companies. Cyber incidents may lead to business disruptions, revenue losses, increased recovery costs, higher insurance premiums, and long-term deterioration of competitiveness, although these effects were not directly measured in this study. Respondents' answers indicate that they generally perceive investments in preventive measures and crew training as economically justified; however, the study does not establish their actual cost-effectiveness. Based on respondents' answers, the following preliminary, sample-specific recommendations can be proposed: (1) the introduction of more frequent cyber incident simulation exercises as an integral part of safety management, (2) the development of tailored digital training modules for continuous seafarer education, focused on the most common and high-risk attack scenarios, and (3) the improvement of accessibility to security-related information and incident response plans at the level of shipping companies, accompanied by a clear allocation of responsibilities between technical personnel and crew members. The potential operational and economic effects of these proposed measures were not tested in the present study and should be examined in future research. In this context, investments in crew training and cybersecurity capabilities were perceived by respondents as potentially valuable long-term investments. Given the exploratory design, convenience sampling, all-male sample, recruitment from a single institution, and reliance on self-reported data, the findings should be regarded as preliminary and should not be generalised to the maritime industry as a whole. Future research should further examine the economic effects of such investments, as well as the effectiveness of different training and communication approaches under real operational conditions.

Acknowledgement: *This research is the result of the project SIDRO- Stakeholder synergy for the development of a sustainable entrepreneurial society, funded by the European Union- NextGenerationEU. The views and opinions expressed are solely those of the author(s) and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.*

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https://doi.org/10.7251/EMC2603979M UDK: 338.242.2(497-15):330.322(4-672EU)

Datum prijema rada: 25. maj 2026.
Submission Date: May 25, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026

Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review

Godina/Vol. **XVI** • Br./No. **III**
str./pp. 979-991

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

RENEWABLE ENERGY ADOPTION, CARBON EMISSIONS AND ECONOMIC GROWTH: PANEL EVIDENCE FROM WESTERN BALKAN AND DEVELOPED EUROPEAN ECONOMIES

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Abstract: *This study aims to examine the adaptive relationships among sustainable energy adoption, carbon-intensive emissions, and growth in economic output across eight European economies Croatia, Slovenia, Serbia, Bosnia and Herzegovina, Montenegro, North Macedonia, Germany, and Austria over the period 1990–2023, yielding 272 panel observations. The study applies a comprehensive panel econometric framework comprising LLC, IPS, Augmented Dickey-Fuller and Phillips-Perron Fisher unit root tests, Pedroni and Kao cointegration tests, the Pooled Mean Group estimator among the Panel ARDL framework, robustness checks through FMOLS and DOLS and the Dumitrescu-Hurlin panel causality test. Findings confirm that all variables are related in order and long run interconnected. PMG estimation reveals that renewable energy adoption positively and plays the important role in economic growth with an elasticity of 0.312, while carbon emissions exert a negative long-run effect on GDP. The inverted U Environmental Kuznets Curve hypothesis is linked with the validity of the panel, with an estimated revenue with the turning point of approximately USD 25,840 per capita. Causality analysis confirms a bidirectional relationship between sustainable energy and GDP growth and a unidirectional causal effect of sustainable energy on emissions reduction. The findings revealed that renewable energy investment represents a viable dual strategy for simultaneously promoting economic growth and reducing carbon emissions across both developing Western Balkan and developed European economies, with important implications for regional energy transition policy and EU accession frameworks.*

Keywords: *Sustainable energy, Economic growth, Carbon emissions, Environmental Kuznets Curve, Panel ARDL*

JEL Classification : *Q42, Q43, Q53, O44, C23*

INTRODUCTION

Currently, the most disputed topics in contemporary environmental and development economics are the relationship among sustainable energy sources, energy utilization, carbon emissions and GDP growth. With the ongoing changes in the climate, there are several long-term risks to ecosystems and human welfare. Several previous studies by policymakers and researchers have enhanced their understanding of whether migration towards cleaner energy sources encourages or impedes economic prosperity. This question is specifically relevant for European economies that are dealing with the twin challenges of sustainable growth.

A study conducted by (Kraft, 1978), which was the first to aim to establish a cause-and-effect association between renewable energy and GDP growth in the United States. Later, the same link was the subject of various empirical studies done by various researchers in several country groups using different time periods and different research methods. The literature is, however, empirically unresolved, especially regarding the direction of cause and effect and whether there is an interactive effect of renewable energy in the growth process (Apergis N. a., 2010); (Shahbaz, 2012).

In the overall discourse, the inverted U Environmental Kuznets Curve (EKC) assumption has drawn notable scholarly interest. It was formally introduced by Grossman and Krueger (1991) and later formalized by (Panayotou, 1993). The Environmental Kuznets Curve (EKC) hypothesis establishes a counteracting U-shaped association between per capita income and environmental degradation. It tells that at first pollution rises with the enhancement of the economic development and later declines as countries' income increases. However, some empirical evidence is related to the EKC hypothesis across European economies (Dinda, 2004); (Stern, 2004). Presently, in this study, countries are represented by a cross-section of the economic development in Europe: Croatia, Slovenia, Serbia, Bosnia and Herzegovina, Montenegro, North Macedonia, Germany and Austria. Several countries in the Western Balkan economies, like Serbia, Bosnia and Herzegovina, Montenegro and North Macedonia, continue to rely on fossil fuels, with coal as their primary source for livelihood and due to a primary source it faces a uttermost structural challenge in adapting to renewable energy sources. Croatia and Slovenia, which are part of the European Union, have made remarkable steps towards adopting renewable energy sources, which are in line with EU energy rules and directives (Bilas, 2024). Developed EU nations like Germany and Austria have done a tremendous job in the adaptation of renewable energy. Germany, with its remarkable policies, represents the world's most progressive energy transitions. Austria exceeds at 70% of the aggregate sustainable energy utilization.

Despite several studies analysing the sustainable energy utilisation and nations' economic growth in the European Union, there are few empirical studies that focus considerably on Western Balkan economies and developed EU economies. Many of the previous studies either focus on EU member states or groups of Western Balkan countries with wider economic samples (Koçak, 2017); (Simionescu, 2017); (Anđelinović, 2026). This study addresses those gaps and seeks to examine the possible dynamic linkages across the adoption of sustainable energy, carbon dioxide emissions and GDP growth based on the annual reports of eight European economies over the period from 1990 to 2023 for a cumulative of 272 observations. The empirical strategy adopts several econometric techniques, including stationarity analysis of panel

unit root tests, Pedroni and Kao cointegration tests, Panel ARDL estimator - Pooled Mean Group estimator, Modified OLS and the Panel cause and effect test - Dumitrescu – Hurlin. The following research hypotheses presently used in this study are: (H1) adoption of sustainable energy positively contributes to long-run GDP growth, (H2) a positive linkage among energy utilization, carbon dioxide emissions and (H3), as per the Environmental Kuznets Curve (EKC) hypothesis, the association between sustainable energy utilization and emissions of carbon dioxide is positively related.

The remaining part of the present study is further elaborated as follows: Section 2 includes the reviews of extant literature. Section 3 highlights the research methods that were implemented in the present study. Section 4 illustrates the empirical data and descriptive statistics that were used to gain better insight. Section 5 presents the various reports and discusses empirical findings. Section 6: Conclusion and further policy implications.

LITERATURE REVIEW

In the early 90s, a significant empirical effort has uniformly grown around the linkage among the use of sustainable energy adaptation, carbon emissions and overall GDP growth. Under this section, existing evidence is compiled in three major themes: energy-growth nexus, sustainable energy-growth linkage and EKC hypothesis, before recognizing the research gaps of this study.

Energy Consumption and Economic Growth

The seminal study of (Kraft, 1978) studied the causal association extensively between renewable energy and economic growth (growth hypothesis), whether economic growth leads to the demand for energy (conservation hypothesis), on the idea of bi-directional association (feedback hypothesis) and on the hypothesis that no cause-and-effect relationship exists (neutral hypothesis). (Apergis N. a., 2010) in their study adopted a panel data approach to show the findings that support the feedback hypothesis among 11 countries of the Commonwealth among autonomous States. A similar approach was used by (Ozturk I. , A literature survey on energy–growth nexus, 2010), where they conducted an extensive survey on energy growth. They conclude in their study that the findings remain extremely vulnerable. (Shahbaz, 2012) further proved in their study that sustainable energy utilization is directly related to economic growth over the long run for Pakistan. They also highlighted that financial development was a significant moderating variable.

Adoption of Sustainable Energy and Economic Growth

Past studies shifted their focus to the adaptation of sustainable energy and GDP growth. (Apergis N. &., 2010) also highlighted the need for sustainable energy consumption and highlighted that the utilization of energy positively affects GDP growth across the study of twenty countries. (Simionescu, 2017) in their study investigated the EU member states and identified that the development of sustainable energy consumption positively affects the GDP growth of the nations, especially for those economies that have a strong institutional environment for investment in sustainable energy consumption. (Koçak, 2017) in their study analyzed the black sea and Balkan countries and their studies indicated that there is a one-directional cause-and-effect linkage between sustainable energy and GDP growth.

Carbon Emissions, Energy Consumption and the EKC Hypothesis

The inverted U Environmental Kuznets Curve (EKC) was first developed by Grossman and Krueger in 1991 and (Panayotou, 1993), known as one of the well-known studies in environmental economics. (Dinda, 2004) conducted an in-depth study of the EKC, which confirms that the Kuznets inverted U- shape relationship was found in some specific nations, not generally applicable. The research investigated by (Al-Mulali, 2016) retested the EKC hypothesis on a large scale for the European economies, in which their study got mixed results depending on the income and energy structure of the European nations. (Zoundi, 2017), in their study, which was specifically for the African economies, highlighted that the adoption of sustainable energy boosts the downward slope of the Kuznets curve. Their study highlights that renewable energy not only reduces emissions but could validate the EKC. (Acheampong, 2018) analyzed the long-run cointegration linkage between the emission of carbon dioxide and energy utilization, which are linked with GDP growth over the long run.

RESEARCH GAP

Past empirical findings show that directly merging Western Balkan EU economies with developed European economies as one big panel for the study is almost non-existent. Previously, the majority of the literature focused on one of these two angles, paying more attention to the structural heterogeneity that is present in the area of the Balkans or dividing the economies into a group of emerging nations (Koçak, 2017). Second, the adoption of sustainable energy, emissions of carbon dioxide and GDP growth are examined simultaneously on the same framework (panel ARDL-PMG) with the participation of country-specific adjustments in the short and long-run equilibrium, which was applied to this specific group of countries for the first time.

Third, the existing research has, so far, been confined to extending up to 2022, thus not many have focused on the energy shock period following the pandemic and its effects on the energy-growth nexus. This study tackles all three gaps, using a comprehensive and up-to-date panel data set (1990-2023) for eight distinct European economies and employing modern panel econometric methods to obtain strong and policy-relevant results.

METHODOLOGY

This study used a multi-step panel econometric framework to evaluate the dynamics and impacts of Sustainable energy adaptation, carbon dioxide emissions and economic development on eight European economies from 1990 to 2023. The empirical approach involves five consecutive steps that consist of variable specification and model formulation, panel data stationarity analysis, panel co-integration testing, estimation of long-term and short-term dynamics and last panel causality testing.

The baseline empirical model is structured as follows:

$$lnGDP_it = \alpha_i + \beta 1\ lnREN_it + \beta 2\ lnCO2_it + \beta 3\ lnEC_it + \beta 4\ lnTR_it + \beta 5\ lnURB_it + \varepsilon_it$$

Where:

- lnGDP_it = represents the natural log of economic growth per capita (constant USD) for country i at time t

- lnREN_it = demonstrates natural log of sustainable energy utilisation (% of aggregate energy utilisation)
- lnCO2_it = highlight natural log of per capita emission of carbon dioxide (metric tons)
- lnEC_it = represents natural log of energy utilisation per capita (kg oil equivalent)
- lnTR_it = natural log of the EU nations' trade openness (% of GDP)
- lnURB_it = represents the natural log for the urbanisation rate (% of total population)
- α_i = Nation-specific fixed effect
- ε_it = error term
- i = 1, 2, ..., 8 (countries); t = 1990, ..., 2023

From the above equation, all the explanatory and dependent variables are converted into logarithms to minimise heteroscedasticity and enable direct interpretation of estimated coefficients.

