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Psychological Safety and Team Performance: Mapping Key Insights and Emerging Trends

Психолошка сигурност и тимски учинак: Мапирање кључних увида и нових трендова

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Abstract

Purpose: Psychological safety is a central concept in team research, widely recognized as a key driver of team performance. However, the rapidly growing body of research remains conceptually diverse and scattered across multiple disciplinary areas, making it difficult to consolidate dominant themes and new directions. This study maps and synthesizes recent research to identify the field's intellectual foundations, dominant themes, and emerging research fronts shaping current and future work.

Methodology: This study conducts a bibliometric mapping of literature on psychological safety and team performance from 2018 to 2025, analyzing 278 publications retrieved from the Web of Science Core Collection. VOSviewer and Bibliometrix were used to apply performance analysis and science mapping techniques, including keyword co-occurrence, reference co-citation, and bibliographic coupling.

Findings: The results reveal a highly interconnected research landscape in which psychological safety acts as a central hub linking multiple performance-related mechanisms. Dominant themes include leadership, communication and coordination, conflict and diversity, and trust, with recent research highlighting measurement refinement, contextual factors, and practical applications in understanding team performance.

Originality: This study systematically maps and synthesizes recent research on psychological safety and team performance, clarifying a fragmented field by identifying its intellectual foundations, key themes, emerging directions, and context-dependent mechanisms with implications for future research and practice.

Practical implications: The findings offer decision-makers and team leaders actionable insights to enhance psychological safety, optimize team performance, and tailor management practices to complex, dynamic work environments.

Limitations: Future research should expand database coverage and strengthen theoretical integration by exploring multilevel mechanisms, longitudinal designs, and contextual moderators influencing the psychological safety–performance relationship.

Keywords: psychological safety, team performance, team effectiveness, team dynamics, bibliometric analysis, co-citation analysis, bibliographic coupling, co-occurrence network.

JEL classification: M12, M14

Сажетак

Циљ: Психолошка сигурност је централни концепт у истраживању тимова, широко препознат као кључни покретач тимских перформанси. Међутим, брзо растући корпус истраживања остаје концептуално

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разнолик и расут по више дисциплинарних области, што отежава консолидацију доминантних тема и нових праваца. Ова студија мапира и синтетише недавна истраживања како би идентификовала интелектуалне темеље области, доминантне теме и нове истраживачке фронтове који обликују садашњи и будући рад.

Методологија: Студија спроводи библиометријско мапирање литературе о психолошкој сигурности и перформансама тимова у периоду од 2018. до 2025. године, анализирајући 278 публикација преузетих из базе Web of Science Core Collection. За анализу су коришћени алати VOSviewer и Bibliometrix, примењујући технике перформансне анализе и мапирања науке, укључујући анализу ко-појављивања кључних речи, ко-цитирање референци и библиографско повезивање.

Резултати: Резултати показују високо међусобно повезан истраживачки пејзаж где психолошка сигурност служи као централно чвориште које повезује вишеструке механизме повезане са учинком. Кључне теме укључују лидерство, комуникацију и координацију, конфликт и разноликост, и ставове засноване на поверењу, при чему недавна истраживања наглашавају усавршавање мерења, контекстуалне факторе и практичне примене, сигнализирајући помак ка контекстуално осетљивом, механизмима заснованом разумевању његовог утицаја на тимски учинак.

Оригиналност: Ова студија систематски мапира и синтетише недавна истраживања о психолошкој сигурности и тимском учинку, разјашњавајући фрагментирано поље идентификујући његове интелектуалне темеље, кључне теме, нове правце са импликацијама за будућа истраживања и праксу.

Практична примена: Резултати нуде доносиоцима одлука и вођама тимова практичне увиде за побољшање психолошке сигурности, оптимизацију тимског учинка и прилагођавање управљачких пракси сложеним, динамичним радним окружењима.

Ограничења истраживања: Будућа истраживања треба да прошире покривеност базе података и ојачају теоријску интеграцију истраживањем механизма на више нивоа, лонгитудиналних дизајна и контекстуалних модератора који утичу на однос између психолошке сигурности и перформанси.

Кључне речи: психолошка сигурност, тимске перформансе, ефикасност тима, тимска динамика, библиометријска анализа, анализа коцитирања, библиографско повезивање, мрежа ко-појављивања.

ЈЕЛ класификација: M12, M14

Introduction

Teams represent the dominant organizational form through which complex tasks are executed and knowledge is coordinated in contemporary organizations. As a result, team effectiveness and team performance have become central drivers of organizational outcomes and competitive advantage (Mathieu et al., 2019). In this context, team success does not depend solely on individual members' competencies, but also on the quality of team processes, communication patterns, and socio-emotional climates that enable collaboration, learning, and decision-making under uncertainty (Kozlowski & Ilgen, 2006; Salas et al., 2015). A critical question in organizational research is therefore why some teams manage to leverage diverse expertise, openly share information, and detect mistakes early, while other teams remain silent, suppress concerns, and underperform despite comparable resources.

One of the most influential constructs proposed to explain such differences is psychological safety, typically defined as a shared belief that the team is safe for interpersonal risk-taking allowing members to ask questions, express concerns, admit errors, and offer new ideas without fear of negative interpersonal consequences (Edmondson, 1999). Psychological safety is particularly relevant in organizational settings because it directly addresses the broader phenomenon of organizational silence and the (un)willingness of employees to speak up when doing so could prevent harm or improve

outcomes (Morrison & Milliken, 2000). When present, psychological safety enables critical team behaviors such as voice, knowledge sharing, and learning from failure, processes that are widely recognized as performance-relevant mechanisms (Detert & Burris, 2007; Edmondson, 1999).

Team science research further suggests that psychological safety functions as an enabling condition for key performance mechanisms, including team learning, coordination, adaptation, and effective decision-making (Kozlowski & Ilgen, 2006; Salas et al., 2015). In complex and high-risk environments, such as healthcare and operating teams, psychological safety is especially important because it supports error reporting, rapid information exchange, and proactive prevention of adverse outcomes (Edmondson, 2004). Accordingly, psychological safety has become a central topic across organizational behavior, leadership research, and applied psychology.

At the same time, the increasing growth of the psychological safety literature has resulted in conceptual diversification. Psychological safety has been investigated through multiple theoretical lenses (e.g., social exchange perspectives, motivational mechanisms, socio-cognitive interpretations), in a variety of team types (project, innovation, virtual, healthcare), and using heterogeneous operationalizations of both team effectiveness and team performance (Mathieu et al., 2019). This diversification has accelerated in recent years, accompanied by expanding attention to inclusive leadership, team diversity, conflict dynamics, and teams working under digital and hybrid conditions. As a consequence, the research domain connecting psychological safety and team performance has become increasingly fragmented, making it difficult to consolidate cumulative knowledge through traditional narrative reviews.

In such contexts, bibliometric analysis provides a robust and systematic method for mapping scientific knowledge structures. Bibliometric techniques enable the identification of intellectual foundations (highly influential authors and publications), major thematic clusters, and emerging research fronts shaping contemporary scholarship (Donthu et al., 2021). By combining keyword co-occurrence analysis, co-citation networks, and bibliographic coupling, it becomes possible to visualize how research streams cluster conceptually, how foundational knowledge is structured, and which newer topics are gaining momentum.

Therefore, the purpose of this study is to conduct a bibliometric analysis of scientific publications addressing psychological safety and team performance between 2018 and 2025. Using the Web of Science Core Collection (WOS CC) and applying network-based bibliometric techniques in VOSviewer and Bibliometrix (R studio), this study maps the structure of the field, identifies dominant thematic clusters, and highlights recent research trends.

To achieve this objective, the study addresses the following research questions:

- *RQ1: What are the intellectual foundations (most influential publications, authors, and conceptual traditions) of research connecting psychological safety and team performance?*
- *RQ2: What dominant thematic clusters structure the contemporary literature on psychological safety in teams?*
- *RQ3: What emerging trends and research fronts characterize psychological safety–team performance scholarship during 2018–2025?*

This study contributes to the literature in three ways. First, it provides a systematic mapping of a rapidly growing research domain on psychological safety and team performance. Second, it identifies dominant thematic clusters and key performance-relevant mechanisms (e.g., voice, learning, coordination, and conflict) through which psychological safety influences team outcomes. Third, it highlights research gaps and proposes directions for future research, including multilevel explanations, longitudinal research designs, and improved measurement consistency across contexts.

1. Theoretical background

Psychological safety has become a central construct in organizational behavior and team research, largely due to its explanatory power for understanding how interpersonal environments shape collective learning and effectiveness. It is typically defined as a shared belief among team members that the team is safe for interpersonal risk-taking, such that individuals can express concerns, ask questions, admit mistakes, and offer new ideas without fear of embarrassment, rejection, or punishment (Edmondson, 1999). This conceptualization emphasizes psychological safety as a collective team climate, rather than an individual trait, and positions it as a foundation for open and adaptive team functioning.

Importantly, psychological safety directly addresses the broader organizational challenge of silence and self-censorship at work. Morrison and Milliken (2000) describe organizational silence as a systemic phenomenon that prevents employees from speaking up, thereby limiting organizational learning and change. In teams, psychological safety counteracts silence by legitimizing interpersonal risk-taking and reducing the fear-based withholding of voice, information, and feedback elements that are essential for performance, especially in uncertain or complex environments.

The theoretical relevance of psychological safety is strongly tied to team effectiveness models, which propose that performance outcomes are shaped by mediating team processes such as coordination, learning, conflict management, and knowledge integration (Kozlowski & Ilgen, 2006; Mathieu et al., 2019). Psychological safety plays a pivotal role in enabling these processes, making it a mechanism through which teams transform inputs (e.g., diversity, expertise, leadership) into performance outcomes.

A major line of research emphasizes the relationship between psychological safety and voice. Voice behavior refers to employees' discretionary communication of ideas,

suggestions, or concerns with the intent to improve team or organizational functioning (Detert & Burris, 2007). When team members perceive psychological safety, they are more likely to speak up about errors, risks, or improvement opportunities rather than remain silent. This is particularly relevant given that implicit norms can otherwise encourage self-censorship, and Detert and Edmondson (2011) show that “implicit voice theories” can inhibit expression even when opportunities for improvement are obvious. In turn, higher levels of voice contribute to performance by facilitating early problem detection, learning, and more informed decision-making.

Psychological safety is also foundational for team learning behaviors, including reflection, experimentation, feedback seeking, and learning from failure. Edmondson’s work highlights that teams learn more effectively when members can discuss mistakes openly and treat errors as opportunities for improvement rather than sources of blame (Edmondson, 1999; Edmondson, 2004). This is consistent with broader scholarship on learning in organizations, where learning requires conditions that support risk-taking, exploration, and error management (Argote et al., 2020; Frese & Keith, 2015). In dynamic contexts, learning capacity becomes performance-critical, as teams must continually adjust their strategies and coordination patterns.

A further stream of research links psychological safety to knowledge sharing and information exchange. In interdependent teams, performance depends on whether members share expertise, coordinate actions, and integrate diverse perspectives. When psychological safety is present, members are more likely to contribute unique knowledge and engage in constructive discussion. This mechanism is particularly important in knowledge teams where boundaries across roles or expertise domains can create coordination barriers (Faraj & Yan, 2009). In this sense, psychological safety supports performance not only by reducing silence but also by enhancing knowledge integration and collaborative problem-solving.

A consistent finding across the psychological safety literature is that leadership constitutes one of the most important antecedents shaping whether teams develop psychologically safe climates. Leaders influence psychological safety through behavioral signals that define norms of interaction and interpersonal consequences. Nembhard and Edmondson (2006) demonstrate that leader inclusiveness, particularly in professional status-differentiated teams, increases psychological safety and supports improvement efforts in healthcare teams. Similarly, leadership styles characterized by ethical conduct and supportive interpersonal engagement have been linked to psychological safety and voice behaviors (Walumbwa & Schaubroeck, 2009).

While psychological safety is generally viewed as beneficial, its effects on team performance may depend on contextual and compositional factors. Research on diversity and faultlines highlights that subgroup dynamics may reduce open communication and weaken knowledge integration, especially when demographic or professional boundaries become salient (Lau & Murnighan, 1998; Gibson & Gibbs, 2006). Under such conditions,

psychological safety may be particularly critical in enabling teams to leverage diversity rather than suffer from fragmentation.

Similarly, conflict research suggests that psychological safety shapes whether task conflict becomes productive or destructive. Bradley et al. (2012) argue that task conflict can enhance team outcomes only when teams possess a psychologically safe climate that supports open discussion and constructive disagreement. Therefore, psychological safety functions as a moderator that determines whether teams can transform challenging interactions into improved performance.

Psychological safety scholarship has matured into an established research stream, as demonstrated by major reviews and meta-analytic syntheses that consolidate evidence on antecedents, outcomes, and boundary conditions (Frazier et al., 2017; Newman et al., 2017; Edmondson & Lei, 2014; Edmondson & Bransby, 2021).

Recent changes in work design have intensified interest in psychological safety within virtual and hybrid team environments. In remote settings, employees have fewer informal opportunities for sensemaking and relational repair, which may amplify silence and reduce willingness to speak up. Consequently, psychological safety becomes particularly important for sustaining voice, coordination, and performance during virtual collaboration and online meetings (Hao et al., 2022). Emerging research also points to measurement and construct validity challenges when applying psychological safety scales in virtual teamwork contexts, suggesting that hybrid work may represent a boundary condition that requires greater conceptual precision and context-sensitive operationalization (Rødsjø et al., 2024). The expansion of flexible work arrangements highlights the need for supportive organizational climates in which employees can effectively adapt, collaborate, and maintain well-being across diverse work settings (Gašić et al., 2025).

Research on virtual teams indicates that team effectiveness increasingly depends on relational mechanisms such as trust and knowledge sharing in digitally mediated environments (Hodzic et al., 2025). In this regard, psychological safety represents a critical socio-emotional foundation that supports open communication and collective learning in technology-mediated work. A qualitative study by Lechner and Tobias Mortlock (2022) highlights that virtual teams are less likely to develop psychological safety organically over time, suggesting that teams may need to invest proactively in explicit communication routines, relational practices, and leadership behaviors to cultivate a safe climate in virtual collaboration. These findings align with broader perspectives indicating that interpersonal risk-taking is structurally more difficult when interaction is dominated by scheduled meetings and digital channels rather than co-located day-to-day exchanges.

Emerging empirical work further suggests that psychological safety in remote and hybrid environments may depend strongly on contextual factors such as communication quality, leadership support, and organizational practices. For instance, recent qualitative evidence from remote IT and project work indicates that psychological safety is shaped by leaders' responsiveness, interpersonal openness, and the degree to which organizations

provide supportive practices that normalize speaking up and addressing challenges transparently (Pereira, 2024). Taken together, these developments suggest that remote and hybrid work environments do not diminish the relevance of psychological safety, rather, they create conditions in which psychological safety may be both more difficult to establish and more critical for sustaining effective team performance. Future research is therefore needed to clarify the mechanisms through which psychological safety develops in virtual and hybrid teams and to identify leadership behaviors and structural interventions that can reduce interpersonal risk and enable high-performing collaboration in distributed work settings.

Recent evidence from software workplaces suggests that psychological safety is essential for collaboration, knowledge exchange, and effective performance in innovation-driven team environments (Santana et al., 2025). Comparative findings suggest that psychologically safe and cooperative teams are better positioned to develop dynamic capabilities and sustain superior performance across national contexts (Dickel et al., 2026). Psychological safety appears to enhance performance perceptions by strengthening confidence, resilience, and supportive interpersonal dynamics within high-pressure team environments (Sakallı et al., 2026).

The rapid growth and cross-disciplinary diffusion of this literature has produced a fragmented knowledge base with parallel research streams and heterogeneous measurement approaches. To address this challenge, the present study applies bibliometric science mapping to identify the intellectual foundations, dominant thematic clusters, and emerging research fronts in psychological safety–team performance research.

2. Bibliometric methods

2.1. Search strategy and data source

This study adopts a bibliometric research design to systematically map the intellectual structure and thematic development of research addressing psychological safety in relation to team performance. Bibliometric methods are particularly suitable for consolidating fragmented bodies of knowledge by quantitatively analyzing publication patterns, citation relations, and keyword networks. To capture both the foundational knowledge base and the contemporary research front, the study combines performance analysis (descriptive bibliometric indicators) and science mapping techniques (network-based bibliometric analysis). The bibliographic data were retrieved from the Web of Science Core Collection (WoS CC), a widely used and high-quality bibliographic database in management and organizational research. WoSCC was selected due to its strong coverage of peer-reviewed scholarly journals and its compatibility with bibliometric software tools such as VOSviewer and Bibliometrix. The database provides standardized bibliographic records and cited references, enabling robust analyses including co-citation mapping and bibliographic coupling.

A structured topic search was conducted in the Web of Science Core Collection using a predefined query capturing three conceptual components: (1) psychological safety, (2) team performance outcomes, and (3) team- and organization-related context terms. The search query was formulated as follows: ("psychological safety" OR "team psychological safety") AND ("team performance" OR "team effectiveness" OR "group performance" OR "team productivity" OR "team outcome" OR "team success") AND ("team" OR "group" OR "workplace" OR "organization" OR "organizational" OR "employee*"). To ensure the analysis reflects contemporary and emerging research patterns, the time span was restricted to 2018–2025. This period was chosen because it reflects the most recent growth phase of psychological safety scholarship and captures the increasing relevance of modern team contexts.

To ensure data quality and relevance, the dataset was refined using the following inclusion criteria: (1) publications explicitly addressing psychological safety and team performance-related outcomes within team or organizational contexts, (2) peer-reviewed scholarly documents indexed in WoSCC, (3) publications within the defined time period (2018–2025), (4) records providing complete bibliographic metadata necessary for science mapping (authors, titles, sources, keywords, cited references).

Records outside the scope of team or organizational contexts were excluded indirectly through the search query design emphasizing team and workplace terms. The final dataset comprised 278 documents, representing the full sample for subsequent bibliometric analysis. The dataset was limited to 2018–2025 to capture the most recent and rapidly expanding phase of research on psychological safety and team performance. Prior bibliometric guidelines suggest that time span selection should reflect the purpose of the study, especially when mapping current research fronts and thematic developments (Zupic & Čater, 2015; Donthu et al., 2021). Annual publication trends indicate strong growth after 2020, suggesting that this period represents the domain's most dynamic development stage. The selected window also provides an adequate sample size (278 documents) for reliable science mapping while maintaining a focus on contemporary research.

2.2. Bibliometric analysis techniques

To address the research questions, three complementary bibliometric techniques were employed, each capturing a different dimension of the knowledge structure (Donthu et al., 2021):

- Keyword co-occurrence analysis was performed to identify dominant themes and conceptual clusters within the dataset. Keywords were used as indicators of research topics and were mapped based on their frequency of occurrence and co-occurrence patterns. The resulting network allows the identification of thematic clusters, central constructs, and bridging concepts that connect research streams. This method primarily addresses RQ2 by revealing the thematic structure of psychological safety–team performance scholarship.

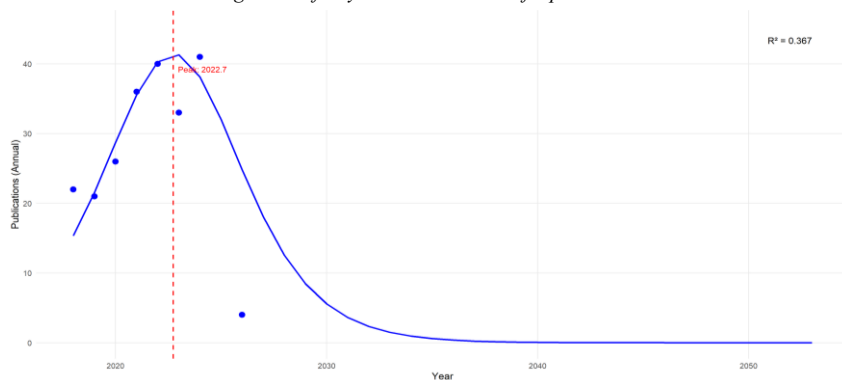
- Co-citation analysis was used to identify the intellectual foundations of the field. Co-citation mapping is based on the principle that references frequently cited together reflect shared theoretical or conceptual origins. This analysis highlights seminal works, foundational theories, and dominant research traditions shaping the field. Co-citation analysis primarily addresses RQ1.
- Bibliographic coupling was applied at the document level to identify the contemporary research front. Unlike co-citation analysis (which highlights historical intellectual roots), bibliographic coupling groups documents based on shared reference lists, capturing current thematic specialization and active research communities. This technique primarily addresses RQ3 by identifying recent clusters and emerging directions.

3. Results

3.1. Performance analysis

This section presents the descriptive bibliometric results of the dataset, offering an overview of publication patterns and the basic performance indicators of the psychological safety–team performance research domain. Performance analysis is essential in bibliometric studies because it provides a quantitative summary of the productivity and impact of the field, including publication growth, influential sources, and key contributors (Donthu et al., 2021). A key initial step in bibliometric research is describing the dataset’s scope, composition, and structure before conducting advanced analyses, for which the Main Information dashboard in the Bibliometrix environment was used (Aria & Cuccurullo, 2017). The analyzed dataset covers 2018–2025 and includes 278 documents across 179 sources, indicating a dispersed and multidisciplinary domain typical of management research and supporting the need to map thematic clusters and intellectual foundations (Zupic & Čater, 2015).

Figure1: Life Cycle - Annual scientific production



Source: Author

Collaboration indicators show strong co-authorship, with 942 authors, an average of 3,74 authors per document, only 29 single-authored works, and 28,42% international collaboration, reflecting the interdisciplinary and globally relevant nature of psychological safety research. Content indicators reveal high conceptual diversity, including 890 author's keywords, 764 keywords plus terms, 15.845 cited references, an average of 16,03 citations per document, and a mean document age of 3,79 years, confirming an active and contemporary research area. Annual publication trends demonstrate sustained growth from 2018 to 2025, despite a brief decline in 2023, indicating rising scholarly interest and the emergence of psychological safety as a performance-critical mechanism in complex and technology-mediated team environments.

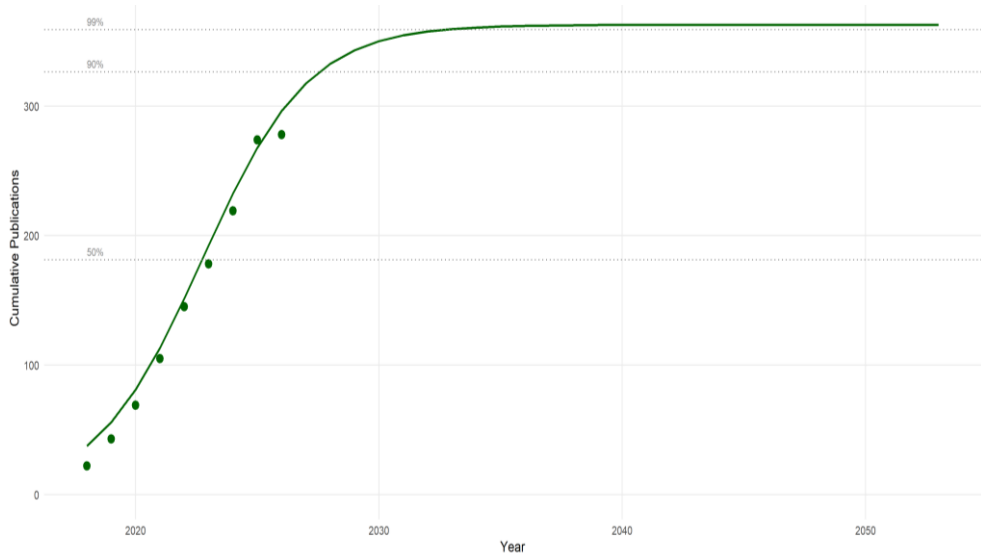
Recent scholarship increasingly examines psychological safety in remote and hybrid teams where digital collaboration can inhibit spontaneous communication and speaking up, as well as in high-reliability settings (e.g., healthcare teams) where silence may lead to serious negative outcomes. Consequently, psychological safety is increasingly framed as a strategic resource that enables voice, learning, coordination, and team effectiveness in modern work environments. Edmondson (2004) emphasizes that healthcare organizations encounter numerous opportunities to learn from errors, yet strong barriers often persist due to blame-oriented cultures, hierarchical structures, and fear of sanctions. Under such conditions, psychological safety enables teams to treat errors as sources of learning rather than as grounds for punishment, thereby increasing the likelihood of early problem detection and process improvement. This stream of research is closely aligned with literature highlighting the shift from a "blame culture" to a "just culture" in healthcare, where organizations seek to foster climates that encourage reporting problems and support systematic improvement (Khatri et al., 2009). Overall, the annual trend signals that the research domain has moved from early development into a phase of maturity and thematic diversification.

The Cumulative Growth Curve (Figure 2) provides complementary evidence on the evolution of this research stream by showing how publications accumulate over time. The curve displays a classic S-shaped diffusion pattern: a gradual increase in early years, followed by a steep growth phase, and then a gradual flattening. The steep middle segment indicates a rapid increase in scientific production—reflecting the point at which psychological safety became widely adopted as a core explanatory construct in team research and began diffusing into multiple contexts (e.g., healthcare teams, leadership research, innovation and creativity studies).

The later flattening of the cumulative curve does not imply a loss of relevance. Instead, it typically indicates that the field is entering a more stable phase, in which growth becomes less explosive and research increasingly shifts toward deeper specialization. In this stage, scholarship tends to focus more on boundary conditions, measurement refinement, context-specific applications, and mechanism-based theorizing rather than basic conceptual introduction. Consequently, the cumulative growth curve suggests that psychological safety–team performance research has reached a stage of consolidation,

while still offering substantial opportunities for advancing theory and empirical knowledge through emerging topics and new organizational contexts.

Figure2: Cumulative Growth Curve



Source: Author

The analysis of the most globally cited documents reveals that the psychological safety–team performance literature is anchored in a set of highly influential works that consolidate team effectiveness research, advance theoretical integration, and extend psychological safety scholarship into diverse organizational contexts.

The most cited paper is Mathieu et al. (2019), which provides a comprehensive synthesis of team effectiveness research and serves as a central reference point for understanding performance mechanisms in team settings. This finding suggests that psychological safety research in relation to team performance is strongly embedded in the broader team science tradition, where performance outcomes are theorized as a function of emergent team processes, coordination dynamics, and learning mechanisms (Mathieu et al., 2019).

A second prominent cluster of highly cited work is directly associated with psychological safety scholarship. Among the most influential publications is Edmondson (2018), reflecting the enduring relevance of psychological safety as an explanatory mechanism for interpersonal risk-taking, voice behavior, and learning in teams and organizations. Psychological safety is increasingly treated not merely as a supportive team climate but as a strategic enabling condition for performance-relevant behaviors, such as speaking up, problem detection, and collective learning, particularly in uncertain or high-pressure work environments (Edmondson & Harvey,, 2018). The central position of this

work confirms that psychological safety has become one of the most widely recognized constructs for explaining why some teams consistently outperform others despite comparable resources.

In addition, the results highlight the importance of integrative team science perspectives. Salas et al. (2018), published in *American Psychologist*, emerges as one of the most globally cited contributions, emphasizing the scientific foundations of teamwork and identifying key coordination and learning processes that determine team effectiveness. The strong citation impact of this work reinforces the idea that psychological safety research is tightly linked to broader teamwork frameworks that prioritize communication quality, mutual monitoring, and adaptive coordination as central performance drivers (Salas et al., 2018). Together with Mathieu et al. (2019), this evidence indicates that psychological safety–performance research is increasingly interpreted through a mechanism-based lens that integrates micro-level interpersonal dynamics with macro-level team effectiveness models.

The presence of Wang et al. (2018), Kim et al. (2020), and others among highly cited works suggests that psychological safety scholarship increasingly connects with broader psychological frameworks of team functioning, employee wellbeing, and organizational behavior in diverse contexts. Overall, the global citation structure demonstrates that the field is simultaneously shaped by (1) foundational team effectiveness syntheses, (2) core psychological safety theorizing, and (3) contextually grounded empirical research streams, reinforcing the multidisciplinary and rapidly expanding nature of psychological safety–team performance research.

3.2. Science mapping and network analysis

While performance indicators provide an overview of productivity and impact, they do not reveal how a research field is conceptually structured or how its knowledge base evolves. To address this limitation, the present study applies science mapping and network-based bibliometric techniques to examine the intellectual and thematic architecture of psychological safety–team performance research. Science mapping enables the visualization of relationships among publications, references, and concepts, thereby identifying dominant research streams, conceptual clusters, and emerging research fronts within a rapidly expanding literature (Zupic & Čater, 2015; Aria & Cuccurullo, 2017; Donthu et al., 2021).

Specifically, three complementary network analyses are employed. First, reference co-citation analysis is used to uncover the intellectual foundations of the field by identifying highly co-cited works that represent shared theoretical traditions. Second, keyword co-occurrence analysis maps the thematic structure of the domain by clustering frequently co-occurring keywords, which reflect major research topics and conceptual linkages. Third, bibliographic coupling at the document level captures the contemporary research front by grouping recent publications that share similar reference profiles, thereby indicating active and emerging areas of inquiry. Together, these techniques provide a

multidimensional understanding of how psychological safety scholarship relates to team performance outcomes, how the field is organized into subdomains, and where future research opportunities are most likely to emerge (Kessler, 1963; Callon et al., 1991; van Eck & Waltman, 2010).

3.2.1. Keyword co-occurrence network

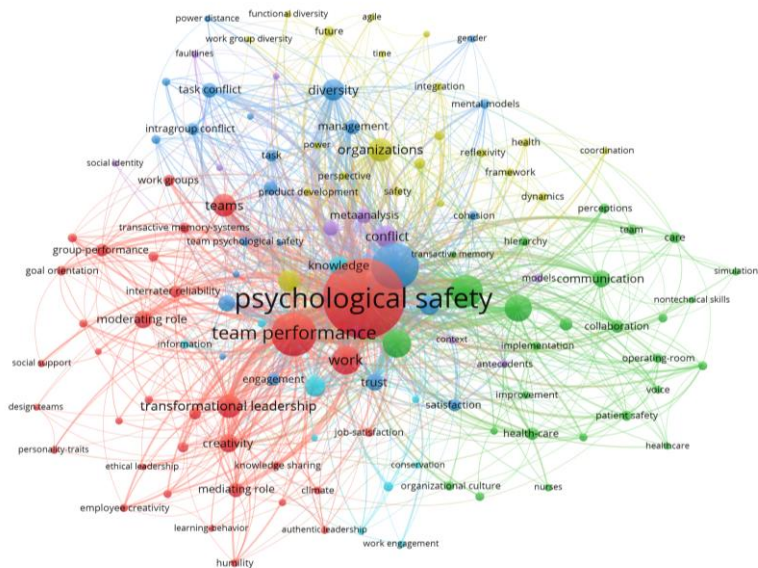
To examine the thematic organization of the psychological safety–team performance literature, a keyword co-occurrence analysis was conducted using VOSviewer (Figure 3). The resulting network is strongly centralized, with “psychological safety” occupying the most dominant and central position, reflecting its role as the conceptual anchor of the field. The structure also shows dense interconnections between psychological safety and performance-relevant team constructs, indicating that the domain is not fragmented into isolated subfields, but rather organized around a shared core. Within this core, “team performance” emerges as the second major hub, tightly linked to constructs that describe both explanatory mechanisms (e.g., communication, trust, knowledge) and boundary conditions (e.g., conflict, diversity, hierarchy). The clustering solution reveals several major thematic clusters that represent dominant research streams:

- **Cluster 1 (Red) – Leadership-driven performance pathway:** The red cluster is centered on team performance, transformational leadership, and innovation-related concepts such as creativity, employee creativity, and knowledge sharing. This cluster reflects a dominant stream examining psychological safety as a mediating mechanism through which leadership styles foster performance by enabling proactive and creative behavior, learning behavior, and open information exchange. The prominence of “mediating role” and “moderating role” suggests a highly mechanism-oriented literature focusing on how psychological safety explains why leadership and climate factors translate into team effectiveness outcomes.
- **Cluster 2 (Green) – Communication, voice, and high-reliability teamwork:** The green cluster is strongly focused on communication, collaboration, and voice, and it includes several context-specific terms such as health-care. This cluster indicates that healthcare teams represent a major applied research domain in which psychological safety is treated as essential for speaking up, coordination, and safe performance. The emphasis on “communication” as a large node confirms that psychological safety research increasingly focuses on interaction processes rather than solely on attitudinal outcomes.
- **Cluster 3 (Blue) – Conflict–diversity dynamics and boundary conditions:** The blue cluster captures the conflict–diversity dynamics stream, with prominent nodes including conflict, task conflict, intragroup conflict, diversity, and work group diversity (including “faultlines” and “power distance”). This stream reflects research examining when interpersonal differences and disagreements improve team outcomes versus when they undermine performance. Psychological safety plays a crucial boundary role in this literature by enabling constructive conflict, fostering open

disagreement without interpersonal threat, and supporting integration of diverse perspectives. This interpretation aligns with evidence that psychological safety determines whether conflict translates into learning and performance gains rather than relationship deterioration and silence (Bradley et al., 2012; Frazier et al., 2017).

- Cluster 4 (Yellow) – Organizational systems, coordination, and adaptive capability:** The yellow cluster reflects a more macro-oriented research stream that emphasizes organizations, management, coordination, integration, framework, and mental models. It highlights scholarship that situates psychological safety within broader organizational systems and coordination architectures. The presence of terms such as agile, future, and dynamics suggests emerging interest in psychological safety as a capability supporting adaptation under uncertainty—particularly relevant in modern organizational forms characterized by fluid teams and cross-boundary collaboration (Edmondson & Lei, 2014; Mathieu et al., 2019). This cluster reinforces that psychological safety is increasingly being discussed not only as a within-team phenomenon but as an organizationally embedded condition tied to system-level coordination and resilience.

Figure3: Co-occurrence network



Source: Author

3.2.2. Co-citation references

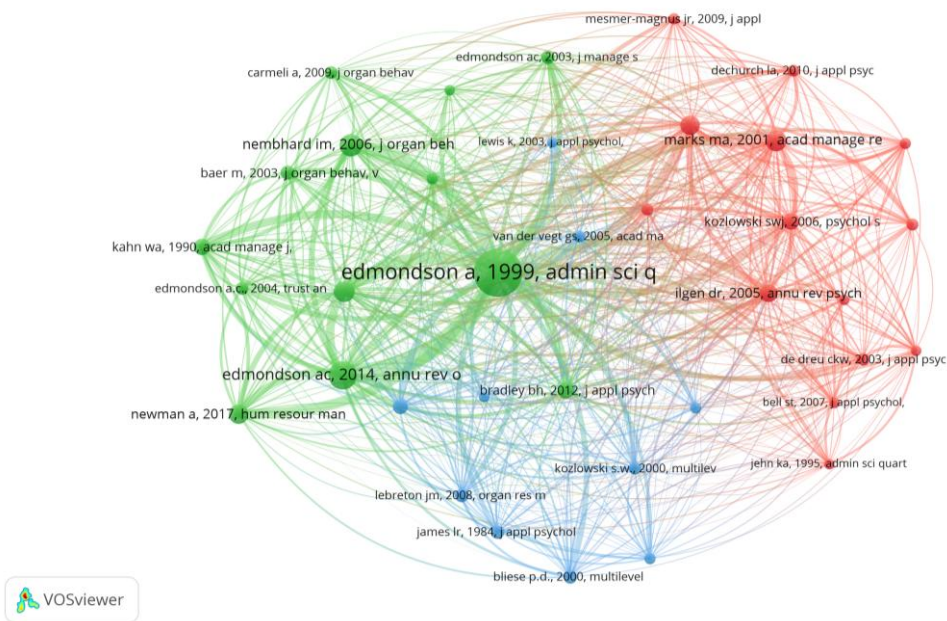
To identify the intellectual foundations of psychological safety–team performance research, we conducted a reference co-citation analysis and visualized the network using VOSviewer (Figure 4). Co-citation analysis reflects the extent to which two references are cited together, thereby revealing shared theoretical roots and dominant intellectual traditions (Donthu et al., 2021). The resulting network exhibits a strongly centralized structure, indicating that the field builds upon a relatively cohesive theoretical core. In particular, Edmondson's (1999) article emerges as the central and most influential node, confirming its foundational role in defining psychological safety as a team-level climate that enables interpersonal risk-taking and team learning. The prominence of this reference demonstrates that contemporary research continues to rely heavily on Edmondson's conceptualization when linking psychological safety to performance-related mechanisms such as learning, coordination, and speaking up. The co-citation network reveals three major clusters:

- **Cluster 1 (Green) – Psychological safety as a learning and improvement infrastructure:** The green cluster represents the dominant foundational stream in which psychological safety is conceptualized as an enabling condition for learning, improvement, and voice in teams, particularly in organizational and healthcare contexts. This cluster includes key contributions focusing on leader inclusiveness and team learning, such as Nembrand and Edmondson (2006) and earlier organizational learning-oriented work connected to psychological safety mechanisms. The strong connectivity among these references indicates that psychological safety research is deeply rooted in theories of collective learning and continuous improvement. Additionally, the presence of integrative works such as Edmondson and Lei (2014) further suggests that the field has increasingly consolidated its theoretical base through review-driven synthesis and conceptual refinement, reinforcing psychological safety as a central interpersonal construct in organizational behavior research. This cluster positions psychological safety not as a general “positive climate” variable, but as a learning infrastructure enabling experimentation, error reporting, and improvement behaviors-processes that are directly performance-relevant in knowledge-intensive and high-stakes teams.
- **Cluster 2 (Red) – Team process theory, conflict, and socio-cognitive dynamics:** The red cluster reflects the intellectual tradition emphasizing team processes, conflict, and socio-cognitive mechanisms underlying team effectiveness. Core references in this cluster include work on team conflict and performance, notably De Dreu and Weingart (2003), along with foundational contributions on teamwork and group processes (Marks et al., 2001). The co-citation structure indicates that psychological safety scholarship has been strongly influenced by classic team effectiveness theories that conceptualize performance as the outcome of emergent states (e.g., cohesion, affect), coordination patterns, and the regulation of conflict. Psychological safety is frequently integrated into this tradition as a contextual condition that shapes whether task disagreements and interpersonal differences translate into constructive outcomes

(learning, creativity, decision quality) or destructive patterns (relationship conflict, silence, reduced performance). This cluster emphasizes psychological safety as a boundary condition for conflict and team dynamics, linking the interpersonal climate to the quality of interaction processes that ultimately determine team outcomes.

- Cluster 3 (Blue) – Multilevel theory and methodological foundations of team research:** The blue cluster represents the methodological and multilevel foundation of the field and includes references that underpin contemporary team research designs and measurement approaches. The presence of Bliese (2000), Klein and Kozlowski (2000), and related multilevel contributions highlights that psychological safety–performance research is increasingly embedded in multilevel theory, recognizing that psychological safety operates at the team level while being influenced by individual perceptions and organizational contexts. In addition, methodological references such as LeBreton and Senter (2008) suggest the relevance of reliability and measurement discussions in constructing valid team-level climate indicators. The integration of these references indicates that the field is not only theoretically but also methodologically grounded in multilevel modeling, aggregation logic, and rigorous team measurement standards. This cluster shows that research on psychological safety and team performance has matured methodologically, emphasizing cross-level mechanisms and robust measurement of team-level psychological safety climate.

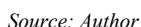
Figure4: Co-citation network



Source: Author

3.2.3. Bibliographic coupling

Figure5: Bibliographic coupling



A large portion of the coupled literature is grounded in contemporary team effectiveness theory and performance mechanisms, which provides the dominant explanatory lens for psychological safety research in the examined period. The visibility of highly coupled works centered on team effectiveness and teamwork science indicates that psychological safety is increasingly positioned as a mechanism embedded in broader process-based models of team performance. Rather than being treated solely as a stand-alone climate variable, psychological safety is integrated with constructs such as coordination, team processes, and emergent states, reflecting a growing interest in explaining how interpersonal climates translate into collective performance outcomes, particularly in complex and dynamic teamwork settings (Mathieu et al., 2019; Salas et al., 2018).

This network reveals several bridging documents positioned between densely connected areas of the map, suggesting emerging efforts to integrate previously separate research directions. These bridging works appear to connect performance-oriented teamwork science with leadership and applied-context research, indicating a trend toward more integrative theorizing. Overall, the bibliographic coupling results demonstrate that recent psychological safety–team performance research is organized around interconnected contemporary streams and is increasingly shifting toward explanatory and context-sensitive approaches, thereby offering a strong foundation for identifying emerging themes and future research opportunities.

To further explore the temporal dynamics of research themes, we examined trend topics across the 2018–2025 period (Figure 6). The trend topic analysis highlights how frequently used terms emerged, persisted, and gained prominence over time, thereby providing insight into the thematic evolution of psychological safety–team performance scholarship. Overall, the figure suggests a shift from early-stage conceptual consolidation toward a more diversified agenda characterized by mechanism-based explanations and context-sensitive applications.

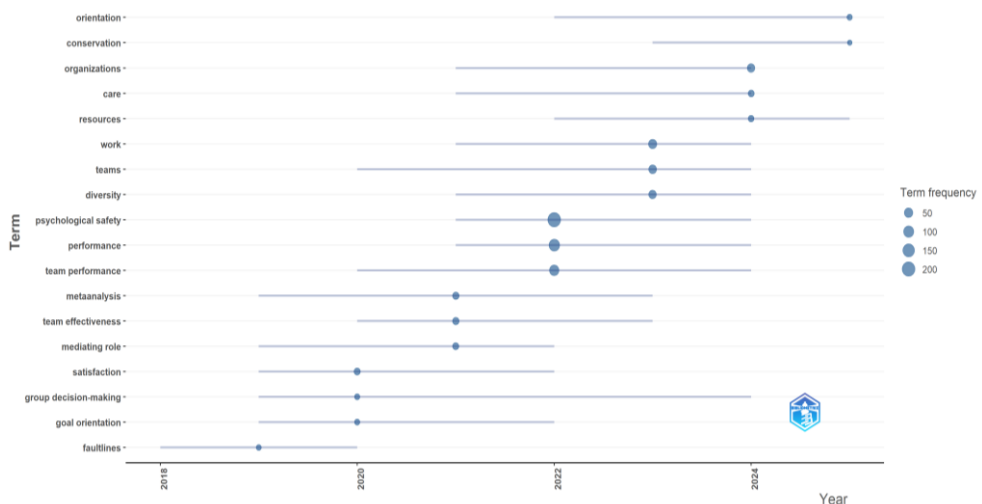
During the earlier phase of the observed period (2018–2020), research attention was primarily associated with classic team effectiveness constructs and group composition themes. Terms such as faultlines, goal orientation, and group decision-making appear as early focal points, indicating that initial studies often situated psychological safety within broader debates on diversity-related dynamics, coordination, and team decision processes. In this phase, psychological safety was frequently discussed together with performance-related outcomes such as satisfaction and team effectiveness, reflecting a dominant focus on establishing core relationships and clarifying conceptual mechanisms.

Between 2021 and 2022, the field exhibits stronger consolidation around its central constructs. The terms psychological safety, team performance, and performance become highly prominent, peaking in frequency around 2022. This period aligns with the most intensive growth phase of the literature and suggests a stronger emphasis on explicitly integrating psychological safety into performance-centered team research. Notably, the appearance of meta-analysis and mediating role as trend topics indicates that the field

increasingly shifted toward evidence synthesis and mechanism-testing approaches, reflecting a maturing research domain that moves beyond simple associations to examine mediation pathways and boundary conditions.

In more recent years (2023–2025), the trend topics indicate further thematic expansion and contextual diversification. Terms such as diversity, teams, and work remain salient, while broader context-level terms including resources, care, and organizations become increasingly visible. These patterns suggest that psychological safety research is extending beyond narrowly defined team processes toward broader organizational and applied contexts, consistent with the growing interest in high-stakes teamwork environments and organizational conditions that support team performance. The persistence of these topics into 2024–2025 implies that the field is entering a phase of specialization and refinement, in which psychological safety is examined as part of larger organizational systems and resource frameworks.

Figure6: Trend topics



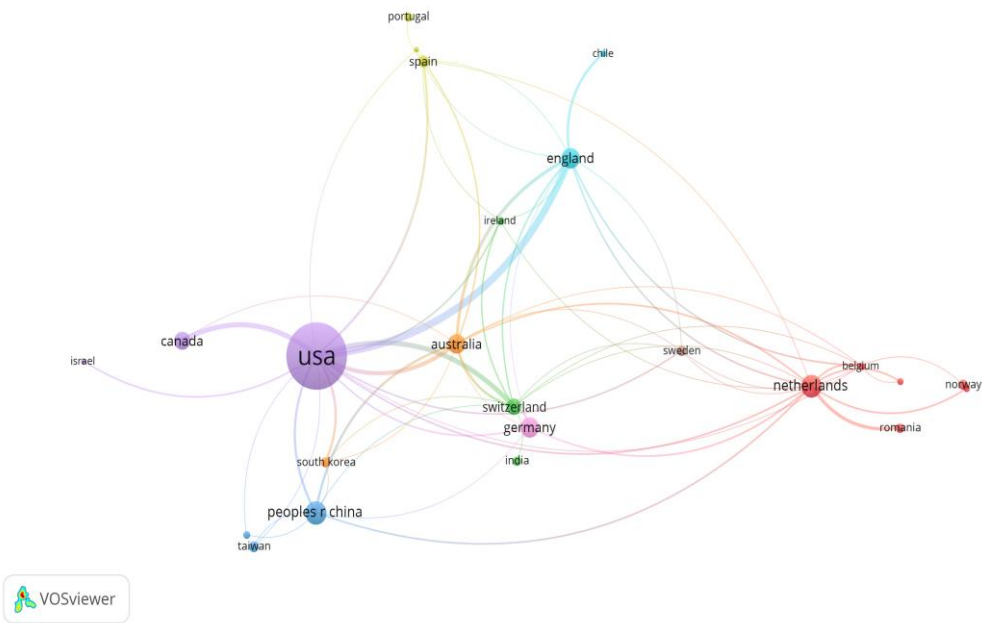
Source: Author

Taken together, the trend topic analysis supports the conclusion that psychological safety–team performance scholarship has undergone a rapid developmental trajectory: moving from early conceptual grounding in team dynamics and composition, to consolidation around performance mechanisms, and most recently toward broader organizational and applied research contexts. This evolution indicates both the maturity of the core construct and the continued emergence of new opportunities for research at the intersection of psychological safety, work design, and complex organizational environments.

3.2.4. Co-authorship by countries

The country-level co-authorship network (Figure 7) reveals a highly internationalized research landscape in psychological safety–team performance scholarship. The United States occupies a dominant and central position, functioning as the primary hub of international collaboration, with strong co-authorship ties to countries such as England, Australia, Canada, China, and Germany. This pattern indicates that the intellectual leadership of the field remains concentrated in Anglo-American research systems, while simultaneously relying on extensive cross-national collaboration. Several European countries, particularly the Netherlands, Germany, Sweden, and Switzerland, form interconnected collaboration clusters, suggesting a strong regional research ecosystem that is closely integrated with the broader global network rather than operating in isolation.

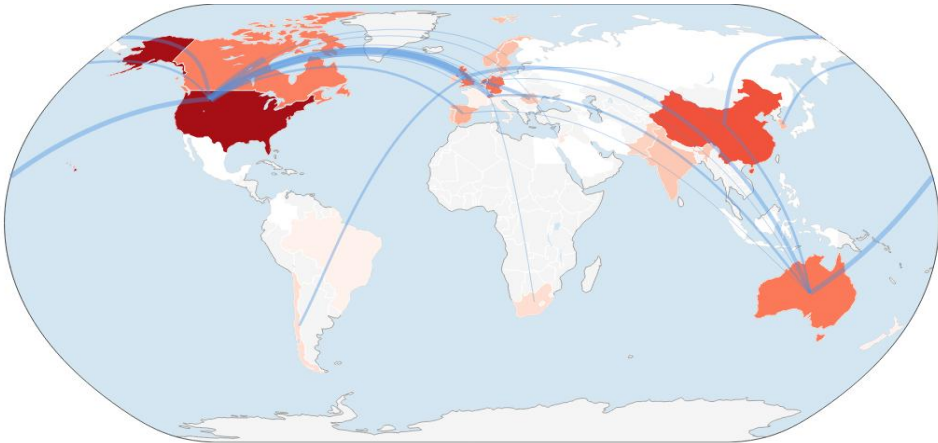
Figure7: Co-authorship network



Source: Author

The global collaboration map (Figure 8) further illustrates that psychological safety research has achieved broad geographic diffusion, with visible contributions from North America, Europe, East Asia, and Oceania.

Figure8: Global collaboration map



Source: Author

Notably, the presence of active collaboration links involving China, South Korea, and Australia points to the increasing globalization of the field and the growing relevance of psychological safety across diverse institutional and cultural contexts. However, the uneven density of contributions across regions also suggests that research output remains concentrated in a limited number of high-income countries, indicating opportunities for future expansion into underrepresented regions. Overall, the international co-authorship patterns underscore that psychological safety–team performance research is both globally connected and structurally asymmetric, with knowledge production shaped by a small number of central countries that act as brokers in the global research network.

4. Discussion

This bibliometric analysis provides a systematic overview of the current state of research in the field of psychological safety and team-level performance, based on a sample of 278 papers indexed in the Web of Science database for the period 2018–2025. By combining performance analysis and science mapping techniques, the paper identifies key trends in publication volume, the most influential papers and authors, dominant topic areas, and the intellectual foundations that shape the current state of this research domain. The results indicate that the field has experienced rapid growth and thematic diversification, with a marked increase in publication activity during the early 2020s. Table 1 synthesizes the principal bibliometric findings by combining descriptive, structural, and evolutionary perspectives, thereby providing an integrated overview of the current state and future direction of psychological safety–team performance research.

Table 1: Integrated Summary of Bibliometric Findings on Psychological Safety and Team Performance Research (2018–2025)

<i>Analytical Dimension</i>	<i>Methodological Approach</i>	<i>Core Findings</i>	<i>Scholarly Contribution</i>	<i>Implications for Future Research</i>
Field Growth and Productivity	Descriptive performance analysis	The dataset includes 278 publications across 179 sources, with strong growth during 2018–2025, indicating increasing academic attention.	Confirms that psychological safety has evolved into an established and expanding research domain within team and organizational studies.	Future studies may compare growth trajectories across databases and disciplines.
Collaboration Structure	Authorship and co-authorship indicators	A total of 942 authors contributed, with an average of 3.74 authors per article and 28.42% international collaboration.	Demonstrates that the field is highly collaborative, interdisciplinary, and internationally connected.	More cross-regional collaboration involving emerging economies would broaden contextual validity.
Intellectual Foundations	Reference co-citation analysis	Edmondson (1999) emerged as the dominant foundational reference, followed by works on team processes, conflict, and multilevel theory.	Establishes that the field rests on three major pillars: psychological safety theory, team effectiveness theory, and multilevel methodological approaches.	Future work should integrate newer perspectives such as digital teamwork, AI collaboration, and dynamic climate models.
Conceptual Structure	Keyword co-occurrence analysis	“Psychological safety” and “team performance” represent the central nodes of the thematic network.	Confirms psychological safety as the conceptual bridge linking interpersonal climate with collective outcomes.	Future studies should examine underexplored constructs such as resilience, inclusion, and algorithmic trust.
Dominant Research Streams	Cluster analysis of keywords	Four clusters were identified: (1) leadership and innovation, (2) communication and voice, (3) conflict and diversity, and (4) organizational adaptation.	Shows that the literature has diversified beyond direct performance effects toward mechanism-based and contextual explanations.	Future studies should investigate cross-cluster integration and longitudinal causal mechanisms.

Contemporary Research Front	Bibliographic coupling	Recent studies are organized around interconnected communities focused on leadership, teamwork science, and applied settings.	Indicates that the field is currently in a phase of theoretical integration rather than fragmentation.	Promising avenues include hybrid work, virtual teams, and AI-enabled team coordination.
Thematic Evolution	Trend topic analysis	Earlier studies focused on faultlines and decision-making, while recent topics include resources, care, and organizations.	Reveals a shift from micro team processes toward broader organizational systems perspectives.	Future research should explore sustainability, employee wellbeing, and adaptive capability.
Global Knowledge Network	Country co-authorship analysis	The United States is the central hub, with strong links to the UK, Australia, Canada, China, and Germany.	Demonstrates global diffusion of the field, although research production remains geographically concentrated.	Greater inclusion of underrepresented regions would enhance external validity and cultural generalizability.

Source: Author

The scientific mapping analyses reveal that psychological safety occupies the conceptual center of the literature and serves as a bridge between several important research streams. The keyword co-occurrence network showed strong linkages between psychological safety and themes such as leadership, communication, trust, conflict, diversity, knowledge sharing, and innovation. This finding suggests that psychological safety is not an isolated topic, but rather a mechanism through which multiple antecedents influence team outcomes. In particular, leadership-related themes were highly visible, reinforcing prior arguments that inclusive, supportive, and empowering leadership behaviors are instrumental in creating climates where team members feel safe to contribute ideas, raise concerns, and engage in learning behaviors.

The presence of communication and voice-related clusters also highlights that the relationship between psychological safety and performance is strongly process-based. Teams do not benefit from psychological safety merely because members feel comfortable; rather, performance benefits emerge because psychologically safe environments facilitate open communication, constructive dissent, rapid error detection, and knowledge exchange. This interpretation aligns with contemporary team effectiveness theory, which emphasizes that performance is generated through interaction processes, coordination quality, and adaptive learning rather than through static team composition alone.

Another notable finding concerns the strong visibility of conflict and diversity themes within the conceptual structure of the field. This suggests that psychological safety increasingly functions as a boundary condition determining whether differences among

team members become a source of creativity and better decision-making or instead lead to relational tension and reduced effectiveness. In diverse teams, disagreements and contrasting perspectives may generate valuable information, but only when members perceive that expressing divergent views is interpersonally safe. Therefore, psychological safety may be particularly important in organizations seeking to leverage diversity as a strategic advantage.

The co-citation analysis demonstrates that the intellectual foundation of the field remains strongly anchored in Edmondson's seminal conceptualization of psychological safety, while simultaneously integrating broader team process theory and multilevel methodological perspectives. This indicates that the field has achieved a relatively coherent theoretical base. Rather than fragmenting into disconnected subdomains, contemporary scholarship appears to build cumulatively on established foundations while refining mechanisms and extending applications. The prominence of multilevel references is especially important, as it reflects the growing recognition that psychological safety is simultaneously shaped by individual perceptions, team interactions, leadership behaviors, and organizational systems.