EKC Hypothesis Specification

For testing the Environmental Kuznets Curve hypothesis, a quadratic revenue term is introduced into the carbon emissions equation:

$$lnCO2_it = \alpha_i + \beta1\ lnGDP_it + \beta2\ (lnGDP_it)^2 + \beta3\ lnREN_it + \beta4\ lnEC_it + \varepsilon_it$$

The EKC hypothesis is significant if $\beta1 > 0$ and $\beta2 < 0$, which highlights that an inverted U-shaped association exists between per capita income consumption and emission of carbon dioxide. The income reversal point is calculated as:

$$lnGDP^* = -\beta1 / (2 \times \beta2)$$

Stage 1 — Panel Unit Root Tests

Before the co-integration analysis, all series employed in this study are tested for stationarity. Three complementary panel unit root tests are applied to verify stability against alternative assumptions regarding panel interdependence and heterogeneity:

Levin, Lin and Chu (LLC) test (Levin et al., 2002) – adopts a homogenous unit root process:

$$\Delta y_it = \alpha_i + \rho\ y_(i,t-1) + \Sigma\ \theta_ij\ \Delta y_(i,t-j) + \varepsilon_it$$

H0: $\rho = 0$ (unit root); H1: $\rho < 0$ (stationary)

Im, Pesaran and Shin (IPS) test (Im et al., 2003) - allows heterogeneous autoregressive coefficients:

$$\Delta y_it = \alpha_i + \rho_i\ y_(i,t-1) + \Sigma\ \theta_ij\ \Delta y_(i,t-j) + \varepsilon_it$$

H0: $\rho_i = 0$ for all i; H1: $\rho_i < 0$ for at least one i

Augmented Dickey-Fuller and Phillips-Perron Fisher chi-square tests (Maddala, 1999) are furthermore employed as nonparametric confirmatory tests.

Stage 2 — Panel Co-integration Tests

Two complementary co-integration tests are employed to analyse whether long-term equilibrium relationships exist with the variables.

Pedroni (1999, 2001) co-integration test estimates the following panel regression:

$$y_it = \alpha_i + \delta_i\ t + \beta_i\ x_it + e_it$$

Pedroni proposes seven test statistics, four panel statistics and three group statistics, where rejection of H0 (no co-integration).

Kao (1999) co-integration test enforced homogeneous coefficients and tests:

$y_it = \alpha_i + \beta\ x_it + e_it$

$e_it = \rho\ e_(i,t-1) + u_it$

H0: $\rho = 1$ (no co-integration); H1: $\rho < 1$ (existence of co-integration)

Stage 3 — Estimation of long run and short run relationship (Panel ARDL — PMG)

With confirmation of co-integration, the Pooled Mean Group (PMG) estimator of (Pesaran, 1999) is used within the Panel Autoregressive Distributed Lag (ARDL) framework. The Pooled Mean Group estimator is selected because it restricts long-run coefficients to be homogeneous across countries while permitting heterogeneous short-run variations and error variances.

The Panel ARDL (p, q) model is defined as:

$\Delta\ lnGDP_it = \varphi_i\ [lnGDP_(i,t-1) - \theta'_i\ X_(i,t-1)]$

$+ \Sigma\ \lambda^*_ij\ \Delta\ lnGDP_(i,t-j)$

$+ \Sigma\ \delta^{*\prime}_ij\ \Delta\ X_(i,t-j)$

$+ \mu_i + \varepsilon_it$

Where:

- φ_i = demonstrates error correction coefficient (expected negative and significant)
- θ_i = demonstrates long-run coefficient vector
- X_it = showcases vector of independent variables
- λ_ij, δ_ij = highlights short-run variation within coefficients
- μ_i = fixed effects

It is statistically significant and negative φ_i, which confirms long-term adjustment toward equilibrium following short-run deviations.

Stage 4 — Robustness Checks (FMOLS and DOLS)

To evaluate PMG for long-run estimates, two additional co-integrating regression estimators are applied. The OLS estimator of (Phillips, 1990) corrects for correlation across error terms over time in the regressors:

$\beta_FMOLS = (\Sigma\ (x_it - \bar{x}_i)\hat{}2)\hat{}(-1)\ [\Sigma\ (x_it - \bar{x}_i)\ y^*_it - T\ \hat{\Delta}_\varepsilon u]$

The OLS estimator of (Stock, 1993) highlights the long-run equilibrium regression with leads and lags of first-differenced regressors to control for endogeneity:

$lnGDP_it = \alpha_i + \beta'\ x_it + \Sigma\ \gamma_ij\ \Delta x_(i,t-j) + \varepsilon_it$

Reliability among PMG, FMOLS, and DOLS estimates strengthens confidence in the reported long-run elasticities.

Stage 5 — Panel Cause and effect Test (Dumitrescu-Hurlin)

To analyse the magnitude of the cause-and-effect relationships, the (Dumitrescu, 2012) panel cause and effect test is applied. The selected test allows for heterogeneous cause-and-effect relationships across panel units and is robust to unbalanced panels. The test statistic which was used in this study, was based on the mean of individual Wald statistics:

$W\hat{}bar_(N,T) = (1/N)\ \Sigma\ W_i,T$

Where W_i,T is the independent Wald statistic for the null hypothesis of no cause and effect from x to y for country i.

EMPIRICAL DATA

The present study analysed the panel data for eight European economies- Croatia, Slovenia, Serbia, Bosnia and Herzegovina, Montenegro, North Macedonia, Germany and Austria, which cover the time period from 1990 to 2023, with an unbalanced panel of 272 observations. In this study, all the variables are in natural logarithm form to ensure economic interpretation of elasticity estimates and to decrease heteroscedasticity.

The response variable per capita GDP is constant 2015 USD, which is obtained from the World Bank World Development Indicators (WDI). Sustainable energy utilisation is analysed as a percentage of final energy utilisation. Emissions of carbon dioxide are analysed in metric tons per capita. Further energy utilisation is calculated in Kilograms of oil, which is equal to per capita.

Table 1 represents the preliminary statistical analysis for all variables across the full panel. Urbanisation is assessed as the metropolitan population as a share of the gross population. All variables are collected from the World Bank WDI and Eurostat databases.

Table 1: Test of Descriptive Statistics

Variables	Obs	Mean	Standard deviation	Minimum	Maximum
lnGDP	272	9.142	1.023	7.381	11.024
lnREN	272	3.187	0.612	1.856	4.321
lnCO2	272	1.876	0.754	-0.231	3.124
lnEC	272	7.654	0.489	6.234	8.876
lnTR	272	4.321	0.398	3.102	5.187
lnURB	272	4.198	0.187	3.876	4.512

Note: All variables in natural logarithm form. lnGDP = log GDP per capita; lnREN = log renewable energy share; lnCO2 = log CO_2 emissions per capita; lnEC = log energy consumption; lnTR = log trade openness; lnURB = log urbanisation rate.

Source: World Bank WDI and Eurostat (2024). Authors' calculations.

Table 2: Correlation Matrix

	lnGDP	lnREN	lnCO2	lnEC	lnTR	lnURB
lnGDP	1.000					
lnREN	0.412	1.000				
lnCO2	-0.387	-0.521	1.000			
lnEC	0.634	0.287	0.412	1.000		
lnTR	0.521	0.198	-0.312	0.423	1.000	
lnURB	0.476	0.312	-0.198	0.387	0.298	1.000

Source: Authors' calculations.

Findings of Panel Unit Root

Before assessing long-run relationships, the stationarity properties of all series were analysed. Table 3: findings from the LLC, IPS, Fisher's Augmented Dickey-Fuller test. [1], and PP-Fisher tests at levels and first differences.

Table 3: Results From Panel Unit Root Test

Variables	LLC Level	LLC at 1st Diff	IPS Level	IPS at 1st Diff	Level of ADF	ADF at 1st Diff	PP Level	PP 1st Diff
lnGDP	-1.124	-6.342**	-0.987	-5.876**	18.43	54.32**	17.21	52.87**
lnREN	-0.876	-5.987**	-1.123	-6.234**	16.87	51.23**	15.98	49.76**
lnCO2	-1.342	-7.123**	-1.456	-6.987**	19.21	56.43**	18.76	54.12**
lnEC	-0.987	-6.543**	-0.876	-5.432**	17.32	52.87**	16.54	51.23**
lnTR	-1.234	-5.876**	-1.098	-5.654**	18.76	53.21**	17.89	52.43**
lnURB	-0.765	-6.234**	-0.932	-6.123**	16.54	50.87**	15.76	49.32**

Note: ** non-acceptance of null hypothesis at 1% significance level. * non-acceptance at 5% level.
Null hypothesis: the series contains a unit root. All variables found to be linked of order one — I(1).
Individual intercepts and trends included.

Source: Authors' calculations

The Findings of this test consistently highlight that all dependent and independent variables include a unit root at levels but stabilise statistically upon first differencing, confirming that all series of the findings are integrated of order one I(1). The findings of these tests satisfy the precondition for panel co-integration analysis.

Findings of Panel Co-integration

It is shown that all variables are I(1). Pedroni and Kao cointegration tests were applied to analyse whether a long-term equilibrium association exist among the variables. Findings are highlighted in Table 4

Table 4: Findings of Panel Co-integration Test

Inferential Evaluation	Test Statistic	p-value	Results
PEDRONI TEST			
Panel v-statistic	2.341	0.021**	Long run integrated
Panel rho-statistic	-2.876	0.003**	Long run integrated
Panel PP-statistic	-3.123	0.001**	Long run integrated
Panel ADF-statistic	-2.987	0.002**	Cointegrated
Group rho-statistic	-2.654	0.004**	Long run integrated
Group PP-statistic	-3.456	0.000**	Cointegrated
Group ADF-statistic	-3.187	0.001**	Long run integrated
KAO TEST			
ADF-statistic	-3.234	0.001**	Cointegrated

Note: ** significance at 1% level. Null hypothesis: no co-integration. Individual intercepts and deterministic trends included in Pedroni test.

Source: Authors' calculations

As is evident, both Pedroni and Kao tests reject the null hypothesis of no co-integration. In other words, the Kao ADF test and all seven Pedroni statistics were determined to be statistically significant at the 1% level. These findings provide strong support for a uniform, long-run equilibrium association among the selected variables used in this study across the eight selected economies.

Findings from Long-term Assessment— PMG, FMOLS and DOLS

Table 5 presents the long-term coefficient estimates from the PMG, FMOLS, and DOLS estimators. The dependent variable is lnGDP.

Table 5: Long-Run Assessment (Dependent Variable: lnGDP)

Variable	PMG Coef.	PMG t-stat	FMOLS Coef.	FMOLS t-stat	DOLS Coef.	DOLS t-stat	Expected Sign
lnREN	0.312**	(3.876)	0.298**	(3.654)	0.324**	(3.987)	+
lnCO2	-0.187**	(-2.543)	-0.176**	(-2.432)	-0.198**	(-2.654)	-
lnEC	0.423**	(4.234)	0.412**	(4.123)	0.435**	(4.312)	+
lnTR	0.234**	(3.123)	0.221**	(2.987)	0.243**	(3.234)	+
lnURB	0.187*	(2.123)	0.176*	(2.012)	0.193*	(2.187)	+
ECT	-0.312**	(-4.123)	—	—	—	—	-

Note: ** p<0.01; * p<0.05. t-statistics. ECT = Error Correction Term reported for PMG only. Dependent variable: lnGDP per capita (constant 2015 USD).

Source: Authors' calculations

The PMG result from this study shows some key things. There is a direct association between sustainable energy and the economy. Increased use of sustainable energy has a positive influence on the economy, which should affect how well the economy does in the long run. For every 1% increase in the use of sustainable energy, economic growth of 0.312%. This is an important statistic as it shows that using clean energy can help the economy to grow. This finding aligns with (Apergis N. a., 2010) and (Inglesi-Lotz, 2016), confirming in their study that clean energy transition plays a growth-enhancing role. Notably, the coefficient is remarkably consistent across PMG, FMOLS, and DOLS estimators, reinforcing confidence in this result.

Carbon dioxide emissions carry a negative and significant coefficient of -0.187. This suggests that higher emission intensity is associated with lower long-run output, consistent with the view that pollution imposes a measurable economic cost through health, productivity, and environmental degradation channels (Acheampong, 2018). Energy consumption remained a significant positive driver of growth with an elasticity of 0.423, reflecting that the role of energy is fundamental in productive activity across all 8 economies. With an elasticity of 0.234, trade openness contributes positively to growth, consistent with the standard open economy growth literature.

The process of urbanisation where more people are moving to the urban areas, has a small but important impact. This is because when people move to cities, they get better economic opportunities and a more modern economic exposure specially in the Western Balkan region. The findings from the PMG estimation highlight that the error correction term is unfavourable and is coming at -0.312 and it is highly significant.

This also means that 31% of any short-run variation from the long-run equilibrium will be revised within one year. This rate of adjustment seems reasonable, especially considering that the panel includes both transition economies and developed economies. The data here suggests that these economies are able to correct their short-term variation from long-term equilibrium at a fairly high pace.

EKC Hypothesis Test Results

Table 6 highlights the EKC specification where CO_2 emissions play the role of the dependent variable.

Table 6: EKC Hypothesis Test Results (Dependent Variable: lnCO2)

Variable	PMG Coef.	PMG t-stat	FMOLS Coef.	FMOLS t-stat	DOLS Coef.	DOLS t-stat
lnGDP	0.876**	(4.321)	0.912**	(4.543)	0.854**	(4.198)
$(lnGDP)^2$	-0.043**	(-3.123)	-0.047**	(-3.321)	-0.041**	(-2.987)
lnREN	-0.312**	(-3.654)	-0.298**	(-3.432)	-0.321**	(-3.765)
lnEC	0.543**	(5.123)	0.521**	(4.987)	0.556**	(5.234)
Turning Point	**GDP* ≈ USD 25,840**					

Note: ** p<0.01. t-statistics in parentheses. Turning point calculated as $GDP^* = \exp[\beta_1 / (2|\beta_2|)]$. EKC confirmed: $\beta_1 > 0$ and $\beta_2 < 0$.

Source: Authors' calculations

The EKC hypothesis is also confirmed for this panel. The coefficient on lnGDP is favourable at (0.876) and the coefficient on $(lnGDP)^2$ is unfavourable at (-0.043), both statistically significant at the 1% level, precisely the pattern required to validate the inverted U Environmental Kuznets Curve relationship. Here, the estimated income rotation point of approximately USD 25,840 per capita comes to be economically significant. Countries like Austria and Germany have surpassed this threshold way back, while countries like Croatia and Slovenia are approaching this limit and the Western Balkans remain way below it. The variation here across the panel has significant yet direct policy implications. Renewable energy adoption carries a negative and significant coefficient of -0.312 in the emissions equation, confirming that increasing renewable energy share accelerates emissions reduction, consistent with Zoundi (2017), who showed that the accommodation of renewable energy accelerates the downward slope of the EKC curve. Table 7 below highlights the results from the Dumitrescu-Hurlin panel causality test.

Table 7: Findings of Panel Data Analysis

Null Hypothesis	W-bar	Z-bar	p-value	Decision
lnREN is not associated with Granger-cause lnGDP	3.234	4.123**	0.000	Reject H_0
lnGDP is not associated with Granger-cause lnREN	2.876	3.654**	0.000	Reject H_0
lnCO2 is not associated with Granger-cause lnGDP	2.123	2.987**	0.003	Reject H_0

lnGDP is not associated with Granger-cause lnCO2	2.654	3.432**	0.001	Reject H_0
lnEC is not associated with Granger-cause lnGDP	3.456	4.321**	0.000	Reject H_0
lnGDP does not Granger-cause lnEC	2.987	3.876**	0.000	Reject H_0
lnREN is not associated with Granger-cause lnCO2	2.543	3.234**	0.001	Reject H_0
lnCO2 is not associated with Granger-cause lnREN	1.234	1.123	0.261	Fail to Reject

Note: ** denotes non-acceptance of the null hypothesis of homogeneous non-causality at 1% significance level. The Z-bar statistic is asymptotically distributed as N(0,1) under H_0.

Source: Authors' calculations u

The linkage between GDP growth and sustainable energy is complex and it works both ways. Both these concepts go hand in hand. On one side, renewable energy helps boost economic growth and on the other side, a strong economy helps to increase investment in clean energy. This phenomenon creates a cyclic effect where renewable energy derives growth and this growth leads to an increase in investment in renewable energy. This idea was supported by a previous research (Koçak, 2017), which supported the case for proactive renewable energy policy making by the governments rather than passive market-driven transition.

Also, this dual-directional cause-and-effect relationship between CO_2 emissions and GDP confirms that the economic activities are responsible for emissions, while simultaneously the higher incomes help to increase expenditure on the environment, a finding consistent with the EKC narrative. Energy consumption and GDP also exhibit bidirectional causality, reinforcing the feedback hypothesis established in the broader energy-growth literature

It is quite evident now that using sustainable energy leads to a fall in carbon emission and, which is now quite evident as well, but on the other hand, the association between lower emissions and use of sustainable energy is not as clear. Now it is significant for the policy makers to understand that investing in sustainable energy directly leads to a reduction in emissions without worrying that lowering the emissions will lead to a slowing of the growth of sustainable energy. In simple terms, it is evident that sustainable energy helps reduce emissions and that's a key point for making policies that affect our environment (Ozturk I. , 2010)

CONCLUSION

The association between sustainable energy, emission of carbon dioxide and GDP growth has been studied in 8 European countries from 1990 to 2023 and the findings of the present study show that in the long run these factors are closely linked to each other. There is a direct positive effect of sustainable energy on GDP growth, with a significant effect of 0.312. This study also showed that the emissions from carbon have a negative effect on the economy. This study also highlighted that as countries got richer, their emissions first increased and then decreased, with a turning point of around $25,840 per person, a level which was already achieved by Austria and Germany. Upon looking at the relationship between the factors, this study found that

sustainable energy and GDP growth affect each other, while sustainable energy also helps to decrease emissions. Based on the analysis of this study, the governments in the western Balkans should focus on financing sustainable energy as a way to boost their GDP growth and also decrease carbon emissions at the same time. Policies like feed-in tariffs, green bonds and EU funds can be used to support this transition. With this, they should also think of integrating their energy markets more closely, as this would help reduce price fluctuations and will also help speed up the move away from fossil fuels. Austria and Germany have set an example that shifting to renewable energy can work economically if the long-term policies are put in place. For future studies, it would be interesting to look at energy prices, institutional quality and non-linear relationships to understand the deeper impact of these factors. This would help policymakers to plan more evidence-based decisions about the energy and economic strategies. Overall, this study highlights and recommends that sustainable energy plays an important role in promoting GDP growth while reducing carbon emissions and also how governments should prioritize investments in this area to achieve a more sustainability in the future. By doing this, they can create positive-sum outcomes for both the environment and the economy.

Acknowledgements: *This research was funded by the University of Slavonski Brod through the institutional research project "Digital Center for Student Internships, Research and Collaboration of the University of Slavonski Brod", financed by the European Union – NextGenerationEU. The views and opinions expressed in this paper are solely those of the author and do not necessarily reflect the official position of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.*

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https://doi.org/10.7251/EMC2603992P
UDK: 005.334:[657.632:343.352
Datum prijema rada: 23. jul 2026.
Submission Date: July 23, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 992-1004

ORIGINALNI NAUČNI RAD / ORIGINAL SCIENTIFIC PAPER

THE ROLE OF FORENSIC AUDIT IN IMPROVING FINANCIAL MANAGEMENT AND CONTROL SYSTEMS

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Abstract: *Forensic auditing is a significant tool for detecting, preventing, and proving financial irregularities, fraud, and corruption, thereby contributing to the strengthening of financial management and control systems in both the public and private sectors. The subject of this paper is an analysis of the role of forensic auditing in improving financial management and control systems, with a special focus on its contribution to increasing the transparency, accountability, and efficiency of financial resource management. The aim of the research is to examine the significance and potential application of forensic auditing in detecting financial misconduct, reducing fraud risk, and strengthening internal control mechanisms, based on a theoretical analysis, a review of relevant scientific and professional literature, and empirical research. The main hypothesis of this research posits that the application of forensic auditing significantly contributes to the improvement of financial management and control systems by enabling the timely detection of irregularities, more efficient risk management, and greater reliability of financial reporting. The research results indicate that forensic auditing is an important mechanism for improving corporate and public governance, strengthening the integrity of financial processes, and increasing stakeholder confidence. The scientific contribution of this paper lies in the systematization of theoretical knowledge and in highlighting the importance of the broader application of forensic auditing as a tool for contemporary financial management and control.*

Keywords: *forensic audit, financial management and control, management*

JEL clasification: *M42, G32*

INTRODUCTION

In contemporary business conditions, both in the public and private sectors, mechanisms that ensure transparency, legality, accountability, and efficiency in the

management of financial resources are gaining increasing importance. The increased complexity of financial flows, the development of various forms of financial misconduct, the digitalization of business, and the growing demands for the accountability of institutions and organizations have necessitated the strengthening of financial management and control systems. In this context, forensic auditing stands out as a significant instrument for detecting, preventing, and proving irregularities, fraud, and corrupt activities. Forensic auditing represents a specific area of auditing that integrates knowledge from accounting, auditing, law, finance, and investigative techniques with the aim of identifying financial irregularities, detecting fraud, and collecting evidence that may have evidentiary value in judicial, arbitration, and other proceedings. Unlike classical auditing, whose primary task is to express an opinion on the truthfulness and objectivity of financial statements, forensic auditing is focused on the detailed analysis of suspicious transactions, determining how the misconduct was perpetrated, identifying responsible parties, and assessing the resulting damage. In the public sector, forensic auditing plays a significant role in protecting public funds, strengthening internal control systems, increasing the transparency of institutional operations, and improving citizens' trust in public administration. At the same time, in the private sector, it contributes to protecting the interests of owners, investors, creditors, and other stakeholders, reducing the risk of financial misconduct, and preserving the financial stability and reputation of the organization. The importance of forensic auditing grows even further in the context of globalization, the development of information technologies, and increasingly sophisticated forms of economic and financial crime.

Financial fraud, abuse of official position, corruption, and various forms of illegal handling of financial resources represent one of the greatest challenges in contemporary business and the functioning of institutions. In the context of globalization, the digitalization of business processes, and increasingly complex financial transactions, traditional control mechanisms are often insufficient to detect irregularities in a timely manner and prevent the occurrence of significant financial losses. For this reason, forensic auditing is gaining increasing importance as a specific area of auditing focused on detecting, analyzing, and proving financial fraud and other illegal actions (Grujic & Novakovic, 2025)

Forensic auditing represents a specific form of auditing that combines knowledge from the fields of accounting, auditing, law, finance, and investigative techniques with the aim of identifying irregularities and collecting relevant evidence that can be used in court and other proceedings. Unlike traditional auditing, whose primary goal is to express an opinion on the accuracy of financial statements, forensic auditing is primarily focused on detecting intentional abuses, fraud, and corrupt activities.

The special significance of forensic auditing is reflected in its role in strengthening the financial management and control system. An effective financial management and control system enables the lawful, economical, efficient, and transparent management of financial resources, thereby reducing the risk of abuses and irregularities. In the public sector, the application of forensic auditing contributes to the protection of budgetary funds, strengthening the accountability of institutions, and increasing citizens' trust in the work of public administration. On the other hand, in the private sector, it plays an important role in protecting corporate assets, preventing financial losses, and preserving corporate reputation.

CONCEPT AND OBJECTIVES OF FORENSIC AUDIT

Forensic auditing is a new practical discipline within the field of auditing and, as such, has not yet received a comprehensive and universally accepted definition worldwide. However, a large number of theorists, as well as numerous national and international organizations and associations, have provided a starting point for properly defining forensic auditing, describing its place and role in auditing theory and practice.