The bibliographic coupling results provide complementary evidence that the current research front is focused less on whether psychological safety matters and more on how, when, and under what conditions it matters. Recent studies appear increasingly concerned with mediation pathways, contextual contingencies, and applied settings such as healthcare, virtual teams, and knowledge-intensive work. This shift suggests theoretical maturation. Once direct associations between psychological safety and performance became well established, scholars moved toward more sophisticated models examining dynamic processes, boundary conditions, and cross-level effects.

The trend topic analysis further supports this developmental trajectory. Earlier research concentrated on team composition, faultlines, satisfaction, and general effectiveness outcomes, whereas more recent themes include resources, care, organizations, and broader contextual variables. This evolution implies that the field is moving beyond micro-level team processes toward a systems-oriented perspective in which psychological safety is embedded within organizational design, leadership architecture, and resource environments. Such a transition is particularly relevant given the growth of hybrid work, digital collaboration platforms, and AI-supported teamwork, where communication barriers and uncertainty may intensify the need for psychologically safe climates.

Overall, the discussion of findings indicates that psychological safety has become one of the most influential explanatory constructs in contemporary team research. Its importance lies not only in promoting employee wellbeing, but also in enabling the interaction processes through which teams learn, innovate, adapt, and sustain high performance. The field now appears well positioned for a next stage of development focused on longitudinal dynamics, multilevel mechanisms, and the management of psychological safety in technologically mediated and globally distributed work systems.

Conclusion

The study contributes to the academic literature in several important ways. First, it provides a comprehensive review of recent and highly relevant scientific literature on the increasingly important topic of psychological safety and team performance. In doing so, the study extends previous narrative and systematic reviews by offering an objective, data-driven synthesis of publication trends, influential papers, collaboration patterns, and thematic development. Second, the study advances theoretical understanding by showing that psychological safety has evolved into a central integrative construct connecting multiple streams of team research, including leadership, communication, learning, conflict management, and organizational adaptation. The results indicate that psychological safety is no longer viewed merely as a supportive team climate, but increasingly as a strategic mechanism through which teams achieve higher levels of coordination, innovation, and performance. Third, through co-citation and bibliographic coupling analyses, the study maps both the historical intellectual foundations and the contemporary research front in this field. The findings show that the domain is grounded in three main knowledge bases: psychological safety as a learning infrastructure, team process and conflict theory, and multilevel methodological perspectives. Finally, the study contributes to future research development by identifying emerging themes such as hybrid work, digital collaboration, healthcare teams, and AI-mediated teamwork. These findings provide a structured roadmap for researchers seeking to extend psychological safety research into new organizational contexts and dynamic forms of teamwork.

The findings also generate several practical implications for managers, team leaders, and organizations. The results highlight that psychological safety should be viewed as a strategic organizational resource rather than a purely interpersonal phenomenon. Teams perform more effectively when employees feel safe to speak up, report mistakes, share ideas, and challenge existing assumptions without fear of negative consequences. Leaders play a key role in creating a psychologically safe climate. Since leadership-related themes are strongly emphasized in the literature, organizations should invest in leadership development programs that promote inclusiveness, openness, constructive feedback, and supportive communication behaviors.

The growing importance of healthcare, remote work, and digital collaboration suggests that psychological safety is particularly critical in complex, high-risk, and technology-mediated environments. Organizations operating in such contexts should intentionally design communication routines, learning systems, and error-reporting mechanisms that encourage proactive participation. In addition, multinational collaboration patterns indicate that psychological safety has global relevance, although cultural and institutional differences may shape how it is implemented. Therefore, organizations managing international teams should adapt psychological safety practices to different cultural contexts while maintaining universal principles of respect, trust, and open communication.

However, the study has certain limitations. The sample is limited to papers from the Web of Science database and the period 2018–2025. Also, bibliometric indicators describe publication and citation patterns, but do not represent evidence of causality between variants. Nevertheless, by combining performance analysis and network science mapping techniques, this study offers a robust and up-to-date overview of a rapidly growing research field, providing a solid foundation for further development of theory and empirical work in the field of psychological safety and team performance.

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Growth factors of audit firms in the Republic of Serbia in the period 2018 – 2022

Фактори раста ревизорских фирми у Републици Србији у периоду 2018-2022. године

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Abstract:

The aim of paper is to investigate the growth of audit firms in the Republic of Serbia during the period 2018 – 2022. Growth was measured as a change in revenue over a fixed period of time. The results indicate that there is significant increasing of audit firms performances measured by sales growth in 2019, and then decreasing in 2020, while in the following years there is increasing of business performance. In order to investigate which factors affect the sales growth rate, regression analysis was conducted. Sales growth was defined as dependend variable, while as independent variable were defined return on assets, current ratio, leverage and corona period as a proxy variable. The results indicate that significant impact on sales growth of audit firms have return on assets, current ratio and corona period. Return on assets and current ratio are significant positive related to sales growth, while corona period is negative related to sales growth. The research results indicate to the profile of audit firms specially from the perspective of growth facotrs. The results can be of interest for managers and owners of audit firms, profesional audit organizations and other in the process of business decisions making.

Keywords: audit firm, sales growth, return on assets.

JEL classification: M40, M42

Сажетак: Циљ рада је да се спроведе анализа раста ревизорских фирми у Републици Србији у периоду од 2018-2022. године. Раст је мерен на основу промене прихода од продаје у току два обрачунска периода. Резултати анализе раста ревизорских фирми указују на повећање раста у 2019. години, а затим на смањење у периоду кризе у 2020. години. У циљу истраживања фактора који имају утицај на раст продаје спроведена је регресиона анализа. Раст продаје дефинисана је зависна варијабла, док су као независне варијабле дефинисане поврат на имовину, текућа ликвидност, задуженост и период пословања током корона кризе. Резултати истраживања указују да значајан утицај на раст продаје имају

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поврат на имовину, текућа ликвидност и пословање током корона кризе. Поврат на имовину и текућа ликвидност имају позитиван ефекат на раст продаје, док пословање током корона кризе има негативан ефекат. Резултати истраживања указују на профил ревизорских фирми посебно са аспекта фактора раста. Резултати су од интереса за менаџере и власнике ревизорских фирми, као и за професионалане ревизорске организације у циљу доношења адекватних пословних одлука.

Кључне речи: ревизорске фирме, раст продаје, поврат на имовину.

ЈЕЛ класификација: M40, M42

Introduction

The audit of financial report increases trust in financial statements through an unbiased and competent expression of opinion on the fair presentation of financial statements (Rodić et al., 2017; Mijić et al., 2014). The financial report is an important source of information in the business decision-making process (Francis, 2011; Jakšić et al., 2012). The quality of services provided by audit companies is crucial for the functioning of the capital market due to the audit of all financial statements of listed companies (whose securities are traded on the market) (Hategan et al., 2022). The auditors have a public role through controlling companies' financial statements, and therefore, auditing represents a regulatory instrument (Detzen & Gold, 2021).

The audit companies are established for the purpose of long-term growth, profitability and sustained competitive advantage. The market of the audit firms in the Republic of Serbia is relatively young, but there is strong competition (Jakšić et al., 2015). Officially, this market has been operating in the Republic of Serbia (RS) since 1996 due to the introduction of positive legislation in this area (Law on Financial Statements Audit, 1996). Since then, the audit firms' market has increased in the number of firms, their size and revenues (Jovković et al., 2021; Gong et al., 2016). The stagnation and lower performance of companies on the audit's service market in the RS, and worldwide also, were recorded under the influence of the financial crisis (2007-2008) and during the period of the COVID-19 pandemic (2020-2021) (Albitar et al., 2020; Haddad et al., 2023; Kljajić & Perić, 2023). In 2024, there are 75 audit companies operating in RS (Chamber of Authorized Auditors, 2024).

Audit firms, can be divided into two groups: 1) audit firms of the so-called "Big Four" and 2) other audit firms that do not belong to the "Big Four". According to this distribution, in the RS is significant the difference between international and local (national) audit firms. Also, the newly established audit firms have major differences in performance but also in the auditor's fee, which consequently have impact on sale, net income and profitability (Jakšić et al., 2012). International audit firms and audit companies with tradition, brand and size have positive relation with audit quality and performance (Chen et al., 2013).

The specificity of the audit firm's business is a highly specialized workforce in terms of education, competence and experience (Samagaio & Rodrigues, 2016). In order to adapt to new business conditions and to improve company's business, the audit profession is providing proactive audit and non-audit engagements, if they don't compromise independence of audit company (tax consulting, financial and business consulting,

corporate finance, accounting services, legal services, corporate consulting services, auditing of information systems, sustainability assurance, human capital and others) (Malsch et al., 2021). Audit fees have stagnated over last decade but large audit firms' revenues from non-audit engagements are growing rapidly (Donelson et al., 2020).

Our study aims to address which factors affect the sales growth rate of audit sector during the period from 2018 to 2022 in Republic of Serbia. Specifically, we review the potential impact of the COVID-19 outbreak on audit fees and sales growth. The paper is structured as follows. Following this Introduction, section 1 discusses the literature review. Section 2 provides the research methodology and sample on audit firm's growth. The result and discussion are reviewed in section 3. The last section presents our conclusion.

1. Literature review

Sales revenue represents the main component of net income. Therefore, stable and continuous sales growth is one of the main factors of achieving better financial performances. There is large number of scientific papers which analyze trend and the factors of sales growth of different sectors. Growth determinants based on financial statements of the agricultural European countries were analyzed by Vuković et al. (2022). The research was based on a sample of 1,333 observations of agricultural companies during the period 2014-2019. The results of multiple regression analysis indicate that return on assets and leverage have positive impact on sales growth, while size of companies has negative influence on it.

Growth and profitability in Australian firms was examined by Fitzsimmons et al. (2005). The research results indicate that profitability has positive and significant impact on sales growth. Beside these findings, research results show that age is negative related to the firms' sales growth. Similar results of sales growth determinants can be found in the paper of Silva and Moreira (2023). They investigated the determinants of corporate sales growth in Portugal during the 2008-2021. The research was based on a sample of 189 thousand unique firms and the regression model was used. The results indicate that sales growth is negative related with the size, age, employees and management gender and productivity. On the other hand, external funding, profitability, belonging to economic group, education and lagged investment have positive influence on sales growth.

The growth of SMEs family business firms in Italy was analyzed by Megaravalli and Sampagnaro (2019). The research was based on a sample of 45,000 family business SMEs of Italy and probit regression model. The authors indicate that liquidity ratio, solvency ratio, age, cash flow and working capital represent the main predictors of company growth. They emphasized that higher liquidity ratio leads to higher potential of firm growth.

Determinants of firm's growth in period of crisis were analyzed by Malinic et al. (2020). Among the results, the authors emphasized importance of infrastructure prerequisites macroeconomic policies for growth of firms in the period of crisis. The

research results indicate that the period of crisis has higher negative effect on firm's growth among former Yugoslavian countries than countries from the group „Visegrad four“.

Mrdak (2019) analyzed the trend of sales growth of audit firms in the Republic of Serbia during the period 2017-2018. The author used descriptive statistics to analyze the trend of sales growth and other performances of audit firms in Serbia. The results indicate that the highest rate of sales growth at the firm level was 1.39. Similarities and differences in the performance of audit firms in Serbia were investigated by Jakšić et al. (2015). They conclude that there is statistical difference in sales between Big4 and other audit firms in Republic in Serbia. Factors such as size and business within international group could provide sales growth. Knowledge transfer, availability of infrastructure, quality employment are characteristics of international network business which provide the possibility of achieving higher sales based on the provision of audit and non-audit services. Furthermore, corporate social responsibility is mechanism for reputation enhancing for audit firms, which lead to increasing the number of audit clients and sales (Gunn, 2022). Among the papers which analyzed the impact of non-financial factors on growth of accounting and audit firms there is paper of Kolvereid and Amo (2019). The analyze of growth of accounting Norwegian firms indicates that versatile human resources and labor and productivity have significant impact of firms' growth. On the other hand, Munuve and Obwogi (2015) analyzed and the impact of financial statements factors on growth of audit firms in Kenya. The research was based on a sample of 122 audit firms and using of regression models. The results indicate that internal control and profitability have positive and significant impact on growth of audit firms.

2. Research and sample

The aim of this paper is to investigate the audit firm's growth. The growth is defined as a measure of the change in revenue over a fixed period of time. According to the fact that the main role of audit firms is to provide independent audit service, the provision of service was taken as a proxy for calculation of sales growth (based on the data of financial statements the proxy is defined as provision of service and sales of goods). The research in paper is divided into two parts. Firstly, the audit firm's growth is research based on the descriptive statistics during the period from 2018 to 2022. The results of this part should indicate on the trend of sales growth. The second part of research should give the answer on the following research question: Which factors affect the sales growth rate? According to the second research question, the following hypothesis was set:

H₀: Independent factors such as return on assets, current ratio, leverage and corona period have significant impact on sales growth of audit firms in Republic of Serbia.

In order to test the research hypothesis, the following regression model is set:

$$Y_{it} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon_i$$

Y_{it} - Sales growth

β_0 - model constant;

β_i - coefficient of independent variables;

X₁ - Return on assets
 X₂ - Current ratio
 X₃ - Leverage
 X₄ - Corona period
 E - error with a normal distribution;
 i - signify each company (i=1,....., n);
 t - signify the period of time (t=1,....., t).

The following table presents the methodology of calculation of variables.

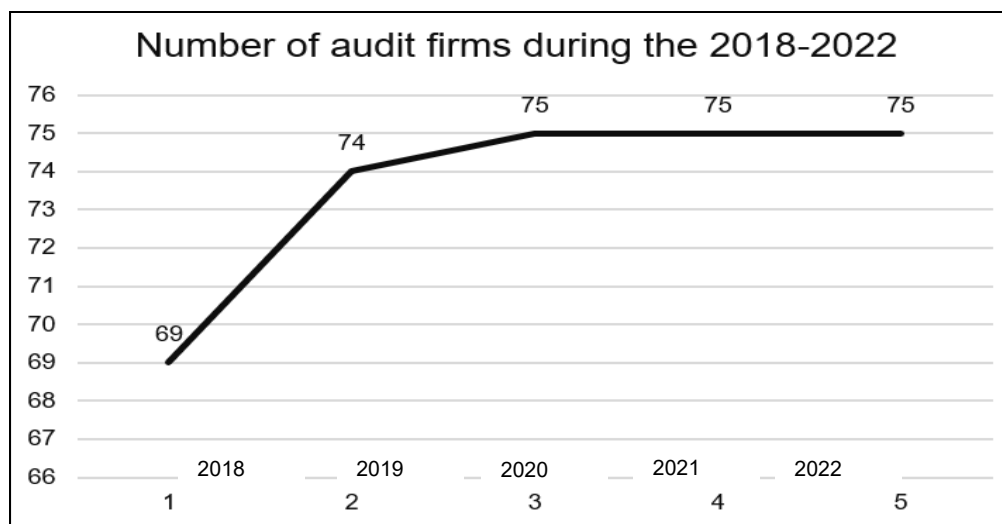
Table 1: Calculation of variables

Variable	Ref.	Type	Calculation
Sales growth	Y_{it}	Dependent variable	$Sales_t / Sales_{t-1}$
Return on assets	X ₁	Independent variable	Net income / Total assets
Current ratio	X ₂	Independent variable	Current assets / Current Liabilities
Leverage	X ₃	Independent variable	Total liabilities / Total assets
Corona period	X ₄	Independent variable	0 - Period before Corona (period 2018-2019) 1 - Period during Corona (period 2020-2022)

Source: Authors research illustration based on Rodić et al. (2017)

The research is based on the financial statements of 368 observations of audit firms in the Republic of Serbia during the period 2018 – 2022. The data was collected from the Chamber of Authorized Auditors (2024) and Business Registers Agency (2023). The sample consists of all audit firms which operating in the Republic of Serbia. The number of audit firms during the observed period is presented in the figure 1. In order to provide statistical analysis SPSS v 23 is used.

Figure1: Number of audit firms during the period 2018 - 2022

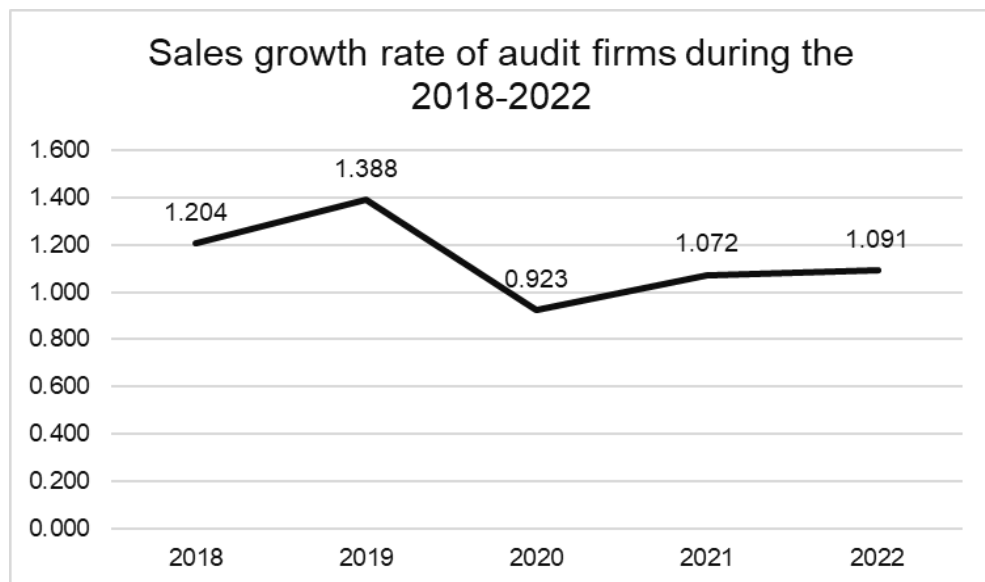


Source: Authors research illustration based on data from Chamber of Authorized Auditors (2024)

3. Results and discussion

The results of descriptive analysis of sales growth trend are presented in the following figure. Based on the aggregate data of provision of services and sales of goods there is the growth in sales in 2019. Total sales in 2019 are for 14% higher than in 2018. Sales growth in 2019 is accompanied by the increasing the number of audit firms. During the period of Covid pandemic sales of audit firms are at the lower level. In 2020 total aggregate sales is at the level of 7.641.125 thousand RSD, while in the previous year audit firms achieved total sales of 8.277.249 thousand RSD (total sales are decreasing for 7.7%). Operating during the period of crisis indicate to the significant lower level of other business performances. Beside the decreasing of sales in 2020, there is also a higher number of audit firms which have negative net income. In 2020 there is 7 audit firms which achieve loss, while the number of these firms in 2018 was 2, and in 2019 was 4. In 2021 there is increasing in the level of total sales for 7,2%, and almost the same trend is in 2022. The improvement in business activities in 2022 is also reflected in other performances such as the reduction of the number of audit firms operating at a loss, improving the level of profitability, and reducing the leverage rate (table 2).

Figure2: Sales growth of audit firms during the period 2018 – 2022



Source: Authors research illustration based on data from Business Registers Agency (2023)

The research results of descriptive statistics of variables are presented in the table 2. The results indicate that there is decreasing the profitability ratio measured by return on assets during the 2018-2020. In 2021 and 2022 average rate of ROA are relative stable, but is not at the referent value of 10% (Rodić et al., 2017). The results of liquidity analysis indicate that audit firms do not have a problem of serving short-term liabilities. Even there

is fluctuating in the level of current ratio in the observed period average rate of current ratio is above referent value of 2. Furthermore, leverage level is almost at the same level during the period 2018 – 2022 with a little trend of decreasing after 2020. The results indicate that there is higher level of liabilities than owner capital. At average audit firms fund structure indicate that there is 77% of liabilities and 23% of capital. These findings must also be analyzed with the fact that the establishment of audit firms requires capital that is less than 1 EUR. Beside this, audit firms must take care that additional borrowing is directed to the realization of business activities. If it is directed to pay the existing obligation, then the audit firms survival is questioned.

Table 2: The results of descriptive statistics of variables

Variable	Minimum			Maximum			Mean		
	2018	2019	2020	2018	2019	2020	2018	2019	2020
Growth	.0000	.0000	.0000	8.8000	16.9003	9.0336	1.2046	1.3883	1.1401
ROA	-.9447	-1.8571	-2.9324	.7338	.7684	.7765	.1011	.0839	.0466
Current ratio	.0343	.1689	.1198	11.9875	28.5992	70.5000	2.0300	2.3275	3.1639
Leverage	.0434	.0781	.0141	4.7032	7.5418	8.2470	.7390	.8070	.7813

Source: Authors research calculation based on SPSS

In order to test multicollinearity, Pearson correlation matrix was conducted (table 3). The multicollinearity problem may be the results of the high correlation between variables. If the correlation between variables is over 0.80, that mean that there is multicollinearity problem. The results in table 3 presents that all correlations are below 0.80, so there is no problem with multicollinearity. Furthermore, multicollinearity was tested by the variance inflation factor (VIF). Since all VIF values are less than 10 (table 4), so there is no multicollinearity between the model variables (see more: O'Brien, 2007).

Table 3: The results of Pearson Correlation matrix

	Growth	ROA	Current ratio	Leverage	Corona
Growth	1	0.136*	0.327**	0.058	-0.033
ROA	0.136*	1	0.208**	-0.537**	-0.007
Current ratio	0.327**	0.208**	1	-0.194**	-0.061
Leverage	0.058	-0.537**	-0.194**	1	-0.010
Corona	-0.033	-0.007	-0.061	-0.010	1

Source: Authors research calculation based on SPSS

The results of regression analysis are presented in the following table.

Table 4: The results of regression model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	VIF
		B	Std. Error	Beta			
1	(Constant)	.852	.147		5.794	.000	
	ROA	.891	.309	.208	2.887	.004	1.019
	Current ratio	.081	.016	.345	5.165	.000	1.010
	Leverage	.163	.107	.108	1.521	.130	1.034
	Corona	-.136	.178	-.050	-.763	.043	1.046
a. Dependent Variable: Growth, R _{sq} .47							

Source: Authors research calculation based on SPSS

The results of the regression model shows that profitability, liquidity and period of corona crises have significant impact on the growth of audit firms during the 2018 – 2022. On the other hand, leverage do not have significant impact on sales growth of audit firms. According to these findings, the answer on research question is given and hypothesis is partially confirmed. The result of R square (0.47) shows that 47% of variance of dependent variable can be explained with defined independent variables. ROA and current ratio have significant positive impact at the level of 95%. According to these findings it can be concluded that the audit firms with higher level of ROA achieve higher growth rate. These findings are according to the other research which confirm that higher rate of profitability in the current period represents the basis for the firms growth (Vuković et al., 2022; Fitzsimmons et al., 2005; Silva & Moreira, 2023; Munuve & Obwogi, 2015). Furthermore, audit firms with ability to pay short-term liabilities in the near-term, achieve higher level of sales growth. These research results are according to the previous research (Megaravalli & Sampagnaro, 2019). Management of audit firms must pay attention to achieve higher, but on the other hand optimal, rate of current ratio. The period of corona crises as independent variable is significant at the level of 95%. This variable has significant negative impact on sales growth of audit firms in Serbia. According to these, audit firms achieve lower level of sales growth rate during the period of corona crisis. These findings are according to the previous research paper which indicate that business during the crises has negative impact on firm performance (Malinic et al., 2020; Haddad et al., 2023).

Conclusion

Sale of services are the main component of net income of audit firms. Therefore, in order to achieve stability in business activities and even increasing business performance, management of audit firms must pay special attention to the possibilities of sales growth. The research results indicate that increasing the profitability has positive and significant impact on sales growth. Audit firms can achieve a higher level of sales if the part of net income goes to the expansion of business activities and to the increasing the number of audit staff.

The results show that higher level of liquidity ratio, measured by current assets, has also significant and positive impact on sales growth. These findings indicate that lack of liquidity are related to the decreasing of sales, and could be one of the main factor of business failure. Furthermore, the research results show that period of corona crisis has significant negative impact on sales growth. Even though the audit firms have a higher level of libalities in the fund structure, the results show that leverage is not significant factor for sales growth. Beside this findings, managers of audit firms must be affraid that additional borrowing should be used for business activities. If the additional borrowing are used for payment of existing obligation, the future business of audit firms may be questionable.

The limitation of research can be explained by the fact that only internal factors are involve in investigation the factors of sales growth and that the research is a based on the audit sector of one country. Future research paper sholud include and external factors or should involve the audit markets from the region which have the similar characteristics. Reserach results show the profile of audit firms, specific from the perspective of how internal factors affect the sales growth. This findings can be of interest for internal and external users such as management of audit firms, owners, audit professional organization etc. in the process of creation of further policy for stable business activities in audit sector.

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Determinants of venture capital fundraising – example of Germany

Утицај детерминанти на прикупљање средстава фондова ризичног капитала – пример Немачке

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Abstract

Purpose: Venture capital is essential for developed markets as they provide possible start-ups with capital, especially the ones which have great prospects of success and growth. There are a few factors which influence the venture capital. Therefore, the study aims to investigate which factors affect significantly venture capital fundraising in Germany.

Methodology: This research is conducted by using a log-lin regression model which covers the data from 2015 to 2024 in Germany. The dependent variable is the amount of venture capital fundraising, whereas independent determinants are unemployment rate, global innovation index, price-to-book ratio, corporate tax rate and industrial index.

Findings: The results show that unemployment rate, global innovation index and corporate tax rate have a significant effect on the dependent variable. However, price-to-book ratio and industrial index have no significance on venture capital fundraising. As a result, venture capital in Germany is mostly influenced by macroeconomic environment.

Originality/value: The results show which macroeconomic determinants have the largest impact on the fundraising of the venture capital funds in Germany, thereby allowing the policy makers to improve the environment for the growth of the venture capital activity. Furthermore, when compared with the results of other studies, this research indicates that there are differences in the impact between developed countries as well. The findings of this research, especially associated with the effects of the impact of the innovation index, are valuable and indicate that investors are not inclined to invest in radical innovations that are associated with high risks and therefore a high possibility of failure.

Practical implications: The results can be used by policymakers and venture capital fund managers in order to attract investors to raise funds for venture capital investments.

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Limitations: One of the limitations is the fact that study covers the period from 2015 to 2024. Also, the results of the research cannot be applied to emerging countries.

Keywords: venture capital fundraising, regression model, Germany, macroeconomic environment

Сажетак

Циљ: Ризични капитал је важан за развијена финансијска тржишта јер обезбеђује почетни капитал за компаније које се оснивају и које имају тенденцију развоја и успеха. Велики број фактора утиче на овај тип капитала у свету. Рад има циљ да испита који фактори значајно утичу на прикупљање средстава фондова ризичног капитала у Немачкој.

Методологија: У истраживању се користи log-lin модел који обухвата податке од 2015. до 2024. године. Зависна варијабла представља износ ризичног капитала који се прикупља за оснивање фондова, док независне варијабле обухватају стопу незапослености, глобални индекс иновација, Р/В рацио, корпоративна пореска стопа и индекс индустријске производње.

Резултати: Log-lin модел показује да стопа незапослености, глобални индекс иновација и корпоративна пореска стопа имају значајан утицај на зависну варијаблу. Међутим, Р/В рацио и индекс индустријске производње немају статистички значајан утицај на зависну варијаблу. Може се произвести закључак да на индустрију ризичног капитала у Немачкој најчешће утиче макроекономски амбијент.