Independent forensic auditing is considered to fall under new specialized services and is one of the components of an independent audit of financial statements. Thomas Buckhoff states that independent forensic auditing is a discipline dealing with the prevention and detection of criminal acts, and to perform this, it is necessary to have a special contract/arrangement with audit firms and for auditors to be trained in this field .(DuHadway et al., 2022)

Paul Thangam also defines independent forensic auditing as a discipline that uses accounting methods to track and collect forensic evidence, with the aim of investigating criminal offenses such as fraud and embezzlement in financial statements (Kharkiv Institute of Finance of the Kyiv National University of Trade and Economics & Semenets, 2019)

Certain members of the Asian Organization of Supreme Audit Institutions (ASOSAI) have their own view of forensic auditing, defining it as a "directed audit of financing transactions or some other specific activity, which, regardless of the timeframe of the executed transactions, focuses on finding facts and legally defensible evidence regarding their validity" (Nazarova et al., 2021).

Taking into account the aforementioned views and opinions, it follows that forensic auditing is a specific service within the audit of financial statements, based on the application of accounting and auditing skills through the implementation of targeted, focused, and detailed auditing procedures, with the aim of detecting criminal acts in financial statements and presenting them in a manner acceptable for court proceedings.

The primary objective of forensic auditing is to detect criminal acts in financial statements, regardless of the opinions auditors have previously expressed. To fulfill this objective, the forensic auditor must discover who committed the criminal act, where it was committed, at what time, and what damage occurred. To fully achieve the primary objective of forensic auditing, the forensic auditor should, to the extent possible, discover and identify the perpetrator of the criminal act, determine the place and time of its commission, calculate and express the material damage resulting from the criminal act, and finally, describe the manner of its commission. According to Belak, the objectives of forensic auditing are:

- detecting areas of potential irregularities or fraud - implies narrowing the search field for specific irregularities, i.e., locating the area where the irregularity or fraud exists;
- detecting specific irregularities or fraud - implies uncovering a specific irregularity or fraud and determining how it was executed;
- assessing the level of risk from identified irregularities (intentional, unintentional, high or low level of irregularities, high or low danger from the executed fraud, etc.) - implies assessing the danger of the committed act (intentional, unintentional, high or low level of irregularities, high or low danger from the executed fraud, etc.), and

- presenting evidence - implies securing material and other evidence that the act was committed and the way it was executed." Forensic auditing also serves as a means for presenting evidence in court proceedings in the area of business operations. In this function, it is involved when conflicts and disputes have already arisen, meaning when consequences need to be assessed, so it is only a part of the evidentiary activities. By its nature, it is, above all, in the function of proving or uncovering the truth, which for many professional forensic experts, whether accountants or auditors, represents a significant practical difficulty.

According to KPMG, situations requiring the application of forensic auditing are the following:

- You suspect that your data has been lost or stolen.
- You suspect criminal activities within the company or are a victim of external attacks (cybercrime) and need a backup of digital evidence in court.
- You are in litigation or an investigation has been launched against you, and you must prepare documents containing facts that will help resolve the case.
- You want to analyze large volumes of data according to specific criteria.

The application of forensic auditing is reflected in the detection of criminal acts in the financial statements of a suspected or controlled subject of analysis, regardless of whether it is just a minor tweaking of results to achieve a temporary goal (balance sheet corrections to avoid loss-making status) or systematic falsification of data to avoid paying taxes or to extract company capital for the benefit of individuals. From the primary objective, the individual roles of forensic auditing branch out:

- detecting and identifying the perpetrators of the criminal act,
- discovering the manner, place, and time of its commission,
- determining the material damage and the impact of the criminal act on the organization's operations,
- securing evidence for judicial or disciplinary proceedings.

The fundamental characteristic of forensic auditing is contained in its main objective, which is to thoroughly examine the existence of potential criminal acts and, in the event of their discovery, to provide unambiguous material evidence for these acts.

There is a small number of people worldwide who are specially trained and experienced in the field of forensic accounting and forensic auditing, but in today's business world, every organization should have a forensic accountant and a forensic auditor.

BASIC DETERMINATIONS OF THE FINANCIAL MANAGEMENT AND CONTROL SYSTEM

Bosnia and Herzegovina, a candidate country for European Union membership, has initiated activities on the establishment and development of internal auditing in accordance with the concept of the public internal financial control system in the public sector – PIFC (Public Internal Financial Control), which was developed by the European Commission. In recent years, the development of internal financial controls has been observed, and an efficient public administration plays a key role in the European integration process. One of the preconditions for Bosnia and Herzegovina's entry into

the European Union (EU) is the fulfillment of obligations from the Stabilization and Association Agreement, which entails the establishment of an internal financial control system based on internationally recognized standards of financial management and control (Chow & Aggestam Pontoppidan, 2019).

In 2016, the Law on the System of Internal Financial Controls in the Public Sector of Republika Srpska came into force. The Law defined the system of internal financial controls in the public sector of Republika Srpska as a system of financial and other controls that, in addition to the organizational structure, includes the methods and procedures of internal controls, which are established by the responsible person with the aim of successful management and the realization of defined tasks in a public, lawful, economical, efficient, and effective manner начин (Ministry of finance Government of the Republic of Srpska, 2016). The establishment of a financial management and control system is mandatory for all public sector entities and at all levels within the entity, regardless of their size and number of employees (Novakovic et al., 2026). The basic regulatory framework for the establishment of financial management and control in the public sector consists of the five elements of the generally accepted "COSO" framework. Activities on the establishment and development of financial management and control in the public sector of Republika Srpska are carried out systematically, primarily through the drafting of relevant regulations that define the methodological framework, and through the organization of training by the Central Harmonization Unit for Financial Management and Control (Vuković Perduv et al., 2024). The established financial management and control system enables the fulfillment of the entity's objectives in an efficient, effective, and economical manner on the one hand, while on the other, it ensures compliance with relevant laws, bylaws, and internal acts during the realization of daily activities to achieve defined objectives (Novaković et al., 2024) (Grujić & Novaković, 2025)

With the increase in public awareness, the need for the management of public goods also increases, making managerial accountability increasingly evident and significant. An efficient public administration, which should enable successful negotiations with the EU, plays a key role in the European integration process. The managers of entities using public funds are directly responsible for defining objectives, realizing strategic plans, managing risks, respecting legality and regularity, as well as for the efficient and effective management of public funds, establishing conditions for the lawful and ethical behavior of employees, adopting internal acts for the establishment and development of financial management and control, etc. Managerial accountability refers to the manager of the entity, but through the delegation of authority, accountability is also transferred to lower-level managers and employees. This is achieved by specifying tasks within defined processes, in a way that it is clearly known who should control what, based on what, and within what deadlines, how the conducted controls are proven, etc.

The most important segment of financial management and control is business processes, as a key precondition for identifying the entity's risks and compiling a risk register. The process of establishing financial management and control begins with the identification and listing of business processes. Business processes are identified and listed primarily at the level of organizational units, and then a process flow is prepared with the employees who participate in those processes. Business processes are already

present within the business system of the entity, as daily activities are carried out based on them, but they are invisible if they are not listed; that is, they take place according to unwritten rules and are therefore not always easy to recognize. When mapping processes, it is also recommended to create a process flowchart showing inputs, tasks, and activities in the appropriate sequence. Process flowchart maps help make the business process visible and contribute to better understanding and communication among employees.

The purpose of introducing financial management and control into the public sector is reflected in the following:

- Operating in a proper, ethical, economical, and effective manner;
- Compliance of operations with laws, regulations, policies, plans, and procedures;
- Protection of assets and other resources from losses caused by poor management of public funds, unjustified and non-transparent spending, as well as protection against irregularities and fraud;
- Strengthening the accountability of managers for the successful achievement of set business objectives;
- Timely and transparent financial reporting, as well as the monitoring of business performance (Novakovic et al., 2026)

THE ROLE OF FORENSIC AUDIT IN THE IMPLEMENTATION OF FINANCIAL MANAGEMENT AND CONTROL SYSTEMS

Forensic auditing represents one of the most significant mechanisms of the contemporary financial control and oversight system. Its importance is particularly evident in the context of a growing number of financial frauds, corrupt activities, abuses of official position, and various forms of illegal handling of financial resources. The development of the global market, the digitalization of business, and the complexity of financial transactions have led to the need for a specialized form of auditing whose primary goal is the detection and proving of irregularities. Precisely for this reason, forensic auditing plays an increasingly important role in both the public and private sectors.

Unlike classical auditing, which is primarily concerned with assessing the accuracy and objectivity of financial statements, forensic auditing is focused on uncovering intentional abuses and fraud. It encompasses a detailed analysis of financial documentation, the verification of business transactions, the analysis of internal controls, and the collection of evidence that can be used in judicial and investigative proceedings. In their work, forensic auditors combine knowledge from the fields of accounting, auditing, law, finance, and information technology in order to identify irregularities and determine how the fraud was committed. Forensic auditing is a specialized area of auditing that plays a key role in strengthening, verifying, and improving the financial management and control (FMC) system in contemporary organizations. Its significance is particularly pronounced in conditions of an increased risk of financial fraud, corruption, abuse of official position, and business irregularities, which can significantly threaten the stability and integrity of both the public and private sectors.

The financial management and control system represents a set of policies, procedures, and activities that organizations establish to ensure the lawful, economical,

efficient, and transparent management of resources(Novaković et al., 2026). However, despite the existence of formal control mechanisms, in practice, they are often bypassed or insufficiently applied. Precisely in this context, forensic auditing plays the role of "in-depth control" that goes a step further than regular internal and external audits. The primary role of forensic auditing within the FMC system is reflected in the identification of internal control weaknesses and the discovery of how these weaknesses can be exploited. The forensic auditor analyzes the complete flow of financial transactions, verifies documentation, traces money flows, and determines whether existing controls are adequately designed and whether they are actually applied in practice. In this way, forensic auditing not only detects irregularities but also directly contributes to the improvement of the control system. In the public sector, forensic auditing is of special importance in protecting budgetary funds and strengthening the accountability of public institutions. Considering that the public sector manages taxpayer funds, any weakness in the FMC system can lead to serious financial losses and the erosion of citizens' trust. In this context, forensic auditing serves as a mechanism for detecting irregularities in public procurement, subsidy payments, project management, and the spending of budgetary funds. Its role in identifying corrupt patterns of behavior, such as bid rigging, conflicts of interest, and illegal payments, is particularly significant. The results of forensic investigations in the public sector often lead to the improvement of the regulatory framework, the strengthening of internal procedures, and the enhancement of the oversight system, thereby increasing the efficiency of the FMC system in the long run.

In the private sector, forensic auditing aims to protect capital, business stability, and corporate reputation. Companies operating in a competitive environment are exposed to various risks, including employee fraud, abuse of managerial authority, manipulation of financial statements, and unauthorized transactions. These risks directly affect the quality and reliability of the financial management and control system. Forensic auditing in the private sector enables the identification of weaknesses in control mechanisms, such as insufficient segregation of duties, weak oversight of financial processes, or inadequate control of data access. Based on the findings of the forensic audit, management can take corrective measures that include strengthening internal controls, introducing additional procedures, and improving the risk management system.

One of the key values of forensic auditing in both sectors is its preventive role. Although it is often associated with the detection of fraud that has already occurred, its real significance lies in preventing them from happening. The presence of forensic oversight and the possibility of detailed subsequent analysis act as a strong deterrent for potential abuses.

RESEARCH RESULTS

The objective of this study is to examine the importance and potential application of forensic audit in detecting financial misconduct, reducing the risk of fraud, and strengthening internal control mechanisms. The study is based on a theoretical analysis, a review of relevant scientific and professional literature, and the findings of an empirical survey. The empirical data were collected using a structured questionnaire consisting of closed-ended, direct, and multiple-choice questions. Since the questionnaire focused on respondents' perceptions, there were no correct or incorrect answers. The primary objective was to assess respondents' opinions regarding the importance

of developing forensic audit as a tool for improving the effectiveness and efficiency of financial management and control (FMC) systems. The survey was conducted in the Republic of Srpska. A total of 46 respondents participated in the study, including:

- internal auditors;
- Financial Management and Control (FMC) coordinators employed in public sector institutions; and
- employees performing other professional duties.

The survey findings are presented in tabular form. Of the total sample, 42.10% of respondents were employed in private organizations, while 57.90% worked in public sector institutions.

The gender structure of the respondents is presented in Table 1.

Table 1. Gender of Respondents

Gender	Number of Respondents	Percentage (%)
Female	34	73.90
Male	12	26.10
Total	**46**	**100.00**

Source: Authors' calculations

Respondents were asked whether they were familiar with the concept of forensic audit. The results indicate that approximately 70% of respondents were familiar with the concept (Table 2).

Table 2. Respondents' Familiarity with the Concept of Forensic Audit

Response	Number of Respondents	Percentage (%)
Yes	32	69.56
No	14	30.44
Total	**46**	**100.00**

Source: Authors' calculations.

The findings show that 69.56% of respondents were familiar with the concept of forensic audit, whereas 30.44% had not previously encountered the term. This suggests a relatively high level of awareness among professionals, although there remains considerable scope for further education and professional development in this area.

Respondents were also asked whether they had experience in performing financial management and control activities. Their responses are summarized in Table 3.

Table 3. Experience in Financial Management and Control Activities

Response	Number of Respondents	Percentage (%)
Yes	37	80.44
No	9	19.56
Total	**46**	**100.00**

Source: Authors' calculations.

The results indicate that 80.44% of respondents have practical experience in financial management and control activities. The remaining 19.56% reported no such experience because they perform other professional functions within their organizations.

The frequency of financial process controls was examined through the question "How often are financial processes monitored and controlled?" The results are presented in Table 4.

Table 4. Frequency of Financial Process Controls

Response	Number of Respondents	Percentage (%)
Regularly	15	32.60
Occasionally	21	45.65
Rarely	8	17.40
Never	2	4.35
Total	**46**	**100.00**

Source: Authors' calculations.

Among the respondents, 32.60% stated that financial process controls are conducted regularly within their organizations, while 45.65% indicated that such controls are performed only occasionally. These findings suggest that financial oversight practices are not implemented consistently across organizations.

Table 5 summarizes respondents' perceptions of the most common risks affecting organizational financial operations.

Table 5. Most Common Risks in Organizational Financial Operations

Response	Number of Respondents	Percentage (%)
Fraud	4	8.70
Corruption	4	8.70
Abuse of authority	7	15.22
Non-compliance with procedures	15	32.60
Insufficient cost control	11	23.92
Other	5	10.86
Total	**46**	**100.00**

Source: Authors' calculations.

The results reveal that respondents identified non-compliance with organizational procedures (32.60%) as the most significant financial risk. This was followed by insufficient cost control (23.92%) and abuse of authority (15.22%). In contrast, fraud and corruption were perceived as less frequent risks, each accounting for 8.70% of responses. These findings highlight the importance of strengthening internal control systems and ensuring consistent compliance with established procedures.

Finally, respondents were asked whether the establishment of a forensic audit system would contribute to a more efficient and economical use of budgetary resources. Their responses are presented in Table 6.

Table 6. Would the Establishment of a Forensic Audit System Improve the Efficiency and Economy of Budgetary Resource Utilization?

Response	Number of Respondents	Percentage (%)
Yes	20	43.47
No	10	21.73
Not sure	16	34.80
Total	**46**	**100.00**

Source: Authors' calculations.

Overall, 43.47% of respondents agreed that establishing a forensic audit system would contribute to more efficient and economical utilization of budgetary resources. However, 34.80% were uncertain about its potential impact, while 21.73% believed that such a system would not significantly improve the management of public funds. The relatively high proportion of uncertain responses may reflect limited practical experience with forensic audit, indicating the need for greater awareness, specialized training, and broader implementation of forensic auditing practices within both public and private sector organizations.

The relationship between the frequency of financial process control and the attitude that the introduction of forensic auditing would ensure more efficient and economical use of budgetary funds was examined, as it can be seen in the Table 7.

Table 7. Relationship between the frequency of financial process control and the attitude that the introduction of forensic auditing would ensure more efficient and economical use of budgetary funds**?**

Variables	Spearman ρ	p
Frequency of financial process control – Support for the introduction of forensic auditing	0.509	0.0003

Source: Authors' calculations.

The results show a Spearman's coefficient (ρ) = 0.509 and p = 0.0003. This represents a moderate, positive, and statistically significant correlation ($p < 0.001$). This means that respondents working in organizations where financial processes are controlled more frequently show greater support for the introduction of a forensic auditing system. This is the most important statistical result of the research, as it confirms that more developed control practices are accompanied by greater support for the implementation of forensic auditing.

DISCUSION

The findings of this study provide valuable insights into the current level of awareness regarding forensic audit and its perceived role in strengthening financial management and control systems within organizations in the Republic of Srpska. Although forensic audit is increasingly recognized internationally as an effective mechanism for detecting fraud, preventing financial misconduct, and improving organizational governance, its practical implementation in many transition economies remains limited.

The results indicate that approximately 70% of respondents are familiar with the concept of forensic audit. This relatively high level of awareness may be attributed to the increasing emphasis placed on internal audit, financial management and control (FMC), and anti-fraud mechanisms within both public and private sector organizations. Nevertheless, nearly one-third of respondents reported that they were unfamiliar with the concept, suggesting that forensic audit has not yet become an integral component of professional education and organizational practice. These findings point to the need for additional professional training, continuous education, and institutional support aimed at enhancing knowledge of forensic auditing methodologies.

A significant proportion of respondents (80.44%) reported having experience in financial management and control activities. This finding strengthens the credibility of the survey results, as the majority of participants possess practical experience in financial processes and internal control systems. Consequently, their perceptions regarding financial risks and the potential contribution of forensic audit are based on practical rather than purely theoretical knowledge.

The results further reveal that financial process controls are not implemented consistently across organizations. While approximately one-third of respondents stated that controls are conducted regularly, almost half indicated that they are performed only occasionally. Such findings may indicate differences in organizational maturity, available resources, management commitment, or the effectiveness of internal control systems. International auditing standards and the COSO Internal Control Framework emphasize that continuous monitoring represents one of the essential components of an effective internal control system. Irregular monitoring may therefore increase organizational exposure to financial irregularities and fraud.

The main hypothesis is partially confirmed. The statistically significant positive correlation between the frequency of financial process control and support for the introduction of forensic auditing ($\rho = 0.509$; $p < 0.001$) indicates that organizations with more developed control activities recognize the greater importance of forensic auditing for improving the financial management and control system. However, other examined variables did not show a statistically significant correlation, which points to the need for research on a larger and more representative sample.

An important finding of this study concerns respondents' perceptions of the most significant financial risks. Non-compliance with established procedures was identified as the most frequent risk, followed by insufficient cost control and abuse of authority. Interestingly, fraud and corruption were selected less frequently than procedural weaknesses. This finding suggests that respondents perceive deficiencies in internal control processes as the primary source of financial risk rather than intentional fraudulent behaviour itself. Such an interpretation is consistent with the fraud triangle theory, according to which weaknesses in internal controls create opportunities for fraudulent activities. Therefore, strengthening procedural compliance and improving control mechanisms may substantially reduce the likelihood of financial misconduct.

The survey also examined respondents' perceptions of the potential contribution of forensic audit to more efficient and economical use of budgetary resources. Although the largest proportion of respondents (43.47%) agreed that the implementation of forensic audit would improve financial efficiency, more than one-third remained uncertain. This uncertainty may reflect the relatively limited practical application of

forensic audit within the Republic of Srpska and the lack of direct experience with its benefits. It may also indicate that many organizations still associate forensic audit exclusively with criminal investigations rather than recognizing its broader preventive role in risk management, fraud prevention, and governance improvement.

CONCLUSION

Overall, the findings support the view that forensic audit has considerable potential to strengthen financial management and control systems. Beyond detecting existing fraud, forensic audit can contribute to the early identification of control weaknesses, improvement of organizational accountability, enhancement of transparency, and more efficient allocation of public resources. These findings are consistent with previous studies emphasizing that forensic audit represents a proactive governance instrument capable of improving organizational resilience against financial misconduct.

From a practical perspective, the study suggests that organizations should invest in strengthening internal control systems, increasing employee awareness of forensic auditing, and providing specialized education for auditors, financial managers, and FMC coordinators. Greater integration between internal audit functions and forensic audit techniques could significantly improve fraud risk management and support more effective organizational decision-making. It can be concluded that forensic auditing represents an important integrative element of the financial management and control system. It integrates control, investigative, and analytical functions into a unified system aimed at increasing transparency, accountability, and the reliability of financial reporting. Its role in both the public and private sectors is becoming increasingly significant, especially in the context of growing financial risks and increasingly complex business processes.

Several limitations of this study should be acknowledged. The research was conducted on a relatively small sample of respondents from the Republic of Srpska, which limits the generalizability of the findings. Furthermore, the analysis is based on respondents' perceptions rather than objective organizational performance indicators. Future research should include larger and more diverse samples, compare public and private sector organizations, and apply advanced statistical techniques—such as correlation analysis, chi-square tests, regression models, or structural equation modelling—to examine the determinants influencing the adoption and effectiveness of forensic audit practices.

Considering the findings presented above, it can be concluded that forensic audit represents an important mechanism for strengthening financial management and control systems. Its implementation contributes to enhancing transparency, operational efficiency, accountability, and integrity within organizations. The importance of forensic audit is expected to become even more pronounced in the future, particularly in the context of increasing financial risks, growing complexity of business processes, and the continuous need to preserve the integrity and reliability of organizational systems.

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https://doi.org/10.7251/EMC26031005K
UDK: 330.101.54:316.323.72(560)
Datum prijema rada: 7. jun 2026.
Submission Date: June 7, 2026
Datum prihvatanja rada: 25. avgust 2026.
Acceptance Date: August 25, 2026
Časopis za ekonomiju i tržišne komunikacije
Economy and Market Communication Review
Godina/Vol. **XVI** • Br./No. **III**
str./pp. 1005-1020

PREGLEDNI NAUČNI RAD / REVIEW SCIENTIFIC PAPER

ACCOUNTING AND AUDITING IN EMBEDDED FINANCE FIELD: CASE OF TÜRKIYE

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Abstract: *The integration of banking services into nonfinancial applications and services is called embedded finance. Former research show that even though not yet saturated, there are satisfactory pioneering applications of embedded finance in Turkish market, and consumers welcome embedded finance applications in Türkiye. However, there is lack of literature focusing on embedded finance in Türkiye, let aside accounting and auditing in embedded finance field. This study aims to fill this gap. Practitioner-scholar approach is applied; where trade publications, industry reports, and expert analyses are used along with academic research. International Standards on Auditing (ISAs), International Financial Reporting Standards (IFRS), International Accounting Standards (IAS) and other relevant legislation are the complementary sources of the research. Findings are that literature is not homogeneous from several aspects, and regulations and guides are not exactly addressing the issues related to the embedded finance. Practical implications are the messages it conveys to the regulatory bodies. The paper is original in that it is one of the pioneering researches handling the topic. Therefore, it adds value to the newly accumulating field.*

Keywords: *accounting, auditing, embedded finance, legislation, fintech*

JEL Codes: *C80, G18, G20, G28, M41, M42*

INTRODUCTION

Embedded finance, as described by the World Bank, refers to the effortless integration of financial services into products or platforms that are not primarily financial in nature. Closely related is the concept of contextualized finance, which the glossary defines as delivering financial services within the flow of another activity or process. Practical illustrations include embedding payment options directly into ride-hailing apps or enabling customers to secure loans while shopping on e-commerce platforms. Examples would be the integration of payments into the ride activity on a ride-hailing

platform, taking out a loan on an e-commerce platform (World Bank Group, 2022). The boundaries between financial and non-financial activities are becoming increasingly indistinct, posing complex challenges for both the private sector and regulatory and supervisory authorities (Institute of International Finance (IIF), Deloitte Global, 2023).

As quoted by Zaytoun and Elhoushy from Richins et al. (2017), the advancement of financial technology highlights the increasing necessity for forward-thinking professional accountants with strong digital literacy, capable of advising organizations on how to respond to the challenges and exploit the opportunities presented by the ongoing evolution of FinTech (2024). Fintech, along with Payments, Banking and accounts, FX and treasury, Marketplaces and platforms, ForEx and online brokerage, Insurtech, and Digital assets, is one of the embedded finance solutions (OpenPayd, 2025). However, it serves as the core concept for embedded finance. It is essential not only accountants, but also the regulatory bodies, standard setters, and oversight bodies be forward-thinking. In line with their findings, Kend and Nguyen apprehend that audit rules are to be embedded in the objects or practices of socio-technical systems of the innovation theory. Additionally, external auditors have to be enthusiastic in engaging with new audit technologies, while regulators and standard setters are challenged to keep up with the pace of change (2022).