Оригиналношћ/ вредност: Резултати показују који макроекономски индикатори највише утичу на фондове ризичног капитала у Немачкој, а на овај начин креатори монетарне политике омогућавају да се на тржишту развијају активности ризичног капитала. Последице, овај рад, у поређењу са резултатима других истраживања, указује да постоје разлике у утицају и међу развијеним државама. Резултати истраживања рада, поготово резултати који се односе на утицај глобалног иновационог индекса, су корисни и показују да инвеститори нису вољни да инвестирају у радикалне иновације које укључују висок ризик и као резултат велику могућност од губитка.

Практична примена: Резултате истраживања могу применити креатори монетарне политике и менаџери фондова ризичног капитала како би привукли инвеститоре да прикупљају средства путем ризичног капитала.

Ограничења истраживања: Једно од ограничења представља чињеницу да студија обухвата период између 2015. и 2024. године. Такође, резултати истраживања се не могу применити на земље у развоју.

Кључне речи: фондови ризичног капитала, регресиони модел, Немачка, макроекономски амбијент

Introduction

Benefits of venture capital fundraising have spread globally for several decades and consequently became a source of finance for small innovative firms which are at the beginning of the life cycle. Also, venture capital caters for firms which cannot afford to get a loan from a bank in order to set up new a business. Moreover, Jeng and Wells (2000) put forward a view that on financial market venture capital interferes between supply and demand side when there is difficulty in raising capital. Venture capital funds are considered to make high-risk investments, where it is crucial to outline that firms, which require venture capital investments, should have prospects for development, long-term growth and success. Milenković and Kalaš (2020) imply that venture capital funds invest in small firms without collateral and business track records as well as small enterprises with growth prospects and limited business track records. Additionally, the authors (Milenković & Kalaš, 2020) emphasize the need for these firms to raise investments in the early stage, i.e. startup investments, especially if they are specialized for creating new products. It is of great significance to state that a lot of companies which are blue-chip nowadays used to acquire startup capital from venture capital funds, e.g. Microsoft, Apple Computer, Amazon, Instagram, SpaceX (Grilli, Latifi, & Mrkajic, 2019). In addition, Bertoni, Colombo and Grilli (2011) claim that venture-capital companies are usually more

successful in terms of growth. One of the reasons might be the fact that venture capital funds choose firms which have more potential to flourish. The authors (Bertoni, Colombo, & Grilli, 2011) strongly claim that the second and main reason is the fact that venture capital funds take care of investments in newly founded firms and keep up-to-date with their improvement.

Although venture capital is a part of private equity investing (Jeng & Wells, 2000), investors are not limited to accredited investors; they can range from public wealthy individuals to privately held companies. Initially, venture capital appeared on the USA market and later spread to European financial market. Somehow, the USA has held a leading position on the global market (Grilli, Latifi, & Mrkajic, 2019). Nonetheless, venture capital is a contemporary means of providing additional capital across Europe, and venture capital fundraising process has attracted many companies that need capital. There are many countries which are highly supportive of venture capital fundraising.

Becker and Hellman (2003) mention in their study that Germany made an attempt to help venture capital funds flourish on a national level. The authors (Becker & Hellmann, 2003) point out that the attempt faced a lot of struggles primarily because Germany is a bank-oriented market. As a result, the German first venture capital fund faced a failure and much effort was required to keep venture capital funds stable. As German venture capital market has been in the spotlight concerning Europe, the focus of this study is on Germany itself. The aim of the research is to identify to which extent unemployment rate, global innovation index, price-to-book ratio, corporate tax rate and industrial production influence venture capital fundraising in Germany. The first part of the study concentrates on literature related to variables already mentioned, whereas the second one focuses on methodology and suitable data for multiple regression. In the final section, the results about the interdependence between venture capital and independent variables are discussed along with the relevance of the literature review to the research findings.

1. Literature review

The determinants of venture capital are numerous, so this part of the study explains the variables among other literature regarding this topic. Ning, Wang and Yu (2014) investigated in their study the impact of various determinants on venture capital investments, as a dependent variable. Along with that, Ning, Wang and Yu (2014) implied that greater industrial index and lower unemployment rate lead to more venture capital investments. In order to test these relationships between variables, multiple regression models were used including lagged-variables models, and the authors are oriented to the USA.

According to Groh and Wallmeroth (2015), it is tested to which extent corporate tax rate, innovation index, unemployment rate and other determinants influence venture capital. By using regression model and panel data from 118 emerging markets, the authors (Groh & Wallmeroth, 2015) have concluded that innovation index has a positive and significant effect on venture capital investments. Furthermore, the unemployment rate and corporate

tax rate did not show significance in the study of said authors, who consider other variables more important.

In the aspect of innovation index, Cui, Zhang & Wang (2024) conducted a research on bidirectional influence between venture capital and innovation by using data from 284 cities in China. One of the findings considering the issue is based on the premise that there is a positive interdependence between venture capital and innovation as it was suggested by the previous group of authors.

According to Jaoui, Amoussou & Kemeze (2022), venture capital fundraising is positively influenced by lower corporate tax rate as well as better innovation prospects. In the case of innovation, the authors (2022) used high-technology exports one year lagged in order to carry out a study, which covers determinants of venture capital investments from 25 African countries. Furthermore, they concluded that innovation represents a primary driver of venture capital investment, as ventures characterized by high-risk yet promising innovative potential are most likely to attract funding.

Additionally, Grilli, Latifi and Mrkajic (2019) stated that both corporate tax rate and industrial production do not have a significant effect on venture capital activity. On the other hand, a dynamic panel data model identified that stock market capitalization strongly influences fluctuations of venture capital. Therefore, it can be concluded that P/B ratio can be an explanatory variable which should be taken into account. In order to obtain relevant results, Grilli, Latifi and Mrkajic (2019) employed snowballing technique on available data. Apart from that, their study covers the data from developed countries (the USA, United Kingdom, Japan and Germany).

Poterba (1989) highlighted the dependence of corporate tax rate on venture capital activity on the USA market. Poterba put forward a view that a link between taxation and venture capital activity is stronger when the focus is on the investments in start-up firms. Eventually, the author came to the conclusion that reductions in the capital tax rate would positively affect venture capital activity and make venture capital investments more attractive. Consistent with their focus on corporate taxation, Edwards and Todtenhaupt (2019) also claim that corporate tax rate makes a negative and significant impact on venture capital funding. Their analysis relies on data concerning venture capital investments in early-stage companies, exclusively related to the USA.

Apart from that, Cherif and Gazdar (2011) questioned whether unemployment rate influenced venture capital both in the form of early-stage investments and in the form of already raised funds. Having tested the data from 21 European developed countries, they realized that unemployment rate had a strong effect on venture capital activity in early stage, whereas unemployment rate did not influence venture capital fundraising.

The study of Gompers and Lerner (1999) stated that lower capital gains tax rates would increase attractiveness of venture capital fundraising in the United States. This was proven by examining venture capital organizations. As far as unemployment rate and P/B ratio are concerned, Félix, Gulamhussen and Pires (2013) pointed out in their research that P/B ratio does not significantly affect venture capital activities in European developed

countries. However, unemployment rate has a strong negative impact on venture capital, and this variable should be examined. This study was broadened by the findings of Felix, Nunes & Pires (2022), who claim that unemployment rate both negatively and significantly contributes to venture capital demand, as well as that unemployment rate is a strong deterrent to entrepreneurial activity. This particular case was tested on data covering European developed countries.

In the light of innovation and unemployment rate, Jandrić and Geršl (2024) point out the importance of unemployment rate and innovation, among other variables, in European developed countries. By using Bayesian model averaging and panel data analysis, they realized that unemployment rate makes a negative and significant impact, whereas innovation positively and significantly influences venture capital fundraising. The authors used research and development to represent innovation in their study.

Further research related to innovation is conducted by Khan, Khan and Hameed (2020), who outline that innovation has a major and positive effect on venture capital. Their collected data refers to developed European and Asia-Pacific countries and the authors used generalized two stage least square (G2SLS) in order to examine the factors.

In her study, Dalal (2021) explores groups of variables which have positive and significant effect on venture capital activity in a sample of developed countries. The main findings are based on the premise that innovation (as part of technological factors) as well as unemployment rate (as part of macroeconomic factors) influence venture capital in a mentioned way.

According to study of Plško (2024), venture capital activities in emerging countries from Central and Eastern Europe are insignificantly affected by capital gains tax rate and unemployment rate. Furthermore, the author (Plško, 2024) suggested other concerning factors. On the other hand, Bonini and Alkan (2011) concluded that corporate tax rate has a negative, but significant effect on venture capital investments in developed countries. The authors used panel data regression to illustrate where non-linear logarithmic transformations apply to all variables.

A better understanding of the literature review regarding the impact of explanatory variables on venture capital fundraising is provided by Table 1 and Table 2 below, which separate authors based on the research results and the type of country they are referring to.

Table 1: List of authors according to the results of their studies

Variable	Negative impact (-)	No significant impact (0)	Positive impact (+)
Unemployment rate	(Ning, Wang, & Yu , 2014), (Félix, Gulamhussen & Pires, 2013), (Felix, Nunes & Pires, 2022), (Jandrić & Geršl, 2024)	(Groh & Wallmeroth, 2015), (Cherif & Gazdar, 2011), (Plško, 2024)	(Dalal, 2021)
Global innovation index			(Groh & Wallmeroth, 2015), (Cui, Zhang, & Wang, 2024), (Jaoui, Amoussou & Kemeze, 2022), (Jandrić & Geršl, 2024), (Khan, Khan & Hameed, 2020), (Dalal, 2021)
Price-to-book ratio		(Félix, Gulamhussen, & Pires, 2013)	(Grilli, Latifi & Mrkajic, 2019)
Corporate tax rate	(Poterba, 1989), (Gompers & Lerner 1999), (Bonini & Alkan, 2011), (Jaoui, Amoussou & Kemeze, 2022), (Edwards & Todtenhaupt, 2019)	(Groh & Wallmeroth, 2015), (Grilli, Latifi & Mrkajic, 2019), (Plško, 2024)	
Industrial production		(Grilli, Latifi & Mrkajic, 2019)	(Ning, Wang & Yu, 2014)

Table 2: List of authors according to type of country

Variable	Emerging countries	Developed countries
Unemployment rate	(Groh & Wallmeroth, 2015), (Plško, 2024)	(Ning, Wang & Yu, 2014), (Félix, Gulamhussen & Pires, 2013), (Cherif & Gazdar, 2011), (Felix, Nunes & Pires, 2022), (Jandrić & Geršl, 2024) (Dalal, 2021)
Global innovation index	(Groh & Wallmeroth, 2015), (Jaoui, Amoussou & Kemeze, 2022)	(Cui, Zhang & Wang, 2024), (Jandrić & Geršl, 2024) (Khan, Khan & Hameed, 2020), (Dalal, 2021)
Price-to-book ratio		(Félix, Gulamhussen & Pires, 2013), (Grilli, Latifi & Mrkajic, 2019)
Corporate tax rate	(Groh & Wallmeroth, 2015), (Plško, 2024), (Jaoui, Amoussou & Kemeze, 2022)	(Poterba , 1989), (Gompers & Lerner, 1999), (Grilli, Latifi & Mrkajic, 2019), (Bonini & Alkan, 2011), (Edwards & Todtenhaupt, 2019)
Industrial production		(Ning, Wang & Yu , 2014), (Grilli, Latifi & Mrkajic, 2019)

2. Methodology and Data

This part of the study focuses on the independent and dependent variables and the appropriate model in order to accurately test formulated hypotheses. As far as dependent variable is concerned, it is transformed into logarithmic number and as such used in the model. On the other hand, all the independent variables are used as they are derived from the source, i.e. in their original form. The data used in the research is taken from Invest Europe, Data World Bank, Country Economy, Companies Market Cap, and Trading Economics. Further information about the sources and variables considered for the model can be found in Table 3.

The adequate method for the study is multiple non-linear regression. More precisely, the examination is transformed into log-lin model and the results of the model will be introduced in the next chapter along with descriptive statistics. The whole statistical research is done in Data Analysis as a part of Excel program.

Table 3: Variables

Variable	Notation	Calculation	Source
Dependent variable			
Venture capital fundraising	log(VC)	Billion dollars	Invest Europe
Independent variables			
Unemployment, total (% of total labor force)	UR	Percent	Data World Bank
Global innovation index	II	Index	Country Economy
Price-to-book ratio	P/B R	Ratio	Companies Market Cap
Corporate tax rate (%)	CTR	Percent	Trading Economics
Industrial production (%)	IP	Percent	Trading Economics

It is crucial to mention that venture capital fundraising refers to the amount of raised venture capital in Germany on an annual basis. This variable will be tested and consequently the results will provide feedback on its fluctuations. Unemployment rate is derived as the exact values from the source and it was calculated as a percentage of total labor force. Global innovation index measures an economy's effectiveness and success. Also, it highlights how the country is ranked among the other countries in terms of economic growth, innovation performance, education, infrastructure and so on (WIPO, 2025). Since it is an index, it can take a value from 0 to 100. Apart from that, all stocks in banks with venture capital entities are included in the study to calculate price-to-book ratio. This indicator is calculated as a subtraction between market stock value and its book value (Mirović, Pjanić, Andrašić & Kalaš, 2024). Corporate tax rate refers to a tax rate that applies to companies. The last variable to be used in the model is industrial production. Its value is expressed in percentage and in Germany industrial production measures the output of companies within the industrial sector of the economy (Economics, 2025).

Once all the variables are explained, it is necessary to make the equation which represents the log-lin regression model:

$$\text{Log}(VC) = \beta_0 + \beta_1 UR + \beta_2 II + \beta_3 P/B R + \beta_4 CTR + \beta_5 IP + \varepsilon \quad (1)$$

In order to identify whether the independent variables have a significant effect on the raised venture capital in Germany, it is essential to formulate hypotheses:

H₁ : Unemployment rate positively affects venture capital.

H₂: Innovation index has a significant positive effect on venture capital.

H₃ : P/B ratio negatively affects venture capital.

H₄: Corporate tax rate has a positive effect on venture capital.

H₅: Industrial production negatively affects venture capital.

3. Results and discussion

This chapter provides the summary statistics regarding independent variables together with regression summary for venture capital. Prior to presenting the results of the model, there is Table 4 below showing descriptive statistics.

Table 4: Descriptive statistics

	log(venture capital)	unemployment rate	innovation index	P/B ratio	corporate tax rate	industrial production
Mean	3.40817	0.03611	57.75600	0.34811	0.29920	-0.00850
Standard Error	0.07090	0.00156	0.22086	0.03455	0.00042	0.01046
Median	3.37912	0.03500	57.98500	0.33140	0.30000	-0.01800
Standard Deviation	0.22421	0.00492	0.69843	0.10927	0.00132	0.03307
Sample Variance	0.05027	0.00002	0.48780	0.01194	0.00000	0.00109
Minimum	3.20303	0.03068	56.55000	0.22650	0.29700	-0.04500
Maximum	3.93676	0.04612	58.80000	0.51920	0.30000	0.06500
Sum	34.08173	0.36113	577.56000	3.48110	2.99200	-0.08500
Count	10	10	10	10	10	10

Source: Author's calculations

Tables 5 and 6 show the results of log-lin regression considering all relevant statistical measurements, followed by an explanation.

Table 5: Summary statistics: independent variables

Regression Statistics	
Multiple R	0.921853214
R Square	0.849813348
Adjusted R Square	0.662080034
Standard Error	0.130333061
Observations	10

ANOVA	df	SS	MS	F	Significance F
Regression	5	0.384469057	0.076893811	4.526705074	0.08428795
Residual	4	0.067946827	0.016986707		
Total	9	0.452415884			

Source: Author's calculations

Table 6: Regression summary for venture capital fundraising

	Coefficients	Standard Error	t Stat	P-value
Intercept	109.5671053	30.32052993	3.61362765	0.022484024
UR	-107.4314938	27.11430332	-3.962170537	0.016647366
II	-0.393072593	0.106223712	-3.70042229	0.020827731
P/B R	0.500106447	0.489713623	1.021222249	0.364886124
CTR	-266.5647566	83.83467215	-3.179648107	0.033546496
IP	-0.60297644	1.876884569	-0.32126453	0.76409595

Source: Author's calculations

In Table 5, R-squared shows that 84.98% of variations of venture capital is explained by variations of unemployment rate, innovation index, price-to-book ratio, corporate tax rate and industrial production. However, standard error shows that the average distance of original data from regression model is 13.03%.

The main part of the regression model presents p-values, which is used for examining statistical significance. Table 6 offers the explanations by emphasizing that unemployment rate, innovation index and corporate tax rate have p-values which are below 0.05. Furthermore, it is concluded that H_1 and H_4 are accepted, meaning that the unemployment rate and corporate tax rate have a significant effect on venture capital,

whereas H_2 is rejected since the results show that industrial index has a negative effect on venture capital fundraising.

On the other hand, price-to-book ratio and industrial production have p-values, which are above 0.05 meaning that these two variables do not have significant effect on venture capital fundraising on the significance level 95%.

After the research results, it can be stated that the results partially correspond to the studies of the authors from the review. Firstly, Groh and Wallmeroth (2015), Cherif and Gazdar (2011) and (Plško, 2024) concluded that the unemployment rate has no significant effect on venture capital fundraising, which does not correspond to the results of this research where it is stated that the unemployment rate has a negative and strong influence on venture capital activities. On the other hand, the findings of Ning, Wang and Yu (2014) and Félix, Gulamhussen and Pires (2013) show the same results as presented in this research.

When it comes to global innovation index in Germany, the results show negative significance between the variable and venture capital activity. It was to be expected, based on the nature of venture capital, that the innovation index would have a positive impact on capital raising, as some authors have proven. Although innovation is generally considered a driver of startup success, and therefore of venture capital fundraising, the negative effect of the innovation index can be explained by the fact that excessive or radical innovation can deter venture capital investments due to higher associated risks, longer commercialization times, and uncertainty regarding market fit. In this context, a high innovation index can signal projects that are too experimental or disconnected from immediate market needs, thereby reducing their attractiveness to investors. However, (Groh & Wallmeroth, 2015) pointed out that innovation index has a positive impact on dependent variable. The results of the next variable - price-to-book ratio, suggest no impact of the ratio on the venture capital, which corresponds to the research of Félix, Gulamhussen and Pires (2013). On the other hand, Grilli, Latifi and Mrkajic (2019) imply that positive interdependence exists between mentioned variables.

The results from this study show that corporate tax rate has a negative, but significant effect on dependent variable. The same results are claimed in the studies of Gompers and Lerner (1999), Poterba (1989) and (Bonini & Alkan, 2011). However, Groh and Wallmeroth (2015), Grilli, Latifi and Mrkajic (2019) and (Plško, 2024) came to a different conclusion, i.e. corporate tax rate makes no impact on venture capital fundraising.

The results of the last independent variable - industrial index, show no significance for the dependent variable, which is also concluded by Grilli, Latifi and Mrkajic (2019). However, Ning, Wang and Yu (2014) present positive interdependence between the variables.

In addition, it is necessary to note that the results vary based on the development of countries. Following the list of authors from Table 2 together with the research results, it could be assumed that unemployment rate, corporate tax rate and global innovation index

significantly impact venture capital fundraising in developed countries. However, it is inconclusive for other groups of countries, since the listed authors that discuss emerging countries presented quite the opposite results.

Conclusion

Since venture capital activity is thought to be one of many tools for gaining start-up capital for a number of companies, it is necessary to consider its crucial determinants. This research suggests that the factors of great significance are unemployment rate, global innovation index and corporate tax rate. These determinants should be considered since they influence the dependent variable. On the other hand, price-to-book ratio and industrial index might not be under examination as they do not influence venture capital activities in the period 2015-2024.

Consequently, investors should consider determinants that have a positively significant impact on venture capital fundraising, as these are considered to be leading factors for attracting this type of capital.

The primary rationale for undertaking this type of research is to outline main factors which have significant impact on venture capital fundraising. Thus, this research could be a reliable source of information for both Germany and other developed countries. Keeping in mind the outcomes of the research, policymakers as well as venture capital fund managers in mentioned countries should devote more attention to macroeconomic setting and create a suitable environment concerning significant factors. Apart from them, entrepreneurs who are in need of this particular capital also have to consider macroeconomic events because the prospects of their start-ups highly depend on these events.

As far as limitations are concerned, it is essential to outline that the period in study covers years from 2015 to 2024 and therefore many conclusions regarding the topic might not be applied to the years which are not included in the research. Also, research results might not be used as a relevant example among emerging countries since their macroeconomic environment differs up to an extent.

All things considered, since this is a contemporary issue, further research into the venture capital industry is warranted to identify additional factors that may influence fundraising in the foreseeable future. Numerous factors influence venture capital activity on financial markets, and tracking these dynamics closely is crucial for safeguarding financial stability in developed countries.

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The impact of innovation on ESG performance

Утицај иновација на ESG перформансе

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Abstract

Purpose: The main objective of the paper is to explore how different types of innovations contribute to ESG performance in companies. The study aims to distinguish the specific effects of technological and organizational innovations on environmental, social, and governance dimensions, thereby clarifying their role in sustainable corporate development.

Methodology: To achieve the research objective, data were collected from 113 companies in Serbia during 2025. Structural Equation Modelling was applied to examine the relationships between types of innovations and ESG performance dimensions, enabling a precise assessment of their individual impacts.

Findings: The study confirms that innovations are essential for improving ESG performance. Technological innovations have the strongest impact on environmental outcomes, while organizational innovations are most influential in strengthening governance practices. Social performance is positively affected by both types of innovations, though to a lesser extent.

Originality/value: This research provides novel insights into the differentiated effects of innovation types on ESG dimensions, contributing to the literature by linking innovation strategies with sustainability outcomes in a transitional economy context. It highlights the importance of distinguishing between technological and organizational innovations when evaluating ESG performance.

Practical implications: The findings can help hotel managers and policymakers design innovation strategies that align with sustainability goals. Companies seeking to improve environmental outcomes should prioritize technological innovations, while those aiming to strengthen governance should focus on organizational innovations. These insights are particularly valuable for decision makers in emerging economies striving to balance competitiveness with ESG commitments.

Limitations: The study is limited to companies operating in Serbia, which may restrict the generalizability of findings to other contexts. Additionally, the analysis is based on cross-sectional data collected in 2025, preventing the assessment of long-term innovation effects. Future research should expand to comparative international samples and longitudinal designs.

Keywords: innovations, ESG performance, technological innovations, organizational innovations, Structural Equation Modelling.

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JEL classification: M14, O30, Q56

Сажетак

Циљ: Истраживање има за циљ да идентификује ефекте технолошких и организационих иновација на еколошке, друштвене и управљачке димензије, у контекстну одрживог корпоративног развоја.

Методологија: Подаци су прикупљени применом структурираног упитника на примеру 113 компанија у Србији током 2025. године. У истраживању је примењено моделирање структурних једначина како би се испитале везе између врста иновација и димензија ESG. Овакав приступ омогућава прецизну процену појединачних утицаја.

Резултати: Резултати истраживања потврђује да су иновације неопходне за побољшање ESG учинка. Технолошке иновације имају најјачи утицај на еколошке исходе, док организационе иновације највише утичу на јачање пракси управљања. На друштвени учинак позитивно утичу обе врсте иновација, мада у мањој мери.

Оригиналност/вредност: Ово истраживање пружа нове увиде у диференциране ефекте врста иновација на ESG димензије, доприносећи литератури повезивањем иновационих стратегија са исходима одрживости у контексту транзиционе економије. Истиче важност разликовања технолошких и организационих иновација приликом процене ESG учинка.

Практична примена: Резултати истраживања могу да послуже менаџерима у хотелима и креаторима друштвених политика у дизајнирању иновационих стратегија које су усклађене са циљевима одрживости. Компаније које желе да побољшају еколошке резултате требало би да дају приоритет технолошким иновацијама, док оне које желе да ојачају управљање треба да се фокусирају на организационе иновације. Ови увиди су посебно вредни за доносиоце одлука у земљама у развоју које теже да уравнотеже конкурентност са ESG обавезама.

Ограничења истраживања: Ограничење истраживања односи се на чињеницу да су у истраживању учествовале само компаније које послују у Србији. Ово ограничење узорка може имати утицаја на генерализацију налаза на друге контексте. Поред тога, анализа се заснива на попречним подацима прикупљеним 2025. године, што спречава процену дугорочних ефеката иновација. Будућа истраживања требало би да се прошире на упоредне међународне узорке и лонгитудиналне дизајне.

Кључне речи: иновације, ESG перформансе, технолошке иновације, организационе иновације, моделирање структурних једначина.

ЈЕЛ класификација: M14, O30, Q56

Introduction

The dynamic nature of the business environment, driven by rapid changes in consumer habits and technological advancements, implies that only innovative companies can successfully adapt and remain competitive (Josimović et al., 2024). Innovation enables firms to meet market needs more efficiently than competitors by creating new products and optimizing processes, thereby allowing them to retain a larger share of consumer surplus or transfer it to consumers. As Kay (1993) emphasizes, innovation represents a central source of competitive advantage. However, the accelerated pace of technological development intensifies competition, stimulates the emergence of new markets, products, and services, and significantly shortens product life cycles, suggesting that innovation should be viewed not as a permanent, but as a difficult-to-sustain source of competitiveness (Josimović et al., 2025). The sustainability of innovation depends both on competitors' ability to imitate practices and on the availability of resources.

In addition, demographic shifts such as migration and population aging, combined with the convergence of consumer preferences and growing environmental awareness, compel enterprises to engage more intensively with sustainable practices. Excessive and uncontrolled resource exploitation has made the promotion of sustainability a societal

priority, further requiring companies to align with the concept of sustainable business. Under such circumstances, firms are driven to seek new, more efficient alternatives to maintain competitive advantage, or to combine existing alternatives in ways that exploit their synergistic effects (Josimović et al., 2024). This shift redirects the impact of innovation from purely economic and financial outcomes toward non-economic performance. A promising alternative that reconciles both requirements is innovation aimed at improving ESG performance - environmental, social, and governance outcomes—as the three dimensions of the ESG framework. Green innovations exemplify such an approach, serving as a valuable mechanism for mitigating resource and environmental constraints while advancing the sustainable development of industry (Wang & Li, 2020).

Although opponents of the ESG concept argue that companies have only one responsibility, maximizing profits (Radivojević et al., 2022), numerous empirical studies demonstrate that firms adhering to ESG principles can achieve competitive advantage and improve business performance (Alsayegh et al., 2020). This has been well documented across industries (Wu et al., 2020; Radivojević et al., 2022; Pimić et al., 2024). Unlike adherents of neoclassical theory, who emphasize profit as the sole objective, these studies show that environmental outcomes are also essential for superior profitability. In other words, companies can achieve high profits by implementing and promoting sustainability practices.

Positive effects of such practices are typically realized through enhanced corporate image and reputation (Liu & Hamori, 2020), which in turn improve competitiveness and market share by increasing demand for products and services. Business improvements are also frequently achieved through resource savings, reduced energy consumption, lower waste generation, and decreased emissions of harmful substances. These outcomes are largely the result of technological and organizational innovations. Hence, achieving and sustaining significant ESG performance is inseparable from a company's capacity to innovate. Put differently, the ability to innovate business processes is a prerequisite for conducting business in line with sustainable behavior (Ortiz-Villajos & Sotoca, 2018).

Despite this observation, limited scholarly attention has been devoted to examining the direct impact of innovation on firms' ESG performance. This gap in the literature represents a research void that the present study seeks to address. Moreover, empirical evidence suggests that the effect of innovation on firm performance is highly context-dependent (Anokhin & Schulze, 2009). Factors such as firm age, type of innovation, and cultural environment substantially shape the extent to which innovation influences performance outcomes. Existing studies therefore do not allow for universal or definitive conclusions, underscoring the importance of macroeconomic circumstances in which firms operate. Accordingly, the aim of this research is to identify the impact of innovation on ESG performance in general, and more specifically within enterprises in the Republic of Serbia. The specific macroeconomic conditions, primarily stemming from social developments of the late twentieth century and inefficiencies of the privatization process necessitate an examination of these effects under such circumstances.