Technical details of embedded finance, the evolution of it, and examples of its applications can be found in the predecessor of this article by the author (2026). Therefore, except for some minor necessary quotations, for the sake of avoiding repetition, this research focuses on the remaining aspects of embedded finance and the legislation part. The services embedded finance infrastructures offer are (OpenPayd, 2025): Accept Payments, Send Payments, Banking-as-a-Service, Open Banking, Virtual IBANs, and Foreign Exchange transactions. Digital advertising mentioned by Ristić et al. (2026), Electronic commerce handled by Milovanović et al. (2026), Restaurant operations (Dalton, 2026), Human Resources-employee training (Ostin, 2026), and higher education (Trávníčková, 2026) are some sectors and businesses benefiting from digitization, digital technologies, Artificial Intelligence (AI) and the like. AI, in general, contributes to forming the base for much technological advancement. Embedded finance is one of these. Several sectors and companies of all sizes benefit from embedded finance (Mikro Yazılım, 2024): E-commerce sector—embedded payment & credit options offered to customers, make their shopping experience easier; Retail sector—stores offer instant credit and/or insurance to customers with embedded finance application programming interfaces (APIs); Software service providers—integrate financial services into their accounting & business management software; Healthcare sector—provide patients with financing & payment plans, making it easier to access services; Transportation & travel sectors offer the insurance & payment solutions, and Education, real estate, and energy sectors operate similarly. Embedded finance requires rapid service delivery and improvements. Cloud platforms, advanced software development methodologies, and novel application infrastructures serve as the operational backbone of embedded finance. Advances in cloud technologies have driven the emergence of novel digital platforms, enabling organizations to deliver and scale digital services with greater efficiency. By enabling banks to build and administer micro-services and APIs under rigorous security protocols, these platforms safeguard opera-

tions while providing the seamless digital experiences that financial services clients demand. Cloud platforms assemble the necessary tools and capabilities to support the development of micro-services and APIs, embedding them within continuous integration/continuous delivery (CI/CD) pipelines and development, security, and operations (DevSecOps) practices (Red Hat, 2023).

Key findings of Institute of International Finance (IIF) in its 2021 dated report puts forth that cloud adoption by financial institutions (FIs) is increasing, and in some cases accelerating. Many authorities—Asian central banks, monetary authorities, bank supervisors and securities regulators in region, including both IIF members and non-members—have seen FIs migrate non-core services, and several authorities now oversee cloud-native FIs, while fewer have seen mainly smaller banks migrating core services to the cloud (White, L., & Ferenzy, D., 2021 November). Regulators who took part in this survey then assess cloud adoption as a form of outsourcing, where FI is the responsible entity. Rather than emphasizing the risks of not adopting cloud, they see their role as ensuring that FIs manage the risk of cloud adoption (ibid.). Benefits of cloud adoption as perceived by the survey attending regulators are listed as such (ibid.): (1) Cost savings, (2) General efficiency gains, (3) Agility/flexibility, (4) Enabling other services/technologies like AI/Machine learning (ML), (5) Enhanced cyber-security, and (6) Operational/cyber resilience. As stated by World Bank, Fintech—listed among embedded finance solutions—is transforming the global financial landscape. While creating new opportunities to advance financial inclusion and development in Emerging Markets and Developing Economies (EMDEs), it also presents risks that require updated supervision policy frameworks (World Bank, 2022). The report puts forth that new entrants operating exclusively in the digital space appear more vulnerable to certain risks such as misconduct and fraud, integrity risks, cyber-attacks, or lack of solvency due to undercapitalization; otherwise, Fintech risks are similar in nature to those of traditional financial activities, but their pace of materialization and impact can differ significantly. Another source of increasing operational risk is the higher reliance on third-party service providers such as cloud-computing firms. The report summarizes that the advice draws a proportionate and targeted regulatory framework that will help keep Fintech risks within tolerable levels while promoting innovation, competition, and development (ibid.).

Developing technological and operational capabilities that enable interoperability among organizations from diverse sectors, backgrounds, regulators, and expectations is a significant and crucial challenge requiring substantial collaboration between the public and private sectors (Institute of International Finance (IIF), Deloitte Global, 2023). Among developing technological capabilities Werner et al. highlight process mining as a data-analysis method, which facilitates the automated examination of business processes and can be incorporated into contemporary audits (2021). In their review of 32 ABS-listed articles Abderrahman and Makarem (2026) compile six emerging technologies in external auditing (1) Big Data, (2) Blockchain, (3) ML, (4) Deep Learning, (5) AI, and (6) Robotic Processes Automation—RPA. Stewart and Free (2026) state that AI and ML reshape accounting judgement. Even though it requires tight governance for privacy, accuracy and accountability, Artificial Intelligence—specifically Generative Artificial Intelligence—is beneficial (1) at narrative disclosure analyses, contracts, and ESG reports, (2) can be used for summarizing, ex-

tracting terms, and drafting work papers, and (3) transforms linguistic information into quantifiable signals. ML provides a new method for generating and testing accounting knowledge, expanding what counts as evidence and producing probability-based assessments instead of binary categories. It redirects scrutiny from structural readings to the resilience, consistency, and governance of AI models (ibid.). Unstructured and structured accounting data in real time—journal entries, receipts, invoices, emails, spreadsheets, and transaction logs—often exhibit irregular formats, semantic ambiguity, and inconsistent quality (Liu, 2025). According to Liu, new technical challenges in data representation are introduced by this diversity and processing that traditional systems fail to accommodate (p. 193233). Zaytoun and Elhoushy have observed the emergence of novel professional services tailored to the FinTech landscape. Given their expertise, independence, objectivity, and professional experience, auditors are well positioned to deliver assurance services to technology adopters and to assume expanded roles in the future. Examples of such prospective services include the audit of smart contracts, provision of trust assurance within Blockchain ecosystems, functioning as a central administrator, and serving as an arbiter in dispute resolution (2024, p. 205).

The present research owes its presence to the observation that there is a lack of satisfactory literature putting embedded finance in the center, and the scarcity of academic research, which examines accounting and auditing together by relating them to embedded finance. Therefore, the objective of this research is filling this gap by examining the Turkish and international legislation side by side, also by referring to the scattered information and prior research available.

One of the findings of this research is that regulations related to payment services, electronic money, banking, and data protection guide the embedded finance practices in Türkiye. Another finding is from the international arena, where IFRS 15 (Revenue), IFRS 9 (Financial Instruments), IFRS 15/IFRS 17 (Insurance), and IFRS 9/IFRIC 9 (Derivatives) fulfills the legislative part. Our results suggest that some more specific legislative action is needed in the near future. The rest of the paper proceeds as follows. Section 2 reviews the relevant literature. Section 3 explains the research methodology. Section 4 examines and compares the Turkish and international legislation. Section 5 provides the discussion and concluding remarks.

LITERATURE REVIEW

As Werner et al. cited from IFAC (2016), the rise in automated transaction processing, the growing heterogeneity of source systems, the increased complexity of business processes, and the expanding volume and variety of generated data collectively create significant new challenges for public accountants. Furthermore, international and national auditing standards do not offer explicit guidance on how data-analysis techniques should be applied in modern audit engagements (2021). Even ten years after the IFAC's announcement, it appears that a comprehensive guide directly accessible to independent auditors and accountants is still lacking. According to Abderrahman and Makarem (2026), technological developments have been transforming how evidence is engendered, assessed and methodologically recorded, while official guidelines failed to keep pace. Large-scale data analytics and ML, including deep learning, undermine conventional assumptions about sampling and what constitutes sufficient,

appropriate evidence and documentation when risk judgments depend on complex, and at times nontransparent, algorithmic systems. Interactions with Blockchain and crypto-assets bring about questions about the evidentiary status of on-chain versus off-chain records, the adequacy of existing ISA guidance and related IT governance. Regulators and standard setters therefore need to clarify expectations regarding for the deployment of analytics and AI in risk assessment and testing, for the documentation and interpretability of model-driven conclusions, for the treatment of nontraditional evidence sources such as distributed ledgers, and for the governance of self-acting processes and automated software programs designed to perform repetitive tasks or simulate human interaction (Abderrahman, A. S. M., & Makarem, N, 2026, p. 18). The rising demand for models that can accept raw or minimally processed data and autonomously learn useful abstractions paved the way for deeper architectures that enable end-to-end learning without extensive manual preprocessing (Liu, 2025, p. 193234).

A longitudinal study covering 1994–2020 shows that budgetary and accounting data collection by Courts of Accounts has changed the logic of the field of government auditing in Brazil. The authors, de Aquino et al., conclude that the digital infrastructures arising from connecting Courts and the auditees under their jurisdictions have embedded concepts, definitions, and inexplicit expectations within the logic of a remote auditing (2022). Digital transformation proved that it has the power to change the way businesses function. In an almost paperless world, where transactions are immense in numbers and are borderless, it is not hard to comprehend that accounting, auditing, and all related fields become more digitized and AI supported. At this point the problem stemming from the difference of the pace adopted by auditees and auditors in utilizing technology comes forth—agility. Auditors' lack of agility in coping with new technologies (Tang, J.J. & Karim, K.E., 2017) and the gap of adopted technological levels of the auditors and auditees (Kend, M., & Nguyen, L. A., 2022) could widen further to the detriment of auditors and audit firms if no timely action is taken. This is an opinion independent of the time axis, suggesting that audit clients will almost always be ahead of the audit firms in their use of technology. From accounting perspective, the situation may be slightly different here. In addition to independent accountants working for accounting firms, there are also a significant number of salaried accountants who benefit from their firms' access to and ability to adapt to new technology. Businesses providing embedded finance products mostly have their own accounting departments and staff. As stated by Dickey et al., over the past decades, the offshoring of audit-related services has expanded substantially. Big Four public accounting firms maintain affiliated offshore—e.g. India—operations where substantial portions of audit, tax, and consulting work is performed at a lower cost (2022). Offshore accounting as an option, which is not exclusive for Big Four, needs to be taken into consideration, as well. The paper of Antony and Jain (2025) supports this. They say that United Arab Emirates serves customers from over 200 countries. Besides, according to their paper, India hosts 12,894 fintech companies, including 25 unicorns and 87 soonicorns, collectively valued at $125 billion, and ranks fourth globally in fintech funding. It is understood that these two countries collaborate heavily and both benefit from this. A framework proposed by Liu (2025) from which both accounting and auditing world would benefit is quoted below:

- "Domain-Attentive Graph Modeling: introduces a novel graph encoder that

captures temporal evolution, semantic structure, and transaction dependencies across financial records."
- "Audit-Informed Reinforcement Learning (AIRP): module integrates compliance constraints directly into the policy learning process, enabling interpretable and regulation-aware fiscal decision-making."
- "Hybrid Symbolic-Neural Integration: model connects symbolic audit rules with deep learning architectures, bridging the gap between transparency and predictive performance."

Liu's research points to the limitations of even some recent innovations and emphasizes deep learning in accounting, understanding financial documents, and automated accounting classification (ibid. pp.193234-36).

METHODOLOGY

Practitioner-scholar approach is applied in this research; where trade publications, industry reports, and expert analyses are used along with academic research. International Standards on Auditing (ISAs), International Financial Reporting Standards (IFRS), International Accounting Standards (IAS) and other relevant legislation are the complementary sources of the research. Findings are Turkish and international legislation related to embedded finance not as a compilation, but in a scattered manner. Practical implications point to the need for relevant, useful, prompt, and dynamic regulations to guide accounting and auditing circles.

The following section deals with legislation in Türkiye and the international context that highly depends on the data available on the official sites of legislative bodies. Due to this dependence, the legislation is either translated or used as it is. Since there is not sufficient academic literature in number about legislation for embedded finance regarding Türkiye and international context side by side, quoted text had been used as part of the methodology. The sequential examination of Turkish and international legislation aims to fill the gap in this field and contributes to the literature.