While prior studies have extensively examined the role of innovation in enhancing competitiveness and sustainability, limited attention has been devoted to its direct impact on ESG performance, particularly in transition economies such as Serbia. This gap underscores the need for empirical investigation into how innovation shapes ESG outcomes under specific macroeconomic conditions.

Accordingly, the present study aims to explore the relationship between innovation and ESG performance in Serbian enterprises. The paper is structured as follows: Section 2 reviews the relevant literature, Section 3 outlines the methodology, Section 4 presents the empirical findings, and Section 5 discusses implications. Section 6 is conclusion.

1. Literature review

Numerous empirical studies show that innovations have great potential to influence the performance of companies (Hervas-Oliver et al., 2018; Son et al., 2018; Ahmad & Wu, 2022). In recent years, the growing focus on sustainable corporate behavior has spurred increased research into how innovation impacts a company's ESG performance (Xu et al., 2021; Daugaard & Ding, 2022; Sofie & Augustine, 2024). Studies on the impact of innovations on environmental performance dominate the literature. The findings of such conducted studies (Choe 2022; Zhang, 2021; Zheng et al., 2022) can be summarized in the following conclusion: innovations have a great potential to significantly reduce the negative effects of a business on the environment during the production process and save resources, which is closely related to their impact on the environment and society. This is mainly achieved through resource and energy savings (Choe, 2022), which are related to technological progress (Zheng et al., 2022). In other words, the authors contend that innovation contributes to enhanced ESG outcomes, with a pronounced effect on environmental performance.

However, when talking about innovation, it should be borne in mind that innovation is a multi-layered phenomenon (Kleinknecht et al., 2002), and that different types of innovations can have different impacts on the performance of a company (Damanpour et al., 1989). Innovation can be understood as the creation and exploitation of new and existing knowledge that connects market and technological opportunities (Dougherty, 1992). The multidimensional nature of innovation has led to the absence of a universally accepted classification within the scholarly literature. The prevailing typology typically differentiates between product, process, and organizational innovations. In the context of sustainability-oriented development, however, an alternative categorization that distinguishes technological, organizational, and social innovations has gained prominence (Salamzadeh et al., 2022). This framework broadly converges with the conventional classification, while simultaneously underscoring the wider societal dimension of sustainable innovation. Within this perspective, technological innovations encompass both product and process innovations as defined in the prevailing typology. Technological innovations focus on activities at the organizational level that reduce vulnerabilities and improve technological efficiency through changes in products, processes, or infrastructure.

Organizational innovation involves integrating sustainability into an organization's culture, processes, and strategy (Dukanac et al., 2025).

In the literature, particular emphasis is placed on the influence and importance of technological innovations on firms' ESG performance (Wang et al., 2024). Thus, research by Huang et al. (2023) shows that digital innovations have a positive impact on ESG performance of companies. The positive impact of technological innovations on ESG performance of companies can also be found in the papers of Yang et al. (2024), Liu et al. (2024), Cao et al. (2023), as well as Huang et al. (2023). The results of these studies indicate that the positive impact is mainly achieved through the reduction of carbon emissions and savings in consumption of resources. The findings of these authors, consistent with previous findings, imply that technological innovations drive ESG performance primarily by improving the environmental dimension of the concept. Accordingly, this provides the foundation for proposing a hypothesis:

H_{1.1} Technological innovations have a positive impact on environmental ESG performance of companies operating in the Republic of Serbia;

In the literature, few studies have addressed the impact of these innovations on the other two dimensions of the concept. Such is the research of Zheng et al. (2022). These authors have shown that green innovation, which is mainly associated with technological progress, has a positive impact on all three dimensions of the ESG concept. Similar findings were presented by Asadi et al. (2020), Dicuonzo et al., (2022), as well as Wang et al. (2024). Xu et al. (2021) have demonstrated the positive impact of innovation on the environmental and social dimensions of the ESG concept. In light of these findings, Daugaard & Ding (2022) and Sofie & Augustine (2024) point out that innovation is an intrinsic driver for improving overall ESG performance. Accordingly, this provides the foundation for proposing a hypothesis:

H_{1.2} Technological innovations have a positive impact on social ESG performance of companies operating in the Republic of Serbia;

Wang et al. (2023) confirmed that digital transformation enhances the quality of corporate governance. Similarly, Dedeić & Brnjas (2013) validated the hypothesis that the application of modern technologies, particularly information technologies, significantly accelerates improvements in corporate governance. Comparable findings were reported by Buglea et al. (2025), who examined the relationship between digital transformation as a proxy for technological innovation and non-financial performance metrics (ESG), including governance. Their results indicate a positive impact of technological innovations on governance performance. A positive relationship between technological innovations, specifically digitalization and digital transformation and corporate governance performance was demonstrated by Jelovac et al. (2022). Accordingly, this provides the foundation for proposing a hypothesis:

H_{1.3} Technological innovations have a positive impact on governance ESG performance of enterprises operating in the Republic of Serbia;

González-Blanco et al. (2018) examined the influence of non-technological innovation encompassing organizational and marketing innovation on the environmental performance of Spanish manufacturing firms. The study found a significant positive effect of technological innovation on environmental outcomes, thereby supporting the hypothesis that such innovation enhances environmental performance. Similar findings were presented by Sancak (2023). Accordingly, this provides the foundation for proposing a hypothesis:

H_{2.1} Organizational innovations have a positive impact on environmental ESG performance companies operating in the Republic of Serbia;

Gebhardt et al. (2023) analyzed the impact of organizational innovations on ESG performance, with particular emphasis on their effect on social performance. Their findings indicate that organizational innovation significantly enhances social outcomes. Similarly, Dey et al. (2020) established that organizational innovation facilitates the adoption of social practices, which constitute key components of the social dimension of ESG performance in SMEs. The findings of these authors suggest that:

H_{2.2} Organizational innovations have a positive impact on social ESG performance of enterprises operating in the Republic of Serbia;

Liang & Li (2023), through their analysis of organizational resilience, demonstrated that organizational innovations enhance governance performance, thereby reinforcing overall ESG outcomes. Complementary evidence is provided by Sierdovski et al. (2022), who, in the context of sustainable business practices, showed that the development of organizational innovation capacities improves organizational performance via strengthened ESG results. Their findings particularly underscore the advancement of management performance, as firms strive for greater efficiency and effectiveness in processes and products. Accordingly, this provides the foundation for proposing a hypothesis:

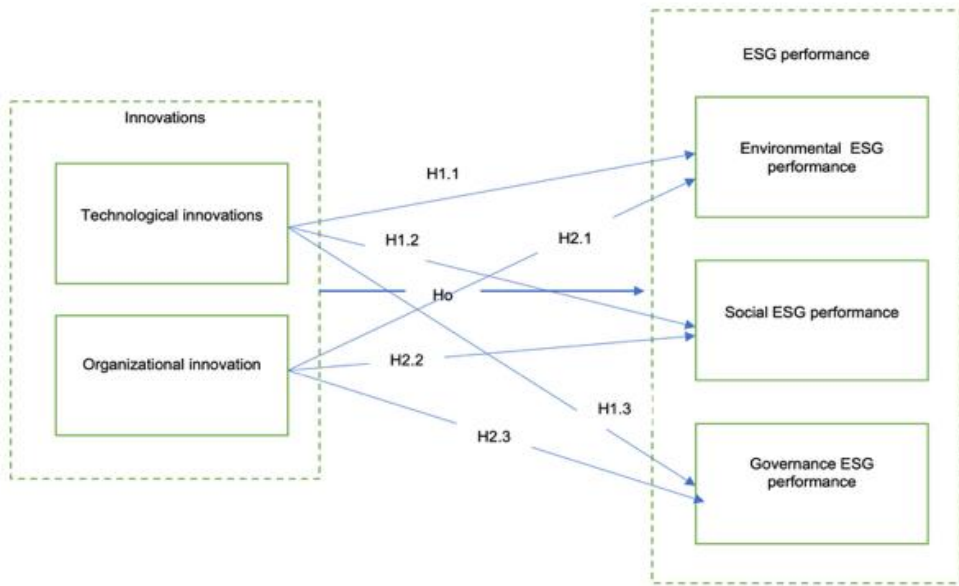
H_{2.3} Organizational innovations have a positive impact on governance ESG performance of companies operating in the Republic of Serbia.

However, in contrast to these studies, there are authors, such as Afum et al. (2021), Zhao et al. (2021), Zheng & Iatridis (2022), who question the impact of innovation on the dimensions of the ESG concept. Thus, Zhao et al. (2021) point to a negative impact of these innovations, particularly on the social dimension of the ESG concept, while the evidence from Afum et al. (2021) is difficult to interpret. The findings of the research are in a similar vein (Ahmad & Wu, 2022). By analyzing the literature in this area, Ahmad & Wu (2022) concluded that no generalizable finding can be established regarding the impact of innovation on ESG performance. Their findings suggest that the overall impact of innovation on business performance is an aggregate effect resulting from both positive and negative intermediary effects that need to be further moderated by contextual factors. This attitude is consistent with (Rosenbusch et al., 2011). Given the limited academic literature explicitly addressing how organizational innovations affect ESG performance - particularly regarding how these two types of innovations influence the dimensions of the ESG concept - the aim of this research is justified. An exception is the research by Zhu & Huang (2023), which documented the positive impact of organizational innovation on ESG performance.

However, these authors did not study the impact of these innovations on individual dimensions of the concept, but rather analyzed them at an aggregated level.

Based on the hypotheses, the proposed research model is presented in Figure 1.

Figure1: Research model



Source: Authors

2. Research methodology

The lack of data regarding the ESG performance of companies operating in the Republic of Serbia means that the ESG performance must be expressed through latent variables. In other words, data on ESG performance concerning all three dimensions of the ESG concept are collected using a questionnaire, developed from relevant literature. Table 2 shows the items from the questionnaire and their sources.

Table 1: Questionnaire

Variables	Item	Source	FL	AVE	CR
Technological innovations (TI)	The company is proactive in new product and/or service development.	Yang et al., (2019). Nikolic et al., (2022)	0.945	0.74	0.92
	The company introduces new products or services.		0.873		
	The company introduces numerous changes in business processes.		0.811		
	The company introduces innovations in logistics processes.		0.809		

Organizational Innovation (OI)	The company innovates in the organizational structure.	Nikolić et al., (2022).	0.852	0.68	0.91
	The company adopts modern management methods.		0.783		
	The company innovates its marketing strategies.		0.901		
	The company innovates its quality management system.		0.794		
	The company innovates the HRM system		0.791		
	The company innovates information systems.		0.852		
Environmental performance (EV)	The company has a number of environmental certifications.	Asadi et al., (2020).	0.753	0.62	0.80
	Company's overall environmental performance has improved over the past five years.		0.771		
	Consumption of resources, e.g. Water, electricity and gas have decreased over the past three years.		0.846		
	The company's regulations are in line with environmental regulations.		0.798		
Social performance (CR)	The customers' motivation has increased during the last 3 years	Asadi et al., (2020). Barbosa et al., (2024).	0.783	0.65	0.81
	The customers' satisfaction has increased during the last 3 years.		0.873		
	The company provides more social or environmentally friendly services in the community		0.762		
	The company serving more beneficiaries (disadvantaged people) or solving environmental issues		0.814		
Governance performance (GG)	The company is characterized by transparent reporting	Cantele et al., (2024).	0.873	0.64	0.90
	The company applies key sustainability performance indicators.		0.762		
	Fair business practices are promoted		0.806		
	Clearly defined procedures are in place to mitigate the risk of corruption among board members.		0.815		
	There are clearly defined procedures for the fair management of conflicts of interest among internal stakeholders.		0.738		

Source: Authors

The validity of the questionnaire was tested using factor analysis, i.e. convergent and divergent validity testing, as well as the internal consistency of items using the reliability coefficient. The adequacy of the sample was confirmed by KMO measure of 0.834, as well as the Bartlett's sphericity test ($\chi^2 = 253$, $p < 0.001$). Participants received an email

containing a link to the questionnaire. The research analyzed a sample of companies from different industries operating in the Republic of Serbia. The sample includes large companies according to the IAS classification criterion that have implemented certain ISO standards related to the ESG concept, such as ISO 9000, 14000, and 26000. This avoids the influence of industry-specific characteristics on both innovation and ESG, because different industries face different pressures for innovation and ESG compliance under EEC regulations. The survey included 113 companies that met the above criteria. The data was collected in 2025. Items from the questionnaire were evaluated using a Likert scale from 1 - strongly disagree, to 5 - strongly agree.

3. Results of the analysis

Before testing the hypotheses, we assessed the fit of the proposed model. As shown in Figure 2, the goodness-of-fit statistics were calculated for the five-factor measurement model. Table 1 also presents the results of the factor analysis. All items exhibited factor loadings above 0.60, with no cross-loadings exceeding 0.30, which justified their retention for subsequent analyses. The reliability coefficients ranged from 0.80 to 0.91, indicating strong internal consistency. Model fit indices were satisfactory: Comparative Fit Index (CFI) = 0.91, Bentler-Bonett Normalized Fit Index (NNFI) = 0.91, and Root Mean Square Error of Approximation (RMSEA) = 0.024. Average Variance Extracted (AVE) values ranged between 0.62 and 0.74, confirming good convergent validity. Overall, these results suggest a strong fit between the hypothesized measurement model and the observed data. Divergent validity was assessed using the Fornell-Larcker criterion, with results shown in Table 2. As indicated, the values along the main diagonal exceeded the inter-factor correlations, thereby supporting the discriminant validity of the questionnaire.

Table 2: Divergent validity

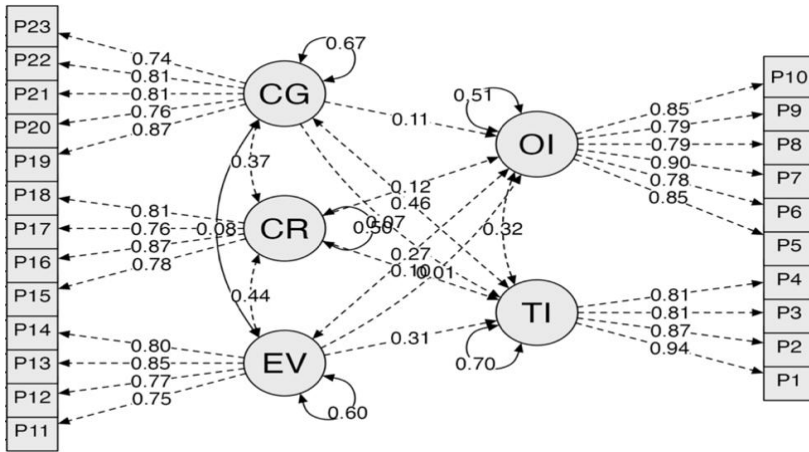
	TI	OI	EV	CR	GG
TI	0.860				
OI	0.421	0.825			
EV	0.154	0.087	0.787		
CR	0.183	0.112	0.034	0.806	
GG	0.123	0.276	0.054	0.097	0.800

Note: All correlation coefficients are statistically significant

Source: Authors

The hypotheses were tested using structural equation modelling, with results reported in Table 3 and illustrated in Figure 3. The model demonstrated acceptable fit, as indicated by the following indices: Comparative Fit Index (CFI) = 0.90, Bentler-Bonett Normalized Fit Index (NNFI) = 0.90, and Root Mean Square Error of Approximation (RMSEA) = 0.025, thereby confirming the validity of the proposed model.

Figure2: Research model



Source: Authors

Table 3: Structural equation modelling results

Latency factor	Coefficient	St. error	Z-Test	p-value	Result
EV - TI	0.311	0.008	38.875	0.000	H _{1.1} is accepted.
EV - OI	0.011	0.001	11.000	0.000	H _{1.2} is accepted.
CR - TI	0.096	0.021	4.571	0.000	H _{1.3} is accepted.
CR - OI	0.121	0.011	11.000	0.000	H _{2.1} is accepted.
CG - TI	0.065	0.003	21.667	0.000	H _{2.2} is accepted.
CG - OI	0.114	0.018	6.333	0.000	H _{2.3} is accepted.

Source: Authors

The structured estimates presented in Table 3 demonstrate that all hypotheses are supported.

4. Discussion of the results with possible implications

The results presented in Table 3 are consistent with expectations. All the proposed hypotheses can be accepted as valid, given that the p-values exceed the significance threshold at the 0.05 confidence level. These findings confirm that innovations play a significant role in achieving ESG performance, in line with the conclusions of numerous authors such as Xu et al. (2021) and Wang et al. (2024), who emphasize that innovation is critical to identifying win-win strategies through which economic growth can be attained in a sustainable manner. However, the findings call for a more nuanced analysis of their individual effects, particularly considering the limited resources and capacities that companies can allocate to innovation. As noted by Leonidou et al. (2013), innovations typically demand substantial resources and capacities, while their benefits are often not immediately observable, which influences firms' willingness to implement them. The

results of this study indicate that technological innovations are the most influential, exerting the strongest impact on environmental ESG performance. This outcome is expected, given that such innovations directly enhance resource efficiency and contribute to the reduction of emissions, waste, and energy consumption. Due to their material nature, technological innovations exert a more pronounced effect on environmental outcomes compared to the so-called soft organizational components. This finding corroborates the arguments of Amores-Salvadó et al. (2014), as well as the empirical evidence reported by Cao et al. (2023). At the same time, it contrasts with the conclusions of González-Blanco et al. (2018), who emphasize that non-technological innovation contributes to achieving better environmental performance.

The smallest impact of these innovations on governance ESG performance can be explained by the fact that the digitalization processes are largely completed and that the effects of digitalization are not felt to the same extent as at the beginning of their implementation. The reason for this can also be sought in the fact that technological innovations require integration into the management process for their effects to be felt on organizational improvements. A lack of effective integration may cause less impact. This can be a good motive for future research. The statistical significance of these innovations on governance performance can be explained by increased transparency, improved communication in the enterprise and agility. A somewhat stronger impact on environmental performance compared to governance performance can be explained by the fact that innovative processes and products, through enhancing corporate reputation and/or transferring efficiency gains into donations to the local community, contribute to the improvement of environmental outcomes of companies operating in the Republic of Serbia.

Regarding the impact of organizational innovation on the individual dimensions of the ESG concept, the findings are consistent with expectations. Similar to technological innovations, but in the opposite direction, organizational innovations exert the least influence on environmental performance. This result contrasts with the study of González-Blanco et al. (2018), who argue that organizational innovation has the greatest effect on environmental outcomes. However, the intangible nature of organizational innovations largely explains their limited environmental performance, as they are primarily directed toward improving managerial processes, establishing new stakeholder relationships (in terms of intellectual capital), enhancing communication, and strengthening organizational culture. Consequently, these innovations exert their strongest influence on governance performance, a conclusion supported by the findings of Liang & Li (2023) and Sierdovski et al. (2022). Organizational innovation directly reshapes institutional frameworks, processes, and cultural practices that underpin good governance, thereby exerting a stronger and more direct impact on governance than technological innovation. The same reasoning applies to their significant effect on social ESG performance: by promoting ethical standards, respecting external stakeholders, and introducing criteria of socially responsible behavior, organizational innovations enhance the consistency and scope of socially responsible activities. This, in turn, strengthens corporate reputation and positively contributes to the improvement of the social dimension of ESG. This is in line with Dey et al. (2020) and Gebhardt et al. (2023).

Understanding both the intensity of the impact of innovations on ESG performance and the channels through which these impacts are realized is crucial for balancing the complexity of implementation with their expected effects. With the rational use of limited resources, companies in the Republic of Serbia must make strategic choices depending on the outcomes they seek to achieve. In summary, technological innovations exert the strongest influence on environmental performance, yet they demand the greatest resources and capacities from firms. Conversely, organizational innovations require fewer resources and capacities, but their effects are most evident in strengthening governance performance and least pronounced in environmental protection.

Conclusion

The research confirms the positive impact of innovation on ESG performance. More specifically, technological innovations exert the strongest influence on environmental outcomes, while organizational innovations have the greatest effect on governance performance. These differences can be explained by the material nature of technological innovations, which directly improve resource efficiency and reduce emissions, and the intangible nature of organizational innovations, which reshape managerial processes, stakeholder relations, and governance structures. Taken together, the findings highlight the importance of innovation as a strategic lever for advancing sustainable business, while also underscoring the need for a holistic approach that integrates both technological and organizational innovations to achieve balanced improvements across all dimensions of the ESG framework.

What this study does not reveal, but sets the foundation for future research, is the reasons behind the inefficient integration of technological innovations into managerial processes, which would strengthen their effects on the other two dimensions of the ESG concept. The study also leaves room for similar research, primarily to encourage the use of more objective and quantitative measures of ESG performance. Due to the lack of available ESG data, the study relies on subjective assessments. Although the validity of the questionnaire was tested, the subjectivity of responses inevitably influences the results and, consequently, the conclusions. When interpreting the findings, it is necessary to take into account the limitations arising from the sample. Although the sample included a relatively large number of companies, the requirement that firms had implemented ISO standards related to the ESG concept restricts the generalizability of the results. Therefore, future research is recommended to include a more heterogeneous sample.

The research directly examined the impact of innovation on ESG performance. Nevertheless, it is well established that a variety of factors can shape the effects of innovation. Future studies are therefore encouraged to investigate intermediary and conditional variables, such as regulatory frameworks, organizational culture, and leadership, that may moderate or mediate the relationship between innovation and ESG outcomes. Moreover, the present study did not address the dynamic interactions between innovation and ESG performance over time. Subsequent research could expand the scope by employing causal methods to explore these dynamics, thereby providing deeper insights

into the long-term implications of different innovative strategies for sustainable business. While the study offers valuable evidence on the role of innovation in enhancing ESG performance in the Republic of Serbia, it also underscores the importance of further research that acknowledges its limitations and broadens the analytical framework to strengthen understanding of the causal links between innovation and ESG performance.

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Beyond profitability: Do cash flow management indicators forecast SMEs business failure in the long run?

Изнад профитабилности: Да ли индикатори управљања новчаним токовима предвиђају пословни неуспех МСП на дуги рок?

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Abstract

Purpose: The study examines whether cash flow management indicators can serve as reliable early predictors of small and medium-sized enterprise (SME) business failure. Specifically, it investigates the ability of cash flow-based indicators to forecast business failure three years before the initiation of formal bankruptcy proceedings.

Methodology: A multilayer perceptron (MLP) neural network with two hidden layers is applied to analyze a dataset of Serbian SMEs operating in the Trade and Manufacturing sectors. The model relies exclusively on cash flow indicators and is evaluated using a training-test data split and classification metrics derived from the confusion matrix.

Findings: The results indicate that cash flow indicators provide early signals of SME business failure three years in advance. The model demonstrates high predictive performance, achieving an area under the ROC curve (AUC) of 0.895. Indicators related to operating cash flow generation and debt-servicing capacity emerge as the most influential predictors in this sample, highlighting the importance of liquidity and sustainable cash flow management for long-term business survival.

Originality/value: The study contributes to the literature by focusing exclusively on cash flow indicators and applying a neural network approach to predict SME failure three years in advance. It represents one of the first regional studies combining a cash flow-centered perspective with machine learning methods and long prediction horizon, while analyzing firms within specific industry segments.

Practical implications: The findings offer early warning signals that can support credit risk assessment, financial monitoring, and timely interventions by managers, lenders, and policymakers.

Limitations: The study is limited by a relatively small sample size. While the sector-specific focus reduces structural heterogeneity, it may limit generalizability. Future research could extend the dataset across Balkan economies and incorporate additional or dynamic cash flow indicators capturing year-to-year changes.

Keywords: cash flow management, SMEs, neural networks, machine learning, bankruptcy prediction.

JEL classification: C53, C38, G33, L26, C10

Сажетак

Циљ: Циљ рада је да испита да ли индикатори управљања новчаним токовима могу послужити као поуздани рани предиктори пословног неуспеха малих и средњих предузећа (МСП). Конкретно,

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истраживање анализира способност индикатора заснованих на новчаним токовима да предвиде пословни неуспех три године пре покретања формалног стечајног поступка.

Методологија: У раду је примењена „*multilayer perceptron*“ неуронска мрежа (ен. MLP) са два скривена слоја на узорку српских МСП из сектора трговине и прерађивачке индустрије. Модел се ослања искључиво на индикаторе новчаног тока, а његове перформансе су процењене поделом узорка на тренинг и тест скуп података, као и применом класификационих метрика изведених из матрице конфузије.

Резултати: Резултати указују да индикатори новчаних токова пружају ране сигнале пословног неуспеха МСП три године пре стечаја. Модел показује високе предиктивне перформансе, остварујући вредност површине испод ROC криве (AUC) од 0,895. Индикатори који се односе на генерисање оперативног новчаног тока и способност сервисирања дуга показују се као најзначајнији предиктори у овом узорку, наглашавајући значај ликвидности и одрживог управљања новчаним токовима за дугорочни опстанак предузећа.

Оригиналност/вредност: Рад доприноси литератури фокусирајући се искључиво на индикаторе новчаних токова и примену неуронских мрежа у предвиђању неуспеха МСП три године унапред. Такође представља једно од првих истраживања у регионалном контексту које комбинује приступ заснован на новчаним токовима са методама машинског учења, са дугим хоризонтом предикције, уз анализу предузећа у оквиру специфичних индустријских сектора.

Практична примена: Налази рада обезбеђују ране сигнале упозорења који могу подржати процену кредитног ризика, финансијски надзор и благовремене интервенције менаџера, кредитора и креатора економске политике.

Ограничења истраживања: Истраживање је ограничено релативно малим узорком. Иако фокус на одређени сектор смањује структурну хетерогеност, он може ограничити генерализовање резултата. Будућа истраживања могла би проширити скуп података на привреду Балкана и укључити додатне или динамичке индикаторе новчаних токова који прате промене из године у годину.

Кључне речи: управљање новчаним токовима, мала и средња предузећа, неуронске мреже, машинско учење, предвиђање стечаја.