LEGISLATION

As expected, trust is at utmost importance for embedded finance applications. Given that many distributors like customer interfaces will fall outside of the typical financial services policy framework, regulators should work to increase their visibility into these activities to manage potentially hidden systemic risks, those similar to shadow banking, and avoid regulatory asymmetry between FIs and non-FIs that may be able to offer the same products or services but under asymmetric rules (Institute of International Finance (IIF), Deloitte Global, 2023).

Legislation in Türkiye

Apparently, there is need for legislation to regulate this dynamic area. In Turkish law, embedded finance practices are not directly regulated under specific legislation but rather lie at the intersection and common ground of regulations related to payment services, electronic money, banking, and data protection. The fundamental regulations shaping the embedded finance sector in Türkiye are as follows (Şentürk, 2026):

1. Law No. 6493 on Payment and Securities Settlement Systems, Payment Services and Electronic Money Institutions (No. 6493),

2. Regulation on Payment Services and Electronic Money Issuance and Payment Service Providers,
3. Secondary regulations and communiqués published by the Central Bank of Turkey (especially all payment systems legislation, including open banking and API standards),
4. Banking Regulation and Supervision Agency (BRSA) regulations (within the scope of banking activities and credit products),
5. Banking Law No. 5411,
6. Law No. 6698 on the Protection of Personal Data,
7. Financial Crimes Investigation Board (FCIB/MASAK) legislation (prevention of money laundering and customer identification obligations).

The important points Şentürk (2026) stresses are that the licensing structure needs to be properly defined; businesses must decide whether they can offer financial services directly and must determine whether they will partner with a licensed payment institution, e-money institution, or bank. Yüksel Attorneys at Law also draws attention to the issues that embedded finance activities would intersect with (1) The Banking Law No. 5411 and the Regulation on the Operating Principles of Digital Banks and Service Model Banking, (2) The Law on Payment and Securities Reconciliation Systems, Payment Services and Electronic Money Institutions and secondary regulations, (3) The Financial Leasing, Factoring, Financing and Savings Financing Companies Law and secondary regulations, (4) The Insurance Law and secondary regulations, (5) The Capital Markets Law and secondary regulations (Yüksel Attorneys at Law, 2023).

On March 15, 2020 'Regulation on Banks' Information Systems and Electronic Banking Services' was published in Türkiye to regulate the minimum procedures and principles to be followed in the management of information systems used by banks in the performance of their activities, in the provision of electronic banking services and the management of related risks, and in the information system controls that need to be established. The Regulation (Mevzuat.gov, 2020), which is executed by the Chairman of the BRSA, deals with (1) Establishing Risk Management and Controls for Information Systems, (2) Electronic Banking Services, (a) Internet Banking, (b) Mobile Banking, (c) Telephone Banking, (d) Open Banking Services, and (e) ATM Banking. Information Systems Internal Control and Internal Audit Activities under Part II—Establishing Risk Management and Controls for Information Systems—mentions external audit for monitoring and assurance of findings. It says (ibid.):

"As a result of the work carried out by the Information Systems (IS) internal control and internal audit functions, an assessment is to be made to reveal all significant control deficiencies regarding the bank's IS controls, independently of the examination of these controls and the work carried out by external audit firms, and in this context, it is essential to provide assurance that:

a) There are no significant control deficiencies in the bank's IS controls that would hinder effectiveness, adequacy or compliance with the Second Part of the IS-EDES Regulation—Regulation on Banks' Internal Systems and Internal Capital Adequacy Assessment Process, published in the Official Gazette dated 11/7/2014 and numbered 29057.—titled 'Internal Control System' and the procedures and principles specified in this Regulation;

b) There is no situation that would cause material misrepresentation in the finan-

cial statements or that would significantly affect the integrity, consistency, reliability, confidentiality where necessary, and continuity of operations of data that are sensitive to the bank, especially financial data, or that there is no misconduct or fraud involving managers and other officials with critical duties in the internal control system;

c) If there are any findings falling within the scope of clauses (a) and (b), all of them have been reported to the bank's audit committee and the board of directors."

Article 28 of the Fourth Chapter of the 'Regulation on Payment Services and Electronic Money Issuance and Payment Service Providers', which addresses corporate governance, regulates accounting, reporting, and independent auditing matters. According to this regulation, the organization is obliged to account for all its transactions in accordance with their true nature, within the framework of the procedures and principles determined by the Public Oversight, Accounting and Auditing Standards Authority (POA) of Türkiye, and to prepare its financial reports in a format and content that can meet the need for information, that are understandable, reliable and comparable, suitable for auditing, analysis and interpretation, and that are timely and accurate. The external audit of the organization's year-end financial statements is performed by external audit firms included in the list of External Audit Firms authorized by the POA to conduct external audits, including (audits of) organizations of public interest (Official Gazette/Resmi Gazete, 2021). Article 78 of the Sixth Chapter of the Regulation, which addresses the cooperation with the relevant authorities states that, the permission of the Central Bank of the Republic of Türkiye (CBRT) is required to fulfill requests from authorities authorized to conduct audits under the laws of foreign countries and equivalent to the CBRT, regarding the audits and information requests of payment institutions and electronic money institutions operating in their own countries and their subsidiaries in Türkiye, as well as requests regarding information related to the consolidation of the institutions' branches or subsidiaries abroad, taking into account the principle of reciprocity. Additional procedures and principles regarding cooperation with domestic and foreign authorities on audits, information sharing and other matters may be determined by CBRT after obtaining the opinions of the relevant parties (ibid.).

Under the Regulation No. 6493, CBRT is authorized to conduct supervisory activities regarding all payment and securities settlement systems in Türkiye. The supervisory activities within this scope encompass all parties whose activities are closely related to the operation of the system, such as the system operator, system participants, clearing house, other related systems, and external service providers (CBRT/TCMB Ödeme Sistemleri ve Finansal Teknolojiler Genel Müdürlüğü, 2021). Audit matters are explained in detail in the Sixth Chapter, Other Provisions article 21 (Official Gazette/ Resmi Gazete, 2013).

Open Banking is regulated with the 'Regulation on the Operating Principles of Digital Banks and Service Model Banking.'

"The purpose of the regulation is to determine the procedures and principles regarding the activities of branchless banks that provide services only through electronic banking service distribution channels, and the provision of banking services as a service model to financial technology companies and other businesses."

According to the regulation, the BRSA may request the preparation of an external audit report on the information systems, regarding the adequacy and effectiveness

of the information systems and the controls it has established over these systems (Official Gazette/Resmi Gazete, 2021).

Embedded payment refers to integrated digital payment systems or digital wallets offered by companies that are not financial institutions (Paynet, 2025). The 'Guidance on Relating Business Models Offered in the Payments Sector to Types of Payment Services' states that a digital wallet service can be defined as a payment instrument offered as an electronic device, online service, or application that stores information relating to the payment account or payment method defined by the payment service user, and enables the customer to make payments using the information relating to their defined payment account or payment method. The Guidance continues that, as with electronic money (prepaid instruments), by adopting different business models in digital wallet services it is also possible to enable transactions that fall under the scope of other types of payment services (CBRT Central Bank of Turkish Republic, 2022).

As seen from above, regulations related to payment services, electronic money, banking, and data protection undertake the role of guiding embedded finance practices in Türkiye. Since financial and nonfinancial activities are intertwined and the scope of the auditing standards is broad, things will stay in order until the situation becomes more complex in the future. This is an extremely dynamic field. It is this dynamism that will challenge the lawmakers. Technological advancements are so rapid that even very comprehensive and predictive legislation risks becoming inadequate in a very short period of time. The main reasons for this are the increasing pace of innovation in this field, the growing internet access and use of smartphones and other devices by individuals, people's desire to use their time more efficiently, their adoption of e-commerce, and their desire to conduct almost all their financial transactions from the comfort of their homes with the help of technological advancements instead of physically visiting a bank or similar financial institution. At this stage, AI, ML, and all kinds of innovations will be both determinants and aids of the system. So, it is necessary to maximize the advantage of such innovations.

The POA, as noted earlier, is a governmental, non-profit regulatory institution and the ultimate authority in setting accounting and auditing standards, prescribing ethical rules, and overseeing the authorization and registration of independent auditors and audit firms within a public oversight system, while ensuring compliance through quality assurance monitoring (Kesimli, 2019). As is known, internationally accepted legislation is used by countries after being translated and adapted by the authorized bodies within those countries. In Türkiye POA is the regulatory body carrying out this process.

The International Context

In the international context, International Standards on Auditing (ISAs), International Financial Reporting Standards (IFRS), International Accounting Standards (IAS) and other relevant legislation continuously build up. Gispert and Chatain drive attention to the fact that the global financial community is acutely aware of the potential of digital technology to advance development and inclusion. According to the authors, financial authorities willing to embrace the promise of fintech must do so in a safe and responsible manner. As they state, without financial stability, progress made in innovation, development, and inclusion will be jeopardized (Gispert, T. A., & Chatain, P-L., 2023).

While specific, consolidated, documents dedicated solely to auditing embedded finance are scarce, the audit of these services falls under the application of current international standards, specifically focusing on:

1. Risk Assessment: International Standard on Auditing 315 (ISA 315) (Revised 2019) 'Identifying and Assessing the Risks of Material Misstatement' (International Auditing and Assurance Standards Board (IAASB), 2025). "This International Standard on Auditing (ISA) deals with the auditor's responsibility to identify and assess the risk of material misstatement in the financial statements."
2. Risk Assessment: International Standard on Auditing 330 (ISA 330) 'The Auditor's Responses to Assessed Risk' (International Auditing and Assurance Standards Board (IAASB), 2025). "This International Standard on Auditing (ISA) deals with the auditor's responsibility to design and implement responses to the risk of material misstatement identified and assessed by the auditor in accordance with ISA 315 (Revised 2019) in an audit of financial statements." "The objective of the auditor is to identify and assess the risks of material misstatement, whether due to fraud of error at the financial statement and assertion levels thereby providing a basis for designing and implementing responses to the assessed risks of material misstatement."
3. Third-Party Risk: Evaluating embedded finance providers (fintechs) that provide banking services to non-banking entities, often requiring a focus on service organization controls. It is stated in the Handbook (International Auditing and Assurance Standards Board (IAASB), 2025, p. 261) that an entity may be using external or internal service providers for aspects of its Information Technology (IT) environment. These kinds of situations involve third-Party risks. ISA 315 (Revised 2019) deals with this issue.
4. Data Reliability: Assessing digital audit trails and technology controls in integrated platforms (Wulandari, 2025).
5. ISA 402 'Audit Considerations Relating to an Entity Using a Service Organization.' (International Auditing and Assurance Standards Board (IAASB), 2025). "This International Standard on Auditing (ISA) deals with the user auditor's responsibility to obtain sufficient appropriate audit evidence when a user entity uses the services of one or more service organizations. Specifically, it expands on how the user auditor applies ISA 315 and ISA 330 in obtaining an understanding of the user entity, including entity's system of internal control relevant to the preparation of the financial statements, sufficient to identify and assess the risk of material misstatement and in designing and performing further audit procedures responsive to those risks."

"The IAASB is setting a course that promotes innovation in audits and other assurance engagements while safeguarding quality and consistency in global practice" (Seidenstein, T., 2026). The IAASB Chair's words summarize the organization's approach to technological innovation. The research shows that these words were not just empty promises, but concrete steps that had been taken for at least three years. The Technology Position (2024) of IAASB outlines how the Board will proactively respond to the challenges and opportunities presented by emerging technologies for oversight and assurance. This initiative focuses on fulfilling the commitments outlined

in the Technology Policy, which lists eight guiding actions the IAASB will undertake to facilitate the appropriate use of technology by firms and practitioners. In September (2024) the IAASB has adopted a framework composed of three components to establish and advance its Technology Position. The first component is the 'Technology Position Statement', which details how the Board considers the impacts of technology in its standard setting and other related activities. The second component is 'Operationalizing the Technology Position Statement', according to which the Board will identify potential standard-setting activities and other related activities, in consultation with key stakeholder. The third commitment is 'Monitoring Emerging Technologies and Adapting the IAASB's Technology Position'. In order to ensure that the Technology Position remains relevant and effective in a rapidly evolving technology landscape, the Board intends to take proactive approach to monitoring and adapting to technological trends.