ЈЕЛ класификација: C53, C38, G33, L26, C10

Introduction

Balance sheets and income statements have traditionally served as the primary sources of information for researchers, analysts, and investors in both academic inquiry and practical decision-making. The well-known phrase “*Cash is King*” has become increasingly acknowledged and respected, reflecting the reality that it is cash (not accounting income) that ultimately sustains business activity. Cash enables firms to purchase inputs, pay salaries, service debt, and reward shareholders, making it a more direct indicator of financial resilience than accrual-based earnings. Profit-based indicators in particular may be subject to earnings management, potentially limiting their reliability as predictors of financial distress (Karas & Režňáková, 2020). This limitation may call into question the reliability of purely accrual-based models and underscores the potential benefits of incorporating alternative measures such as cash flow indicators. Managing cash flow involves overseeing the inflow and outflow of funds within a business, which affects its ability to acquire assets, remunerate staff, meet debt obligations, and maintain operational efficiency to achieve strategic goals. Often referred to as treasury management, this practice entails the careful monitoring of cash movements across a firm’s operational, financing, and investment activities (Nasimiyu, 2024). Cash represents a crucial resource for both individuals and organizations, necessary for fulfilling financial commitments and increasingly central to corporate operational strategies (Fisher, 1998). Sound cash management is vital for ensuring organizational stability, enabling future planning, and

honoring obligations. Moreover, effective control over cash flows has been shown to enhance a firm's financial performance (Kroes & Manikas, 2014). The impact of small businesses on national economies is both substantial and multifaceted. Worldwide, they are regarded as key drivers of economic development, fostering entrepreneurship, innovation, and the efficient use of resources (Aren & Sibindi, 2014). In developing countries, SMEs are especially important for promoting economic growth and reducing poverty. Yet, these enterprises frequently face difficulties due to limited stakeholder awareness of effective cash flow management practices (Kongolo, 2010). For instance, in Serbia, an emerging European economy, SMEs account for 42.5% of the total business income (Business Registers Agency, 2023). The primary objective of this study is to examine and quantify the long-term capacity of cash flow indicators for predicting business failure within the SME sector in the Republic of Serbia. Specifically, the research aims to develop a classification model based on Multilayer Perceptron (MLP) neural networks (NN) to detect business failure signals three years in advance. By doing so, the study seeks to overcome the limitations of traditional models that mostly rely on accounting profitability and accrual-based metrics. Research hypothesis is defined as follows: *A predictive model based on Multilayer Perceptron (MLP) neural networks, utilizing cash flow indicators, can accurately identify business failure risk in Serbian SMEs from the Trade and Manufacturing industry three years prior to the formal initiation of bankruptcy proceedings.*

This study is organized into four sections. The first section presents a literature review, initially covering studies that utilize comprehensive financial data for predicting business failure, followed by research highlighting the specific role of cash flows. The second section, "Sample, Materials, and Methods," details the research design, including sampling strategies and methodological considerations. Statistical analysis and model development were performed using IBM SPSS Statistics. To capture complex non-linear relationships within the financial data, a Multilayer Perceptron (MLP) neural network architecture was employed. The third section presents the findings, along with the developed model and its performance evaluation. The fourth section, "Discussion", examines the advantages and limitations of the study and explores its practical implications, preceding the conclusion.

1. Literature review

Research on business failure and bankruptcy prediction has drawn extensively on statistical and machine learning approaches, with logistic regression, decision trees, and k-nearest neighbors among the most widely applied techniques. Early work by Ohlson (1980) marked a turning point, demonstrating that simple financial ratios such as net income to total assets and total liabilities to assets could serve as powerful predictors of bankruptcy. Since then, logistic regression has remained a benchmark method, although its performance is often outpaced by newer approaches. For instance, Papík & Papíková (2024), analyzing nearly 10,000 Slovak firms, reported that logistic regression achieved an overall accuracy of 68.3%, making it the weakest performer when compared against six alternative machine

learning algorithms. Similarly, in the Serbian context, Bešlić-Obradović et al. (2018) applied logistic regression to medium and large enterprises and obtained 82.5% accuracy, while Kuster et al. (2025) developed a general log regression bankruptcy prediction model for Serbian market incorporating both financial and non-financial indicators, achieving an overall accuracy of 72.2% on the test sample for predictions three years in advance.

Decision tree models have also received significant attention. Wang et al. (2014) demonstrated the potential of DTs by developing two models on datasets of 240 and 132 firms, achieving predictive accuracies of 71.6% and 76%, respectively. Expanding this line of inquiry, Lee et al. (2020) constructed a decision tree framework using over 4,300 SMEs and showed that non-financial variables alone could deliver strong predictive power, with 82.7% accuracy on the test set. Even higher predictive performance was achieved by DiDonato & Nieddu (2015), who applied the CRT decision tree algorithm to 100 SMEs and attained 91.6% accuracy using cross-validation, relying exclusively on financial predictors. These findings highlight the flexibility of decision trees in incorporating both financial and non-financial data. In recent years, the k-nearest neighbors method has emerged as a competitive alternative. Aker & Karavardar (2023) applied k-NN models to Turkish SMEs and achieved predictive accuracies ranging from 87% to 92% for horizons of one to three years ahead, outperforming several competing approaches. Similarly, Abdullah (2021) tested k-NN on firms listed on the Dhaka Stock Exchange, finding accuracies of 82% on training data and 85% on test data, underscoring the method's robustness across different contexts. Importantly, methodological innovations have further enhanced the performance of k-NN models. For example, Smiti & Soui (2020) demonstrated that applying oversampling techniques substantially improved the AUC of k-NN predictions, raising it from as low as 0.48–0.64 to consistently strong levels of 0.86–0.86 across five-year horizons.

Inam et al. (2018) showed that neural networks can outperform traditional tools like logistic regression and discriminant analysis, requiring fewer assumptions about input variables while still delivering strong accuracy in classifying firms. Chen & Du (2009) also reported encouraging results, with their backpropagation neural network correctly predicting bankruptcy for Taiwanese companies with over 80% accuracy two years in advance. Barboza et al. (2017) investigated firms in the United States and Canada, comparing neural networks with a range of machine learning approaches. Their findings indicated that models built on indicators such as growth, size, liquidity, and profitability outperformed neural networks, which trailed by roughly 10% in predictive accuracy. Several studies have examined the role of cash flow indicators as primary predictors of business failure. Veronica et al. (2020) developed a business failure prediction model for Indonesian manufacturing companies, using a sample of 92 firms and applying logistic regression. Their findings showed that cash flow measures can reliably predict bankruptcy. Similarly, Bhandari & Iyer (2013) analyzed 100 firms, incorporating seven predictor variables into a discriminant analysis (DA) model. Four of these predictors were cash flow-based, while the remainder were derived from balance sheet and profit and loss accounts. Their matched sample design (50 failed and 50 non-failed firms) enabled the prediction of business failure one year in advance. Özcan (2020) examined business failure prediction in

Turkey, analyzing 66 firms (balanced 1:1 between solvent and failed companies) from various industries. Using logistic regression, the study developed three models to forecast bankruptcy one, two, and three years ahead, achieving accuracies of 87%, 74%, and 68%, respectively, with all predictors derived from cash flow measures. In another study, Karas & Režňáková (2020) investigated 4,350 Czech manufacturing SMEs over the period 2013–2018. Although the dataset was imbalanced (only 40 failed firms), they employed classification and regression trees (CART) and logistic regression based on 17 cash flow ratios. Best reached AUC value is 0.82. In the developed European markets, Rizzo et al. (2020) used cash flow ratios to predict bankruptcy in a couple of economies (Germany, Spain, France, Great Britain and Italy) and multiple activities (Agriculture, Industry, Services, Construction, Commerce and Food). The model has performed well across most tested countries and sectors. The results obtained are almost all adequate; in particular, in Germany and Spain, results have been particularly good, with the best AUC of 0,855 in Spanish “Industry” sector.

2. Sample, materials and methods

Predicting business failure is complicated by a fundamental data imbalance: the number of firms that actually experience failure (bankruptcy) is typically much smaller than those that remain solvent. This imbalance often constrains the effectiveness of predictive models in correctly identifying firms at risk (Masten & Masten, 2012). To mitigate this, prior research frequently applies a 1:1 matching strategy, constructing balanced samples of failed and solvent firms to enhance model reliability and classification accuracy (Altman, 1968; Fletcher & Goss, 1993; McKee, 1995; Cho et al., 2010; Cheong & Ramasamy, 2019). The empirical analysis in this study draws on a sample of 108 Serbian SMEs operating in Trade and Manufacturing industries. Prior models that pool firms of all sizes and sectors often overlook the unique financial dynamics of specific SMEs, which makes a sector-specific approach essential. Accordingly, the dataset here is restricted to SMEs, with equal representation of solvent firms ($n=54$) and failed firms ($n=54$), where failure is defined as the initiation of bankruptcy proceedings. Consistent with established practice (Theobald, 2021), the sample was divided into training and testing subsets using an ~80:20 ratio, including 88 SMEs in the training dataset, and 20 in the testing.

In this study, the variables are divided into dependent and independent categories. The dependent variable is defined in binary form, distinguishing between two outcomes: firms that entered bankruptcy proceedings (coded as 0) and firms that remained solvent and operational (coded as 1). The independent side is represented by nine cash flow management indicators, summarized in Table 1. These indicators serve as explanatory factors, helping to capture financial characteristics linked to a firm’s probability of failure. The variables were prepared in MS Excel using data collected from publicly available financial statements, and for each firm, financial information was traced up to three years prior to its observed status (failed or solvent), which allowed capturing early signals of financial issues in the years leading up to the outcome.

Table 1: Independent variables

#	Label	Calculation	Literature Source
1	OCFTA	<i>Operating Cash Flow / Total Assets</i>	Back et al. (1996), Atiya (2001), Neophytou & Molinero (2004), Ryu & Yue (2005), Abdelwahed & Amir (2005), Charitou et al. (2004), Callejón et al. (2013), Bapat & Nagale (2014), Douglas (2014), Sehgal et al. (2021), Chinedu et al. (2023)
2	OCFTD	<i>Operating Cash Flow / Total Debt</i>	Back et al. (1996), Ryu & Yue (2005), Alfaro (2008)
3	OCFS	<i>Operating Cash Flow / Sales</i>	Neophytou & Molinero (2004), Charitou et al. (2004), Bapat & Nagale (2014), Chinedu et al. (2023)
4	CCL	<i>Cash / Current Liabilities</i>	Back et al. (1996), Ryu & Yue (2005), Alfaro (2008), Chung et al. (2008), Zebardast et al. (2014), Fedorova et al. (2013), Inam et al. (2018)
5	OCFCL	<i>Operating Cash Flow / Current Liabilities</i>	Back et al. (1996), Charitou et al. (2004), Neophytou & Molinero (2004), Bapat & Nagale (2014), Lin (2009), Chinedu et al. (2023)
6	CFNID	<i>Cash Flow Net Result / Total Debt</i>	Leshno & Spector (1996), Virag & Kristof (2005), Brockett et al. (2006), Chen & Du (2009), Ravisankar et al. (2010), Kouki & Elkhaldi (2011), Inam et al. (2018)
7	OCF	<i>Operating Cash Flows</i>	Mossman et al. (1998), Anandarajan et al. (2001)
8	CS	<i>Cash / Sales</i>	Back et al. (1996), Lee et al. (1996), Liang et al. (2016), Brenes et al. (2022), Ryu & Yue (2005), Ravisankar et al. (2010)
9	CFTL	<i>Cash / Total Liabilities</i>	Back et al. (1996), Bryant (1997), Tung et al. (2004), Brenes et al. (2022)

Source: Author

The modeling process was conducted using a machine learning approach based on a neural network (NN), implemented in IBM SPSS software. The predictive power of the model was evaluated using a confusion matrix and the standard performance metrics derived from it (Table 2).

Table 2: Neural Network performance metrics

Metric	Formula
Accuracy	$(TP + TN) / (TP + TN + FP + FN)$
Precision	$TP / (TP + FP)$
Sensitivity (Recall)	$TP / (TP + FN)$
Specificity	$TN / (TN + FP)$
F1-Score	$2 \times (\text{Precision} \times \text{Recall}) / (\text{Precision} + \text{Recall})$

Negative Predictive Value (NPV)	$TN / (TN + FN)$
False Positive Rate (FPR)	$FP / (FP + TN)$
False Negative Rate (FNR)	$FN / (TP + FN)$
False Discovery Rate (FDR)	$FP / (TP + FP)$
Matthews Correlation Coefficient	$(TP \times TN - FP \times FN) / \sqrt{((TP + FP)(TP + FN)(TN + FP)(TN + FN))}$

Source: Author

3. Analysis and results

One neural network (MLP) was developed to predict SMEs failure based on cash flow management indicators *three years in advance*. The network consists of two hidden layers, with 8 neurons in the first and 6 neurons in the second hidden layer, both including bias units. The activation functions were selected through empirical testing: the hyperbolic tangent function was applied in the hidden layers, while a sigmoid function was used in the output node. The sigmoid activation is well-suited for binary classification, as it maps the output to a probability in the (0, 1) range, and this combination yielded the best overall classification performance. The model was trained using the gradient descent algorithm with batch learning, applying an initial learning rate of 0.001 and a momentum parameter of 0.9. All the independent variables were standardized. The neural network model achieved strong predictive performance on both the training and testing datasets (Table 3). These outcomes demonstrate that cash flow-based indicators, when analyzed through a neural network, provide a reliable framework for anticipating business failure among SMEs. The boxplot (Figure 1) illustrates the distribution of predicted pseudo-probabilities generated by the neural network for failed (0) and solvent (1) SMEs. The model clearly differentiates between the two groups. For failed firms, the predicted probabilities are concentrated at higher levels for the “failed” class (blue) and substantially lower for the “solvent” class (red), with limited overlap between distributions. Conversely, solvent firms display higher predicted probabilities for the “solvent” class and markedly lower values for the “failed” class. Although some overlap and outliers are present, indicating instances where the model misclassified or was less confident, the median values and interquartile ranges demonstrate a strong separation between the two statuses. This separation suggests that the neural network, based on cash flow ratios, is effective in discriminating between solvent (healthy) and failed SMEs (that initiated bankruptcy proceedings). The relatively small degree of misalignment in predictions highlights areas for further refinement but does not detract from the overall predictive validity of the model.

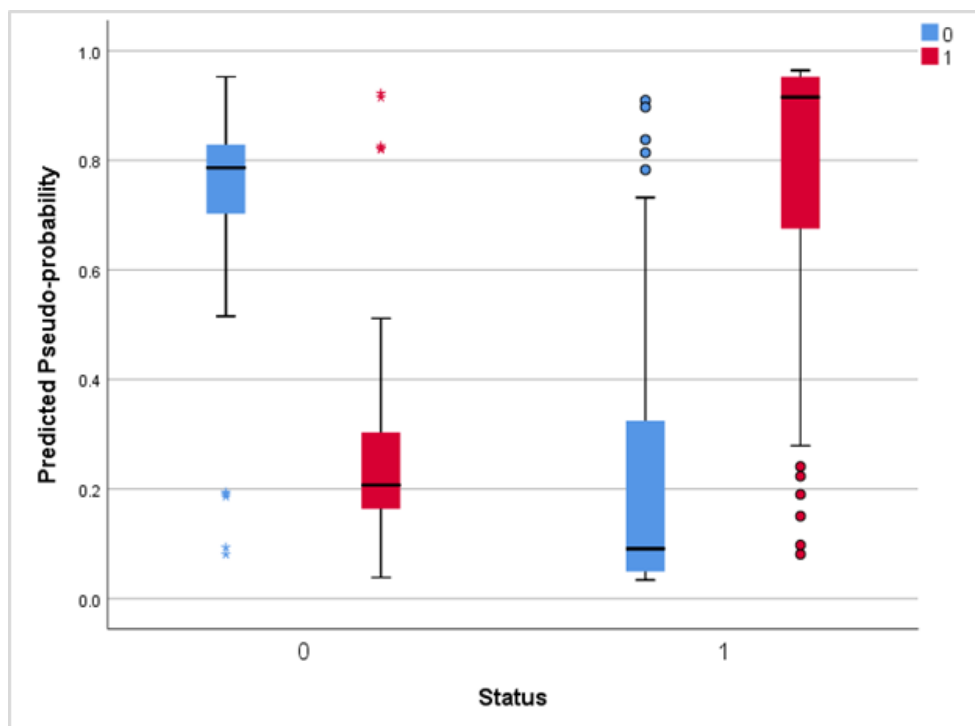
Table 3: NN Results – assessment metrics

Sample	Training	Testing
Accuracy	87.5%	85.0%
Precision	85.1%	81.8%
Sensitivity	90.9%	90.0%

<i>Specificity</i>	84.1%	80.0%
<i>F1-Score</i>	87.9%	85.7%
<i>Negative Predictive Value</i>	90.2%	88.9%
<i>False Positive Rate</i>	15.9%	20.0%
<i>False Negative Rate</i>	9.1%	10.0%
<i>False Discovery Rate</i>	14.9%	18.2%
<i>Matthews Correlation Coefficient</i>	0.75	0.70

Source: Author

Figure1: The Boxplot

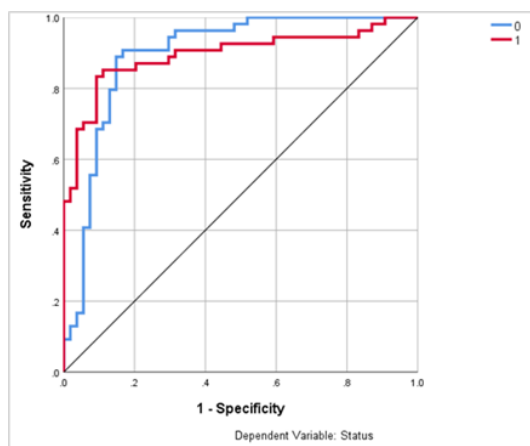


Source: Author, SPSS output

The receiver operating characteristic (ROC) curve is a widely used tool for assessing the performance of binary classification models, as it illustrates the trade-off between sensitivity and specificity (Klepáč & Hampel, 2018). The area under the curve (AUC) provides a single scalar measure that summarizes overall classification accuracy. An AUC of 0.5 indicates performance equivalent to random guessing, while a value of 1 reflects perfect classification, although the latter is rarely attainable in practice. According to established guidelines for interpreting AUC values (Al-Milli et al., 2021), the AUC score obtained for the business failure prediction model (0.895) demonstrates a high level of accuracy. The ROC curve is displayed in Figure 2. The curve for failed firms (blue, coded

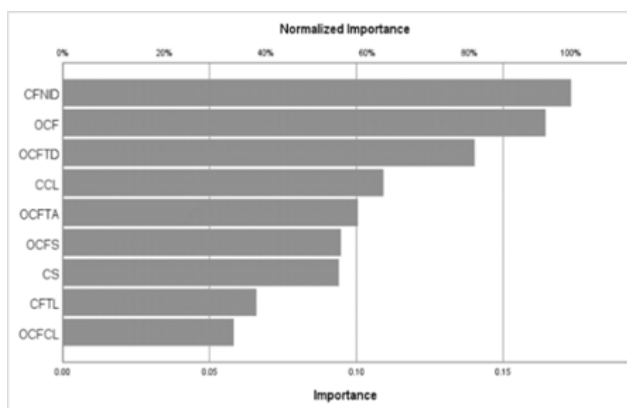
as 0) and the curve for solvent firms (red, coded as 1) both lie well above the diagonal line that represents random guessing. This pattern indicates that the model performs well in separating failed SMEs from those that remain solvent. The overall trajectory of curves demonstrates a favorable balance between sensitivity and specificity. Taken together, the curves confirm that the model provides reliable discriminatory power, supporting its use as an early-warning tool for failure prediction in SMEs from the Trade and Manufacturing sectors.

Figure2: ROC Curve



Source: Author, SPSS output

The results (Figure 3) highlight several cash flow-based indicators as the most influential predictors of business failure, providing practical insights for SME managers. The two strongest predictors, Cash Flow Net Result to Total Debt (CFNID) and Operating Cash Flow (OCF), emphasize the critical role of liquidity and debt servicing capacity. SMEs that generate insufficient cash relative to their debt obligations are at heightened risk of failure, underlining the importance of careful debt management and ensuring that operating activities consistently produce positive cash flows. Other indicators, such as Operating Cash Flow to Total Debt (OCFTD) and Cash to Current Liabilities (CCL), reinforce this point by showing that firms must be able to cover both short- and long-term obligations from internal resources rather than relying excessively on external financing. Similarly, Operating Cash Flow to Total Assets (OCFTA) signals how effectively assets are being used to generate cash, which is crucial for SMEs with limited resource bases. The importance of cash-based ratios relative to sales (OCFS and CS) suggests that revenue growth alone is insufficient; firms must ensure that sales translate into actual cash inflows, as profits may otherwise remain unrealized due to poor collection practices. Meanwhile, Cash Flow to Total Liabilities (CFTL) and Operating Cash Flow to Current Liabilities (OCFCL) underscore the necessity of balancing working capital and maintaining adequate liquidity buffers.

Figure3: Independent variables normalized importance

Source: Author, SPSS output

Taken together, these findings provide a clear message for SME managers: focusing solely on profitability indicators may overlook early warning signals of financial issues. Instead, proactive cash flow management, carefully monitoring the ability to convert sales into cash, cover liabilities, and sustain operations is vital for financial resilience. Policymakers and financial institutions can also use these insights to design more effective support mechanisms and credit assessment tools tailored to SMEs in emerging markets.

4. Discussion

Among the failed firms in the sample, 44 out of 54 reported at least some level of profitability ($ROA \geq 1\%$); 18 had ROA above 5%. This highlights an important insight: profitability alone does not safeguard firms from failure. Cash flow management should remain at the forefront of financial status assessment, complementing traditional profitability indicators.

Research results suggest that business failure can be predicted up to three years in advance relying exclusively on cash flow management indicators, using a neural network (NN) framework. The study represents a contribution to the still limited body of regional evidence on cash flow-based failure prediction in emerging European economies, where liquidity constraints and structural vulnerabilities of SMEs make such early warning tools particularly relevant. To the best of the author's knowledge, this study contributes to the literature in several ways. In contrast to several prior studies, which employ broad sets of financial ratios dominated by accrual-based measures, this work focuses exclusively on cash flow indicators as predictors of business failure. Compared with existing evidence, this research contributes by focusing on an emerging European economy. Furthermore, this cash flow model is tailored to the SME sector and further narrowed to industries particularly exposed to liquidity pressures. Moreover, the model extends the predictive horizon beyond the commonly adopted one-year benchmark in the literature, showing that early warning signals can be reliably extracted three years in advance.

From a practical perspective, the findings carry meaningful implications. For entrepreneurs and managers in SMEs, the identified indicators offer a tangible set of measures that can be tracked proactively to assess financial vulnerability well before default becomes unavoidable. Lenders, investors, and policymakers can similarly benefit from such a focused model, since cash flows directly capture repayment capacity and resilience to shocks. The simplicity of cash flow-based metrics enhances interpretability and makes the monitoring process more accessible for smaller businesses with limited analytical resources. Nevertheless, certain limitations should be acknowledged. Neural networks, while powerful in uncovering non-linear relationships, are often criticized as “black-box” models, offering limited transparency into how decisions are made. This raises challenges for adoption in professional practice, where stakeholders may demand more interpretable justifications for predictions. Future research could address this by integrating explainable AI techniques or hybrid approaches that balance predictive accuracy with transparency. Additionally, the analysis is restricted to SMEs in Serbia’s trade and manufacturing sectors, which may limit generalizability. Expanding the scope across other European emerging markets would strengthen the external validity of the findings.

Conclusion

The findings of this study suggest that business failure among SMEs can be anticipated up to *three years in advance* using exclusively cash flow management indicators analyzed through a neural network framework in Serbia. The model delivered strong results: on the training set, it achieved 87.5% accuracy. On the testing set, performance remained robust, with 85.0% accuracy. The Matthews Correlation Coefficient reached 0.75 for training and 0.70 for testing, underscoring the overall predictive validity of the model. These outcomes suggest that cash flow-based ratios, particularly those capturing liquidity and debt-servicing capacity, may provide a reliable basis for forecasting SME failure. The analysis identified several variables as the most influential predictors, including Cash Flow Net Result to Total Debt (CFNID) and Operating Cash Flow (OCF). These indicators highlight the central role of liquidity and the ability to meet debt obligations, as firms generating insufficient cash relative to their commitments faced the greatest risk of failure. Measures such as Operating Cash Flow to Total Debt (OCFTD) and Cash to Current Liabilities (CCL) further underline the importance of internal financing for both short- and long-term obligations, while ratios relative to assets or sales (OCFTA, OCFS, CS) emphasize the need for efficiency in converting operations and revenues into actual cash inflows. The findings also reveal that profitability alone cannot safeguard firms from business failure. Among failed companies, 44 out of 54 reported positive ROA ($\geq 1\%$), 18 had ROA above 5%. In contrast to several prior studies, this work focuses exclusively on cash flow management indicators and applies a neural network to assess their predictive power. It also extends the forecast horizon beyond the commonly adopted one-year benchmark to *three years ahead*, while tailoring the model to SMEs in Trade and Manufacturing within an emerging European economy, thereby addressing a segment that remains relatively underrepresented in the existing literature. The results *support the hypothesis H_1 , as the MLP model*

demonstrated a high area under the ROC curve ($AUC = 0.895$), indicating its ability to recognize patterns of business failure in Serbian SMEs even three years in advance.

In conclusion, the findings of this study highlight the important role of cash flow management in long-term business sustainability and contribute to the development of more focused, practical, and forward-looking tools for predicting SME failure.

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Determinants of Corruption in the Balkan Countries: An Empirical Analysis

Детерминанте корупције у балканским земљама:
емпиријска анализа

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Abstract

Purpose: Corruption represents one of the most serious problems faced by developing countries, particularly those with a lack of democratic potential. The aim of this paper is to examine, through the application of a dynamic statistical model, the long-term and short-term effects of economic freedom, democracy, and the level of economic development on the level of corruption in the case of Balkan countries.

Methodology: The research is based on panel data for 10 Balkan countries. The observed dependent variable is the World Bank's *Control of Corruption* indicator, while the independent variables include the *Economic Freedom of the World* index published by the Fraser Institute, the *Electoral Democracy Index* published by the V-Dem Institute, and the level of economic development measured by GDP per capita from the World Bank database. The analysis employs an ARDL model, which enables separate examination of the long-term and short-term effects of the independent variables on the dependent variable.

Findings: A statistically significant impact of electoral democracy, economic freedom, and the level of economic development on the level of corruption in the long run has been confirmed. Only economic freedom also has an effect in the short run, with the direction of the effect remaining unchanged.

Originality/value: This is the first study of these determinants of corruption using a sample from the Balkans, and, to the author's knowledge, it is only the second paper in the overall literature to be based on the application of the ARDL model.

Practical implications: Research on the determinants of corruption always has practical relevance in the fight against corruption. Confirmation that corruption is a consequence of a lack of democracy and economic freedom in the Balkans provides guidance for the necessary reforms of the economic and political system.

Limitations: A practical limitation of the study relates to the relatively small number of observed variables, which is a consequence of the choice of the statistical model. Including a large number of variables would lead to the problem of model overidentification.

Keywords: economic freedom, democracy, corruption, the Balkans, ARDL.

JEL classification: P26, O17, B52

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Сажетак

Циљ: Корупција представља један од најозбиљнијих проблема са којима се суочавају земље у развоју, а нарочито оне са недостатком демократског потенцијала. Циљ рада је да применом динамичног статистичког модела испита дугорочан и краткорочан утицај економских слобода, демократије и нивоа економске развијености на ниво корупције у случају балканских земаља.

Методологија: Истраживање се заснива на панел подацима за 10 балканских земаља. Посматрана зависна варијабла је Контрола корупције Светске банке, док су као независне узете Индекс економских слобода у свету Института Фрејзер, Индекс изборне демократије ког публикује В-Дем институт и ниво економске развијености у виду БДП-а *per capita* из базе Светске банке. У анализи је коришћен АРДЛ модел који омогућава засебно испитивање дугорочног и краткорочног утицаја независних варијабли на зависну.

Резултати: Потврђен је статистички значајан утицај изборне демократије, економских слобода и нивоа економске развијености на ниво корупције у дугом року. Једино економске слободе имају утицај и у кратком року, пре чему се смер утицаја не мења.

Оригиналност/вредност: Ради се о првом истраживању ових детерминанти корупције на узорку балкана, при чему је према сазнању аутора у укупној литератури ово други рад који се заснива на примени ARDL модела.

Практична примена: Истраживања детерминанти корупције увек имају практичну примену у борби против исте. Потврда да је корупција последица недостатка демократије и економских слобода на Балкану пружа правац неопходним реформама економског и политичког система.

Ограничења истраживања: Реално ограничење рада односи се релативно мали број посматраних варијабли, што је последица избора статистичког модела. Укључивање великог броја варијабли би довело до проблема прекомерне идентификације модела.

Кључне речи: економске слободе, демократија, корупција, Балкан, ARDL.

ЈЕЛ класификација: P26, O17, B52

Introduction

Due to the inherent complexity of the phenomenon, there is a large number of definitions of corruption, reflecting its various aspects. According to Collier (Collier, 2002), the absence of a generally accepted definition of corruption is the reason why there is no single interdisciplinary theory of this phenomenon. One of the most frequently used definitions is Tanzi's (1995), according to which corruption exists in the case of a deliberate violation of the principle of impartiality in decision-making, with the aim of appropriating benefits for oneself or a related person. In this way, the problem of defining abstract phenomena such as public interest or public opinion, connected with other popular definitions of corruption, was avoided. However, taking into account the choice of corruption indicators, the paper starts from the definition of the World Bank, which defines corruption as the abuse of public authority in order to obtain personal gains.

Historically speaking, the first traces of corruption come from the period before new era (Bardhan, 1997), but the wider interest of the scientific public in this phenomenon came only in the second half of the 20th century, parallel to the process of decolonization and the second wave of democratization. Modern approaches to the study of corruption are based, above all, on individual choices, with individuals constantly calculating the potential benefits and costs of such illicit practicess (Rose-Ackerman, 1978; Becker & Stigler, 1974; Banfield, 1975). The basic orientation is therefore microeconomic, which may obscure the broader social consequences of corruption. In contrast, the foundational, so-called "traditional" approach to corruption, which we encounter in ancient and medieval

philosophers and writers such as Plato, Aristotle, and Machiavelli, focuses on the "corruption" of social norms. That is where the term corruption comes from, lat. com – together, and rumpere-break.

Within contemporary social science, two conflicting approaches to the study of corruption have emerged - the *grease in the wheels* and the *sand in the wheels* approach. While the former emphasizes the positive effects of corruption (Leff, 1964; Huntington, 1968; Nye, 1967), the latter approach views negatively on the impacts of corruption, as a rent-seeking activity, on socio-economic flows (Rose-Ackerman, 1978; Becker & Stigler, 1974). It was only with the development of statistical instruments and cross-national quantitative corruption metrics in the late 20th century that the negative impact of corruption on economic dynamics was empirically confirmed (Mauro, 1995; Gründler & Potrafke, 2019; Lojanica, 2025). Although corruption may yield short-term benefits for specific actors, its overall long-term effect on society is unequivocally negative. The attitude of modern economic theory towards corruption is negative precisely for this reason, and national legislations around the world prescribe corresponding punishments for such behavior.

Contemporary research rarely addresses the effects of corruption, and it focuses on its causes and determinants. This is because the research is practically oriented, since identifying the determinants of corruption is essential for fighting it (Zhang et al, 2023). When studying a complex and multidimensional phenomenon, such as corruption, it is not justified to limit oneself only to economic analysis, but it is also necessary to include wider institutional and political factors. The microeconomic point of view, despite its advantages regarding the possibility of mathematical modeling, observes reality too narrowly, and ignores the essential determinants of corruption. This particularly refers to the role of the institutional environment in which these types of decisions are made. By defining the rules under which interactions between economic subjects are carried out, political institutions influence the probability of the outbreak of corruption (Lederman, Loayza & Soares, 2005), which is why there is a widespread belief that poor regulation and corruption are "two sides of the same coin" (Lambsdorff, 2006).

This research covers a group of ten Balkan countries in the period 2008-2023. The existing literature unjustifiably neglects this region, characterized by certain specificities, and often deals with almost global samples. All countries within this group, with the exception of Greece, have historically had economic-political systems based on extensive suppression of economic and political freedoms. Later in the transition process, corruption became the most serious problem that transition economies faced (Shleifer, 1997). Today, there are findings that in the Balkans, political elites use corruption in order to consolidate their own power (Sotiropoulos, 2017). All these circumstances actualize the need to study the determinants of corruption in this region.

The starting assumption in the research is the existence of a positive effect of economic freedom and democracy on reducing the level of corruption. The basic theoretical explanation of this relationship stems from the fact that a high level of economic freedom

implies the allocation of resources through the market mechanism, in accordance with the free will and personal choice of economic subjects (Gwartney & Lawson, 2003). By encouraging competition and strengthening the role of the market in the economy, economic freedoms reduce corruption, because civil servants have less room to monopolize the distribution of certain goods and services (Lambsdorff, 2006). On the other hand, by limiting economic freedoms, the state opens up space for corruption, because there are opportunities for rent-seeking activities (Rose-Ackerman, 1999; Paldam, 2002). Some authors point out that in rigid economic systems, corruption can occur as a substitute for the lack of economic freedom (Leff, 1964; Carden & Verdon, 2010). On the other hand, there is research that cast doubt on this theoretical relationship (Bilger & Goel, 2009; Yamarik & Redmon, 2017).

In a democratic system, the division of power is a horizontal mechanism, and periodic elections are a vertical mechanism of government control by citizens (O'Donnell, 1994). In such a society, the demands of the public for the transparency of state activities, and the existence of free and objective media complicate and hinder the implementation of secret and illegal activities by government representatives (Andelković, Stefanović & Petrović, 2024). However, in the case of China and Latin American countries, democratization acted in the direction of spreading corruption (Harris-White & White, 1996). Also, Triesman (2000) points out that the current level of democracy in the country is not relevant, but the fact that the country has been exposed to democracy for a long period of time. Only when democratic institutions are rooted in society, elections become a means of controlling government activities (Serra, 2006). That is why the level of corruption in young democracies is higher than in countries with a long democratic tradition.

In addition to economic freedoms and democracy, the influence of the country's level of economic development was examined in the model. More developed countries have lower levels of corruption due to better public management, the existence of the rule of law and the possibility to create an adequate monitoring mechanism. In poor countries, the marginal value of money is higher, which means public officials derive greater utility from accepting bribes (Sandholtz & Koetzle, 2000). Economic development is believed to reduce corruption through the rationalization of public and private roles, as well as through the expansion of education, making corruption more difficult to hide (Treisman, 2000). Economic development enables individuals to better articulate their desires and participate in the political process (Welzel & Inglehart, 2008). In such conditions, instead of worrying about their own existence, people will be more ready for collective action and will seek better quality public management without corruption.

In accordance with the aforementioned specificities of the observed group of countries, the question arises as to what the relationship between the observed variables will be in the period after the end of the transition process. Also, there is the question whether the required level of economic freedom was achieved in that process and whether democracy was sufficiently consolidated in this part of Europe. The application of the dynamic ARDL model allows us to distinguish short-term from long-term impact, which is lacking in the literature dealing with this topic.

The structure of the work includes three units. In the first part, an overview of the existing literature dealing with this issue was carried out. The second part of the paper presents an overview of the used variables and descriptive statistics by variables and by country. The results of the research together with concluding considerations are at the end, in the third part of the paper.

1. Literature review

The study of the influence of economic freedom and democracy on the level of corruption is not alien to economic literature. A large number of studies have confirmed the influence of these factors on corruption (Paldam, 2002; Lambsdorff, 2006; Jichi & Cabro, 2019), however, this relationship is not always monotonous and unambiguous as theoretically assumed. The very impact of economic freedom depends on the initial level of corruption in the country (Bilger & Goel, 2009). According to the quantile regression method, in those countries where there is already a relatively low level of corruption, an increase in the level of achieved economic freedom will have a positive effect, while in the case of highly corrupt countries, it may have an unfavorable effect. The research also showed that democracy becomes an important factor in reducing corruption only in highly corrupt countries. The level of economic development had a positive impact on the reduction of corruption in all used specifications and in all quantiles. Although the research covered nearly one hundred countries, it only observed a single year. This cross-country research is also a primary limitation of the paper.

In contrast, when Picón & Boehm (2019) applied the same quantile regression method, similar to the aforementioned authors, they reached completely different conclusions. In the wider group of analyzed countries, economic freedom and democracy always proved to be important factors, regardless of the level of corruption in the country. Therefore, countries with a lower degree of economic freedom and democracy have a higher level of corruption and vice versa. Parsons (2025) applied MMQR (Method of Moments Quantile Regression) to a panel of 92 developing countries in the period 1995-2021 and confirmed that economic freedoms reduce corruption in all observed quantiles, i.e. at all levels of corruption.

The joint influence of economic freedom and democracy raises certain doubts. Democracy has an impact on the level of corruption only when there is a low or high level of economic freedom, whereby the direction of the impact differs (Saha, Gounder & Su, 2009). Research based on the OLS method has shown that economic freedoms always lead to a reduction in corruption, but the effect of democracy is conditioned by the level of economic freedoms. If there is a low level of economic freedom in the country, the democratization of society will lead to the spread of corruption, and conversely, if there is a high level of economic freedom, it will affect the reduction of corruption. Other researchers came to a similar conclusion (Viana et al, 2019). Based on a sample of 160 countries between 2010 and 2016, it was observed that when the both democracy and economic freedom are included in the model, democracy loses its statistical significance. On the other

hand, research that did not include economic freedoms at all confirmed the influence of democracy on the reduction of corruption (Chowdhury, 2004).

On a panel of 8 ASEAN countries in the period 2012-2021, the impact of economic freedom, democracy and economic development on corruption was examined using fixed effects (Abbas et al, 2022). The authors also included the interaction between economic freedoms and democracy as a separate variable in the model. Individually, economic freedoms and democracy had a negative sign, i.e. they influenced the growth of corruption, but their interaction had a positive sign.

Jichi & Cabro (2019) examined the relationship between economic freedoms and corruption measured by the *Control of Corruption* indicator using the ARDL model and the Granger causality test. The total number of observed countries in the research was 113, and the period covered was 2002-2016. The authors distinguished two separate groups, namely 36 developed countries and 77 developing countries. Economic freedoms had a statistically significant impact on the level of corruption both in the short and long term, with it being higher in the group of developing countries. However, given that the research deals with the isolated impact of economic freedoms on corruption, no control variable is included, so the results must be taken with caution.

There is also research that did not confirm the impact of economic freedom on corruption, but recognized corruption as a factor that affects the level of economic freedom (Yamarik & Redmon, 2017). Using systemic GMM, the authors identified the level of economic development, democracy, foreign direct investment and Protestant religion as factors that influence the level of corruption, while economic freedoms were not statistically significant. On the other hand, in the model with economic freedom as a dependent variable, corruption had a negative effect. The research included a sample of 164 countries in the period 1995-2012, whereby instead of annual data, five-year averages were used, recalculated on the basis of previous and future years.

Despite extensive literature, there is a common tendency to rely on large samples, which often causes researchers to overlook the specific circumstances in which certain countries are developing. In corruption research, one should refrain from making universal recommendations based on a vast number of countries, and instead focus on smaller groups of countries with similar institutional characteristics. The purpose of this research is to fill that gap in the existing literature.

2. Overview of used variables and descriptive statistics

The sample includes a group of ten Balkan countries in the period 2008-2023. The number of observations is 160, and statistical data processing was performed in the eViews 12 program. The dependent variable is the *Control of Corruption* indicator, while the *Economic Freedom of the World*, *Electoral Democracy index* and *GDP per capita* are independent variables. An overview of the variables used, the names used in the model and the source from which they were taken is given below in Table 1.

Table 1: Overview of used variables

Variable	Name in the model	Source
Control of Corruption	CC	WGI
Economic Freedom of the World	EFW	Fraser Institute
Electoral Democracy Index	EDI	Varieties of Democracy
GDP per capita	GDP per capita	World Bank WDI

Source: Authors

The used dependent variable *Control of Corruption* is based on the perception of the extent to which public power is abused for personal gains, including *petty* and *grand* forms of corruption, as well as the very level of "capture" of the state by elites and private interests (Kaufmann & Kraay, 2024). The *Control of corruption* indicator, as well as its frequently used counterpart, the *Corruption Perception Index* (CPI), are composite indicators, which means that when calculating them by country, different sources are used. Data collection is carried out through surveys aimed at households and individuals from the business sphere, but also based on assessments by a large number of experts (Kaufmann & Kraay, 2024). The indicator ranges from 0 to 100, and higher values symbolize a lower level of corruption. The main reason for choosing this indicator is the possibility of observing a longer period of time compared to the CP index (Corruption Perception Index). Due to methodological changes in the CPI calculation, the data are not comparable with the period before 2012 (Transparency International, 2012).

The *Electoral Democracy Index* is based on Dahl's (1971) concept of polyarchy, according to which the ruler is accountable to the people through periodic elections. It is one of *V-Dem's* five higher-ranking indices, which is also included in the creation of the other four. In this way, the fact that there is no democracy, be it liberal, participative, deliberative or egalitarian, without free elections, is recognized. V-Dem's methodology is based on the process of codification of data taken from other sources or obtained by filling out questionnaires by hired experts for each observed country (V Dem, 2021). The value of the indicator ranges from 0 to 1, with higher values indicating a higher level of democracy.

The basis of economic freedoms are personal choice, freedom of exchange of goods, free competition and protection of person and property (Gwartney & Lawson, 2003). They are represented in this research through the *Economic Freedom of the World* (EFW) index published by the Fraser Institute. Index values range from 0 to 10. Values closer to 10 indicate a higher level of economic freedom and vice versa. When creating the index, the Fraser Institute prefers objective data over questionnaires, which are also used. Data are taken from relevant international sources such as the IMF, the World Bank and the World Economic Forum, while data from national sources are rarely used (Gwartney, Lawson & Murphy, 2023). The index includes 44 indicators, grouped into five different sub-indices, all of which have equal weighting (Fraser Institute):

1. The size of the country
2. Legal system and property rights
3. Access to healthy money
4. Freedom of exchange with foreign countries
5. Regulation of credit, labor and business

GDP per capita expressed in current prices, from the World Bank database, was taken as an indicator of economic development. This indicator primarily has the function of a control variable, because even though it is a relatively small sample of economically mostly similar countries, significant differences in the level of economic development have emerged over time, as can be seen from a review of descriptive statistics.

Table 2: Descriptive statistics

Variable	Mean	Std.dev	Max	Min
CC	50.682	12.449	80.861	24.17
EFW	7.064	0.381	7.809	6.059
EDI	0.638	0.15	0.907	0.337
GDP per capita	11563.76	7138.56	32610.11	3981.72

Source: Authors

Descriptive statistics of the data used are given above in Table 2. The average value of the corruption indicator is 50.682, with the highest value in Slovenia in 2009 being 80.861, and the lowest in Albania in 2013 being 24.17. The index of economic freedom in the group had an average value of 7.064, and the highest recorded value was 7.809 in Romania in 2016, while Serbia achieved the lowest recorded value of 6.059 in 2008, which can partly be explained as a consequence of the late transition. The average value of democracy measured by the *Electoral Democracy Index* was 0.638, of which Greece had the highest level of electoral democracy in 2010, even 0.907 on a scale from 0 to 1. On the other hand, Serbia proved to be the country with the least democratic capacity, because in 2021 it recorded the lowest EDI value within the group, of only 0.337. In relation to the rest of Europe, the Balkan countries can be considered less developed - the average value of GDP per capita in the observed period is 11563.76 USD. Slovenia represents the most developed country in the Balkans - in 2023, it had 32610.11 USD per capita. On the other hand, the lowest recorded value of GDP per capita was achieved in Albania in 2015, 3981.72 USD.

Table 3: Overview of the average values of the observed variables by country

Country	BDP per capita	CC	EFW	EDI
Slovenia	25165.01	77.68	7.12	0.829
Greece	22162.89	56.1	7	0.855
Croatia	15224.25	58.77	6.97	0.78
Romania	11377.39	50.12	7.54	0.69
Bulgaria	9369.96	48.54	7.29	0.66
Montenegro	7947.77	52.7	7.07	0.489

Serbia	7549	43.11	6.57	0.462
North Macedonia	6089.88	47.71	6.97	0.523
BiH	5665.97	38.34	6.56	0.545
Albania	5085.47	33.72	7.55	0.53

Source: Authors

Table 3 shows the average values of the used variables for the observed countries. The most economically developed country is Slovenia with an average value of GDP per capita of 25165 USD, while Albania is the least developed with an average value of 5085.47 USD. According to the average value of the *Control of Corruption* indicator of 77.69, Slovenia is also the least corrupt country, while Albania has the lowest average value of 33.72. Romania has the highest average value of the EFW index at 7.54, and BiH has the lowest at 6.57. According to the electoral democracy indicator of 0.462, Serbia is at the bottom of the observed group, while Greece has the highest average value of 0.855.

An examination of the descriptive statistics indicates that the level of corruption is lowest in the country with the highest average GDP per capita, as well as high levels of democracy and economic freedom, which is consistent with the dominant theoretical perspective. However, according to the Fraser Institute's assessment, Albania has the highest average level of economic freedom in the Balkans, yet it is simultaneously the most corrupt country.

3. Research results and discussion of the results

In accordance with the goal of the research, to examine the long-term and short-term impact of economic freedom, democracy and the level of economic development, as well as by choosing ARDL as the method used, we set up the equation of the model. The part of the model that includes the lagged value of the dependent variable as an independent regressor constitutes its autoregressive component, while the part that includes lagged values of the independent variables represents the distributed lag component (Gujarati, 2003). All variables in the model are logarithmized.

$$\begin{aligned}
 \log cc_t = & \alpha_0 + \alpha_{1i} \sum_{i=1}^2 \Delta \log cc_{t-i} + \alpha_{2i} \sum_{i=1}^2 \Delta \log efw_{t-i} \\
 & + \alpha_{3i} \sum_{i=1}^2 \Delta \log edi_{t-i} + \alpha_{4i} \sum_{i=1}^2 \Delta \log gdp_{t-i} + \varphi_1 \log cc_t \\
 & + \varphi_2 \log efw_t + \varphi_3 \log edi_t + \varepsilon_i
 \end{aligned}$$

- $\log cc$ - logarithmic value of the *Control of Corruption* indicator;
- $\log efw$ - logarithmic value of the *Economic Freedom of the World* index;
- $\log edi$ - logarithmic value of the *Electoral Democracy* index;
- α - short-term coefficients;
- φ - long-term coefficients.

The first step in the analysis is determining the order of integration of the observed variables. Checking the existence of a unit root and the order of integration of the observed variables was performed using the Levin, Lin & Chu test. The null hypothesis (H_0) of the test assumes the existence of a unit root, that is, that the observed variables are non-stationary. The obtained results are shown below in Table 4.

Table 4: Overview of Levin, Lin & Chu test values

Variable	I(0)		I(1)	
	t-statistic	p value	t-statistic	P value
<i>logcc</i>	-0.914	0.1802	-	-
<i>D(logcc)</i>	-	-	-2.608	0.0045
<i>logefw</i>	-2.487	0.0064	-	-
<i>logedi</i>	-0.147	0.4412	-	-
<i>D(logedi)</i>	-	-	-7.349	0.0000
<i>loggdg</i>	6.147	1.000	-	-
<i>D(loggdg)</i>	-	-	-5.852	0.0000

Source: Authors

By comparing the obtained p value of the test with the critical value $\alpha=0.05$, we decide to accept or reject the mentioned H_0 hypothesis of the test. First, the stationarity of the variable at level I(0) is checked, and then, if the H_0 hypothesis is accepted, the stationarity of the variable at the first differential I(1) is checked. Of all observed variables, only the independent variable *logefw* with p value of 0.0064 is stationary at level I(0), while all others are stationary only at the first differential I(1). Given that the variables are of different degrees of integration, it is not possible to use a panel regression model based on the method of least squares or vector models such as VAR or VECM. The only suitable model for analysis in the case that the observed variables are I(0) and I(1) degree of integration is the ARDL model (Pesaran & Shin, 1999; Pesaran et al, 2001).

Given the potential presence of cross-sectional correlation among the data, the results of the Levin, Lin & Chu test should be interpreted with caution, as they may be subject to bias. Therefore, an additional verification was conducted using the CIPS test (Cross sectionally augmented IPS). This is a second-generation unit root test designed for situations where cross-sectional dependence is present (Pesaran, 2007). The results are presented below in Table 5.

Table 5: Overview of CIPS test

Variable	I(0)		I(1)	
	t-statistic	p value	t-statistic	p value
<i>logcc</i>	-1.78	>0.1	-	-
<i>D(logcc)</i>	-	-	-3.21	<0.01
<i>logefw</i>	-2.655	<0.05	-	-
<i>logedi</i>	-2.847	<0.01	-	-
<i>loggdg</i>	-1.494	>0.1	-	-
<i>D(loggdg)</i>	-	-	-3.173	<0.01

Source: Authors

The obtained results are similar to those obtained from the previous first-generation test. The only difference is that democracy is no longer integrated of order I(1) but rather I(0). Corruption and the level of economic development remain integrated of order I(1), while economic freedom is integrated of order I(0). Given the different orders of integration of the observed variables, the application of the ARDL model is justified.

Before proceeding with the model estimation, it is necessary to examine the existence of cointegration among the observed variables using the Johansen cointegration test. The decision criterion is set at $\alpha = 0.05$, and the results are presented below in Table 6.

Table 6: Overview of Johansen cointegration test

No. of Coint. Eq	Trace test	p value	Max-Eigen test	p value
None	189.0	0.000	790.2	0.000
At most 1	185.8	0.000	183.9	0.000
At most 2	35.61	0.017	40.45	0.004
At most 3	9.119	0.981	9.119	0.981

Source: Authors

The results of the Trace and Max-Eigenvalue tests are examined, where p-values lower than the significance level α indicate the rejection of the null hypothesis (H_0). Considering that four variables are analyzed, the maximum possible number of cointegrating equations is three, which determines the specific structure of the null hypotheses of the test. The first null hypothesis, which states that there is no cointegrating equation among the variables, is rejected. The same conclusion applies to the second and third null hypotheses, which assume that there is at most one and at most two cointegrating equations, respectively. The fourth null hypothesis is accepted, leading to the conclusion that there are at most three cointegrating equations among the observed variables. Consequently, the analysis proceeds with further empirical investigation.

The ARDL model can be used if the variables are of I(0) and/or I(1) order of integration, and because it uses the lagged value of the dependent and independent variables, the potential occurrence of autocorrelation and endogeneity in the model is controlled for (Pesaran et al, 2001). When calculating the value for choosing the optimal number of legs, the *Akaike Information Criterion* (AIC) was used, and it was determined as (2,2,2,2). An overview of the obtained coefficients is given below in the Table 7.

Table 7: Overview of ARDL model values

Variable	Coefficient	Std. Error	t-stat	p-value
Long Run				
<i>logefw</i>	1.919***	0.66	2.907	0.0049
<i>logedi</i>	1.205***	0.314	3.834	0.0003
<i>loggdp</i>	0.919***	0.266	3.443	0.001
Short Run				
ECT	-0.233***	0.087	-2.682	0.0092
<i>D(logcorr(t-1))</i>	0.002	0.15	0.014	0.9882
<i>D(logefw)</i>	0.647	0.602	1.074	0.2864

$D(\log_{efw}(t-1))$	2.058***	0.674	3.053	0.0032
$D(\log_{edi})$	0.419	0.3	1.397	0.1669
$D(\log_{edi}(t-1))$	-0.425	0.417	-1.018	0.3119
$D(\log_{gdp})$	0.044	0.097	0.45	0.6537
$D(\log_{gdp}(t-1))$	-0.07	0.088	-0.792	0.4306
C	-1.833	0.666	-2.752	0.0076

Source: Authors

The first part of the table contains the coefficients related to the long-term relationship. In the long term, all independent variables are statistically significant with the expected signs, while in the short term, only the value of economic freedoms $\log_{efw}(t-1)$ is statistically significant. This indicates that the effect of the observed factors on corruption is primarily of a long-term nature. All statistically significant variables have a positive sign, indicating that higher levels of economic freedoms, democracy, and economic development are associated with a decrease in corruption. However, there are differences in the intensity of the effects among these variables. With a coefficient value of 1.919, economic freedom exerts the strongest long-run impact on the level of corruption. Democracy has a weaker effect, while the level of economic development, with a coefficient value of 0.919, exerts the weakest impact in the model. Although there is a slight difference between the short-run and long-run coefficients, 2.058 versus 1.919, this is not sufficient to conclude that the effect weakens over time.

Given that the lagged value of the dependent variable—corruption $\log_{corr}(t-1)$ is not statistically significant in the short run, it can be stated that corruption is not an endogenous variable. Therefore, the level of corruption from the previous period does not influence its future level in society.

The fact that the *Error Correction Term* is statistically significant with the appropriate sign speaks of the importance of the long-term relationship. The negative sign indicates that if some unexpected shocks occur in the short term, the system will strive for long-term equilibrium at the rate of 23.3% per year.

Conclusion

This paper argues that researchers studying corruption should avoid universal recommendations based on a huge number of countries, and instead focus on smaller groups of countries with similar characteristics. The possible contribution of this research to the literature dealing with the issue of the determinants of corruption could be in the selection of the observed sample and the methodology used, which enables the separation of short-term and long-term influence of independent variables. The research confirmed the statistically significant influence of economic freedom, democracy and the level of economic development on the level of corruption in the long term. In the short term, economic freedoms with a lag of one year are the only statistically significant variable.

Therefore, changes to economic and political institutions will lead to a reduction of corruption in this region, although one cannot expect immediate results. The creators of the

public management system are advised to persevere with positive reforms, particularly economic liberalization, as research shows it yields results even in the short term. However, further study is needed to examine how these variables interact with corruption.

Finally, it is necessary to highlight a practical limitation of the study, which implies that the results should be interpreted with a certain degree of caution. Apart from the indicator of economic development, the applied model does not include additional control variables. Due to the complexity of the model, which estimates both short-run and long-run coefficients, the inclusion of a larger number of observed variables would increase the risk of overidentification.

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Appendix

Table 1: Overview of DOLS model values

Variable	Coefficient	Std. Error	t-Statistic	P Value
logefw	1.891***	3.83E-10	4.94E+09	0.000
logedi	0.515***	4.86E-10	1.06E+09	0.000
loggdgdp	0.43***	6.55E-11	6.57E+09	0.000

Source: Authors

In accordance with the reviewer's recommendation, a robustness check of the long-run coefficients was conducted using the DOLS (Dynamic Ordinary Least Squares) model (Table 1), which was also estimated in EViews12. The signs of the coefficients remain unchanged, indicating that all three observed factors exert a statistically significant long-run effect on the reduction of corruption. Economic freedom continues to have the strongest impact on the level of corruption, with the value of its coefficient remaining almost unchanged 1.891 versus 1.919, while the coefficients for democracy and the level of economic development have decreased 0.515 and 0.43 as opposed to 1.205 and 0.919, respectively.

The normality of the distribution of the error terms for the observed observations was tested using the Jarque–Bera test. The decision criterion was set at $\alpha = 0.05$. The obtained test values are presented below in Table 2.

Table 2: Overview of Jarque-Bera test values

Jarque-Bera	5.051
p value	0.079

Source: Authors

The null hypothesis (H_0) assumes that the data follow a normal distribution. Since the obtained p-value (0.079) is greater than the significance level α , the null hypothesis cannot be rejected. Therefore, it can be concluded that the data follow a normal probability distribution.

The presence of multicollinearity was examined by calculating Pearson correlation coefficient values. The results are presented below in Table 3.