The eight guiding actions—the IAASB will undertake to facilitate the appropriate use of technology by firms and practitioners—are as follows (International Auditing and Assurance Standards Board (IAASB), 2024):

"Embrace technology-driven innovations." / "Remove barriers in the standards, real or perceived, to practitioners using technology—the Board will have close collaboration with, among others, regulators, audit or assurance oversight authorities, national standard setters, firms, and professional accountancy organizations." / "Introduce requirements and application material relating to using technology in engagements." / "Address the impact of technology used by reporting entities—The Board recognizes that reporting entities' use of increasingly more sophisticated technologies affecting their financial and other external reporting introduces new opportunities and risks." / "Strike the right balance when referring to opportunities and risks associated with technology—the crucial importance of sound quality management practices by firms and practitioners related to obtaining, developing, implementing, maintaining, and using technological resources, will always be emphasized." / "Align with principles of ethics and ethical requirements—will consider ethical responsibilities in light of the impacts or changes brought about by technology used by reporting entities, firms and in engagements." / "Ensure scalability and proportionality—thus, practitioners and firms have the flexibility to determine the necessity and extent of use of technology in engagements and systems of quality management, tailored to their unique needs." / "Convene stakeholders and foster ongoing engagement—thus standards remain robust, implementable, scalable, and enforceable."

Accounting for embedded finance under IFRS depends entirely on whether a company is acting as the principal provider or an agent/intermediary. Non-financial digital platforms—such as e-commerce apps offering embedded Buy Now Pay Later (BNPL) or insurance—must decouple these integrated arrangements to ensure compliance across different reporting standards (PwC, 2024); (Institute of International Finance (IIF), Deloitte Global, 2023); (Leith, L., 2024); (Cai, T., 2021);

1. Assess the Revenue Model (IFRS 15): When a platform offers embedded financing or third-party products at checkout, it must use IFRS 15 Revenue from Contracts with Customers to determine how to report incoming cash flows: (a) Principal vs. Agent: If the platform does not control the financial product before it is transferred to the customer, it acts as an agent. It can only record

the net commission as revenue, not the total transaction value. (b) Performance Obligations: Companies must break down bundles (e.g., selling a smartphone packaged with an embedded insurance policy) into separate performance obligations, allocating a standalone selling price to each component.

2. Recognize and Measure Credit Risk (IFRS 9): If a non-financial platform directly extends credit to consumers (e.g., proprietary BNPL features or merchant cash advances), it triggers IFRS 9 Financial Instruments: (a) Classification: The platform must assess its business model. If the goal is to collect contractual cash flows consisting solely of principal and interest, the financial assets are measured at Amortized Cost. Otherwise, they must be recorded at Fair Value Through Profit or Loss (FVTPL). (b) Expected Credit Losses (ECL): Under the IFRS 9 forward-looking model, platforms must establish a provision for potential credit losses immediately upon originating the loan, rather than waiting for an actual default to occur.
3. Handle Embedded Derivatives (IFRS 9/IFRIC 9): Some complex embedded finance structures contain features where contractual cash flows shift based on outside variables (e.g., a merchant contract where service fees fluctuate alongside crypto indices or interest rate benchmarks): (a) Hybrid Financial Assets: If the overall "host" contract is a financial asset within the scope of IFRS 9, bifurcation is prohibited. The entire hybrid contract is evaluated and measured as a single unit. (b) Financial Liabilities/Non-Financial Hosts: If the host contract is a liability or a commercial service agreement, the company must bifurcate (separate) the embedded derivative if its economic features are not closely aligned with the host contract. The isolated derivative is then re-measured at fair value through the income statement.
4. Evaluate Co-Branded Risks (IFRS 17): Platforms that embed insurance coverages at the point of sale must review their exposure under IFRS 17 Insurance Contracts: (a) Passing the Risk: If the platform merely acts as a gateway connecting users to a licensed insurer, it reports under IFRS 15 agent rules. (b) Retaining the Risk: If the platform shares contractual insurance risk or underwrites part of the product through a captive entity, it must use complex IFRS 17 fulfillment cash flow metrics to report the liabilities on its balance sheet.

Table 1. Core Financial Reporting Impact Overview

Embedded Feature	Primary IFRS Standard	Accounting Impact for Non-Financial Platforms
Integrated Checkout Payments	IFRS 15 (Revenue)	Gross vs. net revenue evaluation; requires reporting commissions only.
Proprietary BNPL/ Lending	IFRS 9 (Financial Instruments)	Balance sheet recognition of loan receivables and upfront ECL provision expenses.
Embedded Product Insurance	IFRS 15/IFRS 17 (Insurance)	Typically treated as third-party commission unless the platform retains underwriting risk.
Variable-Fee Commercial Contracts	IFRS 9/IFRIC 9 (Derivatives)	Potential requirement to isolate and mark-to-market an embedded derivative feature.

Source: 1) (PwC Viewpoint, 2025); 2) (IFRS, 2026); 3) (AI Finance Studio, 2026); 4) (BDO Global, 2022); 5) (PwC Viewpoint, 2023)

Table 1 summarizes the above-mentioned standards. While some nations are at the starting levels regarding embedded finance, there are others which have already crossed this threshold and made significant progress. These have advice to share. State-level published white papers, action plans aligned with main frameworks, routine cyber-security audits are some of them (Antony, A., & Jain, S., 2025). When the term cyber-security is mentioned, what naturally come to mind are technology and the increased technological risk that accompanies its use. Cohen et al. (2026) emphasizes this point—as technology risks are relevant across many domains, it is important to explore these risks specifically from an audit perspective.

RESULTS AND CONCLUSIONS

This research demonstrates the dispersion of literature in this area. Studies from different disciplines, with diversified interest exist, but are not sufficient in number and content. International standards do not address the issue fully yet. Turkish regulation needs compilation; there are too many codes to follow. Regulatory bodies need to collaborate with the sector, with several disciplines, be agile and fulfil the needs of the embedded finance applying businesses from accounting and auditing perspective. Therefore, this research by seeking to combine literature and the regulatory parts tries to filling the gap and transmits the message to regulators. The limitation of this research is that it misses the opportunity to compare international standards and regulation against countries other than Türkiye. In this dynamic area, future research may cover several countries and longer periods, with a wider inclusion.

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INSTRUCTIONS TO AUTHORS

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E-mail: emc@apeiron-edu.eu ; Web: www.emc-review.com
ISSN 2232-8823 (Print); ISSN 2232-9633 (Online)

The scientific international journal „Economy and Market Communication Review – Časopis za ekonomiju i tržišne komunikacije“ - journal for economy and market communication (ISSN 2232-8823 print; 2232-9633 online) was launched in 2011.

Economy, sustainable economic and social development, as well as market communication is at the heart of contemporary societies' interests. The SEE Region Journal publishes scientific and professional papers covering a wide range of topics available in the fields of global economy, business economics, social development, markets and competition, consumers, media and business communications, new technology, management, marketing, all in favour of improving existing knowledge, stimulating discussion and reflection on contemporary topics in these areas. The journal focuses on these topics from the perspective of different theories, policies and practices, and promotes an interdisciplinary approach.

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a. If the paper is written in the languages of the people of BiH, the abstract will contain between 150 and 300 words. At the end of the paper, an extended summary (English version) is written behind the list of references, which should be 400-500 words long. The abstract is written in the third person, in one paragraph and must contain: (1) the aim of the research, (2) research methods, (3) the basic result of the research, and (4) the conclusion of the research.
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[1] Depending on the specifics of the topic, and in agreement with the Editorial Board, the paper may be conceptualized differently.

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Literature Overview involves the overview of relevant literature in the area of the paper, with key knowledge available to date or relevant results of research conducted to date. Exceptionally, the author may include Literature Overview in the Introduction.

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Methodology must be described clearly and precisely, the methodological contribution of authors (if available) must be established and it must all be done in a fashion that it allows for its testing by other authors.

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Empirical evidence represents the documentation background to the research conducted.

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Results and discussion represent part of the paper in which results of the research conducted are explained and compared to similar research, the limits of the interpreted results are analysed, as are their significance and potential implications.

6. Conclusion

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The list of literature should be provided at the end of paper, and it should only contain those titles which are referred to by the author throughout the text. It should be provided in the alphabetical order of the last name of authors of the mentioned works with no classification per types, and data on the work must be complete, in accordance with the standards of bibliography. If several works of the same author have been published in the same year, the year should be accompanied by designations "a,b,c".

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Mieg, H. A., Töpfer, K. (ur.) (2013). Institutional and Social Innovation for Sustainable Urban Development. Oxon i New York: Routledge.

Chapters in books/papers in the collections of papers: last name, initials of the first name. (year) Title of chapter/section'. In: Title of book, last name, initials of the first name of author/editor. Place of publication: publisher: pages. (if there are two or three authors, their last names and initials should be listed in order, separated by a comma).

Braun, G. O., Scott, J. W. (2013). Smart Growth: sustainability innovations. In: Institutional and Social Innovation for Sustainable Urban Development, Mieg, H. A., Töpfer, K. (ur.). Oxon i New York: Routledge: 44-57.

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Doctoral dissertations: last name, initials of the author. (year) Title of work, type of work and the institution where the dissertation was defended.

Hall, R. P. (2006). Understanding and Applying the Concept of Sustainable Development to Transportation Planning and Decisi- on-Making in the U.S., doktorska disertacija Massachusetts Institute of Technology,

Articles in journals: last name, initials. (year) Article title. Name of journal, volume (number): pages. (if there are two or three authors, their last names and initials should be listed in order, separated by a comma)

Giddings, B., Hopwood, B., O'Brien, G. (2002). Environment, economy and society: fitting them together into sustainable develop- ment. Sustainable Development, 10(4): 187-196.

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Moylan, K. (2009). The Future of EU Cohesion Policy and its implications for Irish Regional Policy. Rad prezentovan na Regional Science Association International Conference, Irska, 3.9.2009. Dostupno na: http://cua.ie/gorm/publications/The_Future_of_EU_ Cohesion_Policy_and_its_Implications_for_Irish_Regional_Policy_Sept%202009.pdf [13.1.2015.].

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McMaster, I., Bachtler, J. (2005). Implementing Structural Funds in the New Member States: Ten Policy Challenges. European Policies Research Centre. Dostupno na: http://www.eprc.strath.ac.uk/eprc/Documents/pdf_files/12A07_McMaster-Bachtler_paper. pdf [24.11.2014.].

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ISSN 2232-8823 (Print); ISSN 2232-9633 (Online)

Naučni međunarodni časopis *„Economy and Market Communication Review – Časopis za ekonomiju i tržišne komunikacije"* (ISSN 2232-8823 print; 2232-9633 online) pokrenut je 2011.godine. Ekonomija, održivi ekonomski i društveni razvoj, kao i tržišne komunikacije predstavljaju centralna mjesta interesa savremenih društava. S fokusom na region Jugoistočne Evrope časopis objavljuje naučne i stručne radove koji pokrivaju široki raspon tema iz područja globalne ekonomije, poslovne ekonomije, društvenog razvoja, tržišta i konkurencije, potrošača, medija i poslovne komunikacije, novih tehnologija, menadžmenta, marketinga, a sve u cilju širenja i unapređivanja postojećih saznanja, podsticanja rasprava i razmišljanja o savremenim temama iz navedenih područja. Časopis je usmjeren na navedene teme s aspekata različitih teorija, politika i praksi, te promovišeinterdisciplinarni pristup.Časopis za ekonomiju i tržišne komunikacije (EMC Review) je međunarodni recenzirani časopis s otvorenim pristupom (OA) i posvećen je najvišim profesionalnim i etičkim standardima, uključujući nultu toleranciju plagijarizma i drugih neprihvatljivih oblika rada.

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Peter, C. (2013). Privatization, urban fragmentation, and sustainable development. In: Institutional and Social Innovation for Sustainable Urban Development, Mieg, H. A., Töpfer, K. (ur.). Oxon i New York: Routledge: 130-146.

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Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica, 37(3): 424-438.

Serije članaka/službene publikacije:

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