Table 3: Overview of Pearson coefficient

Variable	logcorr	logefw	logedi	loggdp
logcorr	1.000	-	-	-
logefw	0.042	1.000	-	-
logedi	0.601	0.155	1.000	-
loggdp	0.720	0.078	0.744	1.000

Source: Authors

Only values greater than 0.8 indicate the presence of multicollinearity. Since the obtained values for all variables are below this threshold, it can be concluded that the model does not suffer from a multicollinearity problem.

Status Motives, Hedonism, and Social Media Influencers as Drivers of Luxury Fashion Brand Preference among Generation Z: The Moderating Role of Cosmopolitanism in Serbia

Статусни мотиви, хедонизам и инфлуенсери са друштвених мрежа као детерминанте преференција луксузних модних брендова код генерације Z: модераторска улога космополитизма у Србији

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Abstract

Purpose: The primary objective of this paper is to examine the effects of status motives, hedonism, and social media influencers on luxury fashion brand preferences among Generation Z consumers in Serbia. In addition, the study investigates the moderating role of cosmopolitanism in shaping these relationships.

Methodology: The empirical research was conducted on a sample of 376 respondents belonging to Generation Z in Serbia. Data were collected through a structured questionnaire and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to test both direct and moderating effects.

Findings: The findings indicate that status motives, hedonism, and social media influencers exert a significant positive influence on Generation Z consumers' preferences for luxury fashion brands. Moreover, cosmopolitanism strengthens the impact of these determinants, suggesting that cosmopolitan individuals are more responsive to symbolic, hedonic, and influencer-driven cues in luxury fashion consumption.

Originality/value: This study contributes to the existing literature by integrating psychological motives, social media influence, and cosmopolitanism within a single empirical framework focused on Generation Z consumers. The research offers novel insights from an emerging market context, which remains underexplored in luxury fashion consumption studies.

Practical implications: The results provide valuable guidance for luxury fashion brand managers and marketers by emphasizing the importance of status signaling, experiential value, and influencer marketing strategies tailored to cosmopolitan segments of Generation Z. The findings may also assist decision makers in designing more effective communication and branding strategies in digitally driven consumer markets.

Limitations: The study is limited by its cross-sectional design and its focus on a single country, which may restrict the generalizability of the results to other cultural and market contexts. Additionally, the use of self-

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reported data may introduce potential response bias.

Keywords: luxury fashion brands, Generation Z, status motives, hedonism, social media influencers, cosmopolitanism, Serbia, consumer behavior.

JEL classification: A13, M31, Z1

Сажетак

Циљ: Основни циљ овог рада је да се испита утицај статусних мотива, хедонизма и инфлуенсера са друштвених мрежа на преференције луксузних модних брендова код припадника Генерације Z у Србији. Поред тога, у раду се анализира модераторска улога космополитизма у обликовању ових односа.

Методологија: Емпиријско истраживање је спроведено на узорку од 376 испитаника из Србије који припадају Генерацији Z. Подаци су прикупљени путем структурираног упитника и анализирани применом моделовања структурним једначинама, методом парцијалних најмањих квадрата (PLS-SEM), ради тестирања директних и модераторских ефеката.

Резултати: Резултати истраживања указују на то да статусни мотиви, хедонизам и инфлуенсери са друштвених мрежа имају значајан позитиван утицај на преференције луксузних модних брендова код припадника Генерације Z. Такође, утврђено је да космополитизам појачава утицај наведених детерминанти, што указује да космополитски оријентисани појединци значајно реагују на симболичке, хедонистичке и инфлуенсерски вођене сигнале у потрошњи луксузне моде.

Оригиналност/вредност: Ова студија доприноси постојећој литератури интеграцијом психолошких мотива, утицаја друштвених мрежа и космополитизма у јединствени емпиријски оквир усмерен на Генерацију Z. Истраживање пружа нове увиде из контекста тржишта у настајању, које је и даље недовољно истражено у студијама луксузне модне потрошње.

Практична примена: Резултати рада пружају значајне смернице менаџерима луксузних модних брендова и стручњацима у области маркетинга, наглашавајући значај статусне сигнализације, искуствене вредности и инфлуенсер маркетинг стратегија прилагођених космополитским сегментима Генерације Z. Налази могу бити корисни и доносиоцима одлука у креирању ефикаснијих комуникационих стратегија, као и стратегија брендирања на дигитално оријентисаним потрошачким тржиштима.

Ограничења истраживања: Истраживање је ограничено временским оквиром у коме су подаци прикупљени и фокусом на једну земљу, што може утицати на могућност генерализације резултата на друге културне и тржишне контексте. Поред тога, ослањање на податке прикупљене путем самооцењивања испитаника може довести до одређеног степена пристрасности у одговорима.

Кључне речи: луксузни модни брендови, Генерација Z, статусни мотиви, хедонизам, инфлуенсери са друштвених мрежа, космополитизам, Србија, понашање потрошача.

JEL класификација: A13, M31, Z1

Introduction

The contemporary luxury fashion market is characterized by intense competition, accelerated digitalization, and increasing heterogeneity of consumer preferences, particularly among younger generations (Appiah-Nimo et al., 2023). In this context, Generation Z has emerged as a distinct and influential consumer segment whose purchasing decisions are shaped by a combination of psychological motives, social influences, and value orientations. Unlike previous generations, Generation Z consumers have grown up in an environment of strong global connectivity and the pervasive presence of social media, which has substantially transformed the way luxury fashion brands are perceived and evaluated (Rambocas & Mahabir, 2021).

Generation Z represents a particularly important consumer segment in the luxury fashion industry because its members are highly active on digital platforms, strongly exposed to global fashion trends, and increasingly influential in shaping contemporary consumption patterns through social media engagement and peer-to-peer communication.

In addition, younger consumers are expected to become one of the dominant luxury consumer groups in the coming years due to their growing purchasing power and strong orientation toward symbolic and experiential consumption (Wilska et al., 2023; Zimand-Sheiner & Lissitsa, 2024).

Existing literature indicates that status motives represent one of the key drivers of luxury consumption, as luxury brands function as symbols of prestige, social status, and group affiliation (Yu & Xie, 2026; Zeng et al., 2025). At the same time, hedonism constitutes an essential dimension of luxury consumption, given that the purchase and use of luxury fashion products are closely associated with emotional gratification, pleasure, and personal fulfillment (Luo et al., 2021). In addition to individual motives, social media influencers have become increasingly influential in shaping consumer attitudes and behaviors, particularly among younger consumers (Zou et al., 2025). Through visually oriented content, personal branding, and perceived authenticity, influencers play a significant role in forming preferences for luxury fashion brands (Lee et al., 2025; Manuel, 2023).

Although these variables have been examined extensively in isolation (Mancusi et al., 2025; Wang et al., 2025; Wilska et al., 2023), a substantial research gap remains regarding their integration within a unified analytical framework, especially in studies focusing on young consumers in emerging markets. Moreover, prior research (Jham et al., 2024; Lee et al., 2025; Zeng et al., 2025) has paid limited attention to the role of cosmopolitanism as a value orientation that may condition the strength and direction of the effects of status motives, hedonism, and influencer marketing on luxury fashion brand preferences (Das & Mukherjee, 2019). Cosmopolitanism, understood as openness toward global trends, foreign brands, and international lifestyles, may serve as a critical explanatory factor in understanding why identical marketing stimuli do not exert uniform effects across all Generation Z consumers (Figueiredo et al., 2021).

Against this background, the present study aims to examine the direct effects of status motives, hedonism, and social media influencers on luxury fashion brand preferences, as well as the moderating role of cosmopolitanism in these relationships. The empirical analysis is conducted in the context of Serbia, thereby extending existing insights derived primarily from developed markets and contributing to a deeper understanding of Generation Z consumer behavior in emerging economies.

Beyond its theoretical contribution, this study also offers important practical implications. The findings provide valuable guidance for luxury fashion brand managers in designing more effective marketing strategies targeting Generation Z consumers, particularly with regard to brand positioning, influencer selection, and the customization of communication messages based on consumers' value orientations. Furthermore, the results may support more informed decision-making in the areas of branding and digital marketing within contemporary consumer markets.

1. Literature review

Luxury fashion consumption has been widely examined within the broader field of consumer behavior research, where purchasing decisions are understood as the outcome of interactions between individual motivations, emotional responses, and social influences (Rodrigo et al., 2023). Foundational theories of consumer behavior emphasize that consumption extends beyond functional utility and often serves symbolic and experiential purposes, particularly in the context of high-involvement and image-oriented products such as luxury fashion brands (Rambocas & Mahabir, 2021).

From a theoretical perspective, this study is grounded in the Stimulus–Organism–Response (S-O-R) model, which conceptualizes consumer behavior as a process in which external stimuli influence internal cognitive and affective states, ultimately leading to behavioral responses (Gan et al., 2025). In the context of luxury fashion consumption, status cues and influencer-generated content may be viewed as external stimuli, while hedonistic feelings and value orientations represent internal organismic states that shape consumers' evaluative responses toward brands (Jestratijevec et al., 2024).

In addition, the study draws on symbolic consumption theory, which posits that consumers use products and brands as symbols to express identity, social status, and self-concept (Sulhaini et al., 2022). Luxury fashion brands are particularly suited for symbolic consumption due to their visibility, exclusivity, and strong associative meanings. This theoretical lens provides a foundation for examining the role of status motives in shaping luxury fashion brand preferences (Loureiro et al., 2020).

Furthermore, the experiential dimension of luxury consumption is explained through hedonic consumption theory, which highlights the role of pleasure, emotional arousal, and sensory gratification in consumer decision-making (Zimand-Sheiner & Lissitsa, 2024). Luxury fashion brands often deliver value through aesthetic design, emotional appeal, and immersive brand experiences, making hedonism a central determinant of preference formation, especially among younger consumers (Tam & Lung, 2025).

Finally, the increasing influence of digital environments necessitates the incorporation of social influence and persuasion theories, including source credibility and parasocial interaction frameworks, to explain the impact of social media influencers on consumer behavior (Orús et al., 2026). Influencers function as modern opinion leaders who shape brand perceptions and consumption aspirations, particularly within digitally native segments such as Generation Z (Naeem, 2026).

By integrating these complementary theoretical perspectives, the present study develops a comprehensive framework for analyzing luxury fashion brand preferences among Generation Z consumers. The following subsections elaborate on the key constructs—status motives, hedonism, social media influencers, and cosmopolitanism—and formulate the hypotheses that underpin the proposed research model.

1.1. Status Motives and Luxury Fashion Brands

Status motives originate from classic sociological and economic theories of consumption, particularly conspicuous consumption theory and symbolic interactionism, which emphasize the role of consumption as a means of signaling social position and identity (Naeem, 2026). According to this perspective, individuals use visible and socially recognized products to communicate prestige, success, and group affiliation. Luxury fashion brands are especially suitable for such signaling purposes due to their high visibility, symbolic value, and association with exclusivity and social distinction (Eastman et al., 2024).

In the context of fashion consumption, status motives are closely linked to the desire for social recognition, admiration, and differentiation from others. Previous research suggests that consumers who are strongly motivated by status considerations are more likely to prefer luxury fashion brands, as these brands function as powerful markers of social standing and personal success (Bai et al., 2021). This tendency may be particularly pronounced among younger consumers, for whom social comparison and peer evaluation play a central role in identity construction (Mrad et al., 2020).

For Generation Z consumers, luxury fashion brands not only represent material possessions but also serve as tools for self-presentation in both offline and digital environments. The visibility of fashion products on social media further amplifies their status-signaling function, reinforcing the link between status motives and luxury brand preference (Bai et al., 2026; Sharma et al., 2024).

H₁ Status motives have a positive effect on luxury fashion brand preferences among Generation Z consumers.

1.2. Hedonism and Luxury Fashion Brands

Hedonism is grounded in hedonic consumption theory, which emphasizes the experiential, emotional, and sensory dimensions of consumer behavior. Unlike utilitarian consumption, which is primarily driven by functional benefits, hedonic consumption is associated with pleasure, enjoyment, fantasy, and emotional arousal (Luo et al., 2021). Luxury fashion products are inherently hedonic in nature, as they offer aesthetic appeal, tactile satisfaction, and emotional gratification beyond their basic functional purpose (Ostovan & Khalili Nasr, 2022).

The literature consistently highlights hedonism as a central driver of luxury consumption, suggesting that consumers derive pleasure not only from owning luxury items but also from the purchasing process itself (Chen et al., 2025). Feelings of excitement, indulgence, and self-reward are commonly associated with luxury fashion consumption, making hedonism a critical determinant of brand preference (Appiah-Nimo et al., 2023). Among Generation Z consumers, hedonic motivations may be particularly salient due to their emphasis on self-expression, emotional experiences, and lifestyle enjoyment (Zimand-

Sheiner & Lissitsa, 2024). Luxury fashion brands often align with these preferences by offering immersive brand experiences and emotionally engaging narratives that resonate with younger consumers' desire for pleasure-oriented consumption (Thongmak, 2025).

H₂ Hedonism has a positive effect on luxury fashion brand preferences among Generation Z consumers.

1.3. Social Media Influencers and Luxury Fashion Brands

The growing influence of social media has transformed traditional models of consumer persuasion, giving rise to source credibility theory and parasocial interaction theory as key frameworks for understanding influencer marketing. Social media influencers act as opinion leaders who shape consumer attitudes through perceived expertise, attractiveness, and authenticity. Unlike traditional celebrities, influencers are often perceived as more relatable and trustworthy, particularly by younger audiences (Hosen et al., 2025; Zou et al., 2025).

In the luxury fashion context, influencers play a crucial role in shaping brand perceptions and consumption aspirations. By showcasing luxury fashion products in everyday or aspirational settings, influencers reduce psychological distance between consumers and luxury brands, making them appear more accessible and desirable (Lee et al., 2025). This effect is especially strong among Generation Z consumers, who actively engage with influencer-generated content and rely on social media as a primary source of product-related information (Kong et al., 2021). Empirical evidence suggests that influencer endorsements significantly affect brand awareness, attitudes, and purchase intentions, particularly when influencers are perceived as credible and congruent with the promoted brand (Gao et al., 2026; Lee et al., 2024; Marić et al., 2022; Yoo, 2023). Consequently, influencer marketing represents a powerful mechanism through which luxury fashion preferences are formed among younger consumers.

H₃ Social media influencers have a positive effect on luxury fashion brand preferences among Generation Z consumers.

1.4. The Moderating Role of Cosmopolitanism

Cosmopolitanism is commonly conceptualized as an individual-level value orientation reflecting openness toward foreign cultures, global lifestyles, and international products (Cleveland & Bartsch, 2019). Rooted in cultural openness and global identity theories, cosmopolitanism captures consumers' willingness to embrace diversity and transcend national boundaries in their consumption choices. In the context of fashion, cosmopolitan consumers tend to favor globally recognized brands that symbolize modernity, sophistication, and international belonging (Cleveland & Balakrishnan, 2019).

Rather than acting solely as a direct predictor of consumption behavior, cosmopolitanism may function as a moderating variable that shapes how consumers respond to different motivational and social stimuli. Cosmopolitan individuals are generally more receptive to global status symbols, hedonic brand experiences, and internationally

oriented influencers, which may intensify the effects of status motives, hedonism, and influencer influence on luxury fashion brand preferences (Bao et al., 2025; Cooke et al., 2022; Figueiredo et al., 2021; Javornik et al., 2021; Yoo, 2024).

For Generation Z consumers, cosmopolitanism may be particularly relevant due to their exposure to global media content and transnational cultural flows (Rambocas & Mahabir, 2021; Rodrigo et al., 2023; Zimand-Sheiner & Lissitsa, 2024). As a result, the strength of the relationships between the key determinants and luxury fashion brand preferences may vary depending on the level of cosmopolitan orientation.

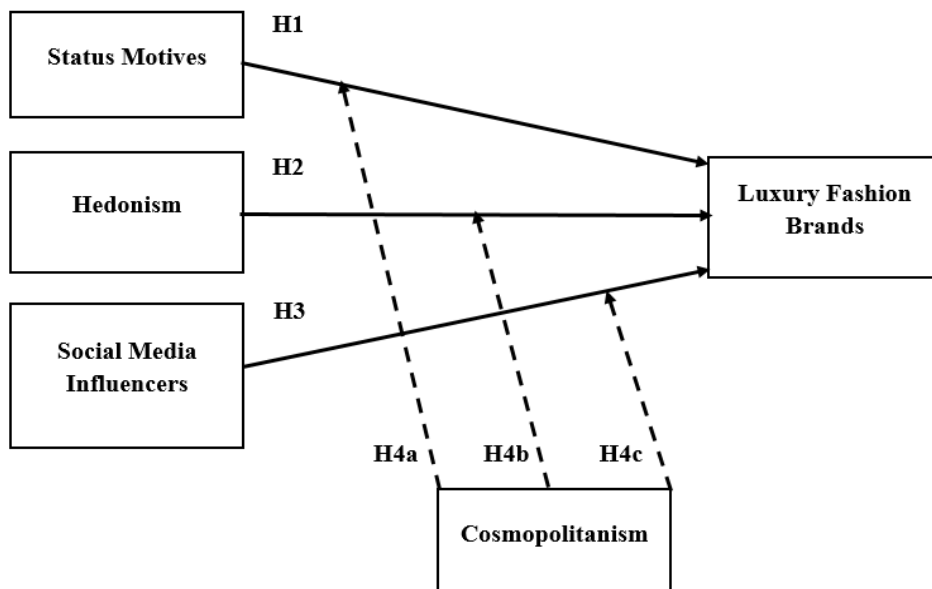
H_{4a} Cosmopolitanism positively moderates the relationship between status motives and luxury fashion brand preferences.

H_{4b} Cosmopolitanism positively moderates the relationship between hedonism and luxury fashion brand preferences.

H_{4c} Cosmopolitanism positively moderates the relationship between social media influencer influence and luxury fashion brand preferences.

Figure 1 presents the conceptual research model, illustrating the proposed direct effects of status motives, hedonism, and social media influencers on luxury fashion brand preferences, as well as the moderating role of cosmopolitanism among Generation Z consumers.

Figure1: Conceptual model



Source: Author

2. Research methodology

The empirical research was conducted using a quantitative approach with the aim of examining the relationships between status motives, hedonism, social media influencer influence, cosmopolitanism, and luxury fashion brand preferences among Generation Z consumers in Serbia. Data were collected through a survey-based research design, employing both face-to-face and online questionnaire administration. The target population consisted exclusively of individuals belonging to Generation Z, which ensured generational homogeneity and enabled a focused examination of consumption patterns characteristic of this cohort. The final sample included 376 valid responses, providing an adequate basis for structural equation modeling and moderation analysis. The study employed a non-probability convenience sampling approach, given the specific focus on Generation Z consumers and the practical accessibility of respondents through educational institutions and digital communication channels. The empirical research was conducted at the end of 2025.

The respondents primarily consisted of individuals engaged in formal education, including participants of secondary education age, undergraduate and graduate university students, as well as young adults at the early stages of their professional careers. This sample structure reflects the prevailing socio-educational profile of Generation Z in Serbia and is particularly relevant for the study of luxury fashion consumption, given the importance of identity formation, peer influence, and intensive engagement with digital platforms during this life stage. The data collection process was conducted over a three-month period. Face-to-face questionnaires were administered in educational settings, while the online version of the questionnaire was distributed through social media platforms and student communication groups frequently used by Generation Z respondents. Participation in the study was voluntary and anonymous, and respondents were informed that the collected data would be used exclusively for academic research purposes.

All research constructs were measured using multi-item scales adapted from well-established studies in the fields of consumer behavior, luxury consumption, and influencer marketing (Appiah-Nimo et al., 2023; Eastman, et al., 2025; Gao et al., 2026; Lee et al., 2024; Rambocas & Mahabir, 2021; Rodrigo et al., 2023; Tam & Lung, 2025; Yoo, 2024). Responses were recorded using a seven-point Likert scale ranging from strong disagreement to strong agreement. Prior to the main analysis, the reliability and validity of the measurement model were assessed to ensure the adequacy of the applied measurement instruments (Table 1).

Data analysis was performed using Partial Least Squares Structural Equation Modeling (PLS-SEM) within the SmartPLS 4 statistical software package, which is well suited for complex research models, theory development, and the examination of moderating effects.

Table 1: Measurement items, Cronbach's alpha, and Composite reliability

Variables	Statements	Cronbach's alpha	Composite Reliability
Status Motives	SM1. Purchasing luxury fashion brands helps me signal prestige and social status to others. SM2. Wearing luxury fashion brands makes me feel respected and admired by people around me. SM3. I prefer luxury fashion brands because they enhance my social image.	0.887	0.871
Hedonism	HED1. Buying luxury fashion products gives me a strong sense of pleasure and enjoyment. HED2. I purchase luxury fashion brands because they make me feel good emotionally. HED3. Luxury fashion shopping is an enjoyable experience for me, not just a practical decision.	0.869	0.836
Social Media Influencers	SMI1. Social media influencers strongly affect my opinions about luxury fashion brands. SMI2. I am more likely to prefer luxury fashion brands that are promoted by influencers I follow. SMI3. Influencers on social media increase my interest in luxury fashion products.	0.928	0.902
Cosmopolitanism	COS1. I am open to global fashion trends and international lifestyle influences. COS2. I prefer fashion brands that are popular worldwide rather than only locally. COS3. I feel connected to global culture through fashion and consumption.	0.868	0.898
Luxury Fashion Brands	LFB1. I prefer luxury fashion brands when choosing clothing and footwear. LFB2. Luxury fashion brands are my first choice when I want to express my personal style. LFB3. Compared to non-luxury brands, I am more attracted to luxury fashion brands.	0.947	0.935

Source: Author

The internal consistency reliability of the measurement scales was assessed using Cronbach's alpha and Composite Reliability (CR). As shown in the results, Cronbach's alpha values for all research constructs range from 0.868 to 0.947, exceeding the recommended threshold of 0.70 and indicating a high level of internal consistency. Similarly, Composite Reliability values range from 0.836 to 0.935, which also surpasses the suggested minimum value of 0.70. These findings confirm that all constructs demonstrate satisfactory reliability and that the measurement items consistently reflect their underlying latent variables (Fornell & Larcker, 1981; Nunnally, 1978).

3. Research results

Table 2 presents the Average Variance Extracted (AVE) values for all research constructs included in the measurement model, providing an assessment of the extent to which each latent variable explains the variance of its observed indicators and thereby offering evidence of convergent validity.

Table 2: Average variance extracted (AVE) for research variables

Variables	AVE
Status Motives	0.713
Hedonism	0.747
Social Media Influencers	0.687
Cosmopolitanism	0.698
Luxury Fashion Brands	0.772

Source: Author

The results show that all AVE values exceed the recommended threshold of 0.50, ranging from 0.687 to 0.772. This indicates that each construct explains a substantial proportion of the variance in its indicators, thereby confirming satisfactory convergent validity of the measurement model. The findings support the adequacy of the constructs for further structural model analysis (Fornell & Larcker, 1981). Table 3 reports the key goodness-of-fit indices used to evaluate the adequacy of the proposed structural model for luxury fashion brand preferences, providing a comprehensive assessment of the model's overall fit in relation to commonly accepted standards.

Table 3: Model fit indicators for the Luxury Fashion Brands

Indicators of model validity	Research model – Luxury Fashion Brands	Recommended value
χ^2/df	1.726	<3
GFI	0.902	>0.9
IFI	0.909	>0.9
TLI	0.928	>0.9
CFI	0.968	>0.9
RMSEA	0.001	<0.08

Source: Author

The results indicate that the research model demonstrates a good overall fit. All fit indices meet or exceed the recommended threshold values, with the χ^2/df ratio below the suggested limit of 3 (Bagozzi & Yi, 1988) and incremental fit indices (GFI, IFI, TLI, and CFI) exceeding 0.90 (Byrne, 1998). In addition, the RMSEA value is well below the recommended maximum of 0.08, indicating an excellent approximation of the model to the observed data (Hair et al., 2006). Overall, these findings confirm the adequacy of the proposed model and support its suitability for further hypothesis testing. Table 4 presents the results of the Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis, illustrating the effects of the independent variables on luxury fashion brand preferences among Generation Z consumers.

Table 4: PLS-SEM results – Impact of independent variables on the Luxury Fashion Brands

Independent variables	Path coefficient	Standard error	T statistics	P values
Status Motives	0.447	0.055	6.598	0.000**
Hedonism	0.398	0.059	5.781	0.000**
Social Media Influencers	0.425	0.077	6.257	0.000**

*Notes: Level of statistical significance: **0.01*

Source: Author

The results of the PLS-SEM analysis indicate that all hypothesized direct relationships are statistically significant and positive. Specifically, status motives exert a strong positive effect on luxury fashion brand preferences ($\beta = 0.447$, $t = 6.598$, $p < 0.01$), providing full empirical support for H₁. This finding suggests that prestige-related and symbolic considerations play a crucial role in shaping Generation Z consumers' preferences for luxury fashion brands.

Hedonism also demonstrates a significant positive influence on luxury fashion brand preferences ($\beta = 0.398$, $t = 5.781$, $p < 0.01$), thereby confirming H₂. This result highlights the importance of pleasure-oriented and emotional motivations in luxury fashion consumption, indicating that Generation Z consumers are strongly driven by experiential value and enjoyment when forming brand preferences.

Furthermore, social media influencers exhibit a substantial positive effect on luxury fashion brand preferences ($\beta = 0.425$, $t = 6.257$, $p < 0.01$), supporting H₃. The magnitude and statistical significance of this relationship emphasize the central role of influencer-driven communication and digital opinion leadership in influencing luxury fashion consumption among younger consumers. Overall, these findings provide robust empirical evidence in favor of the proposed direct effects and confirm the relevance of the integrated research model.

Table 5 reports the results of the moderation analysis conducted within the PLS-SEM framework, examining the moderating role of cosmopolitanism in the relationships between the independent variables and luxury fashion brand preferences.

Table 5: Moderation of Cosmopolitanism in the PLS-SEM model (dependent variable: Luxury Fashion Brands)

Relations	Path coefficient	Standard error	T statistics	P values
Status Motives X Cosmopolitanism	0.297	0.047	5.298	0.003**
Hedonism X Cosmopolitanism	0.221	0.052	4.335	0.004**
Social Media Influencers X Cosmopolitanism	0.265	0.043	5.174	0.001**

*Notes: Level of statistical significance: **0.01*

Source: Author

The results indicate that cosmopolitanism significantly moderates all hypothesized relationships between the independent variables and luxury fashion brand preferences. Specifically, the interaction between status motives and cosmopolitanism exhibits a positive and statistically significant effect ($\beta = 0.297$, $t = 5.298$, $p < 0.01$), providing empirical support for H_{4a} . This finding suggests that the influence of status motives on luxury fashion brand preferences is stronger among Generation Z consumers with higher levels of cosmopolitan orientation.

Similarly, the interaction effect between hedonism and cosmopolitanism is positive and statistically significant ($\beta = 0.221$, $t = 4.335$, $p < 0.01$), thereby confirming H_{4b} . This result indicates that cosmopolitan consumers are more responsive to hedonic motivations when forming preferences for luxury fashion brands, reinforcing the experiential dimension of luxury consumption.

Furthermore, the moderating effect of cosmopolitanism on the relationship between social media influencers and luxury fashion brand preferences is also supported ($\beta = 0.265$, $t = 5.174$, $p < 0.01$), providing evidence in favor of H_{4c} . This finding underscores the role of cosmopolitanism in amplifying the effectiveness of influencer-driven communication, suggesting that globally oriented Generation Z consumers are particularly receptive to influencer endorsements in the luxury fashion context.

Overall, the moderation results highlight the pivotal role of cosmopolitanism as a value-based mechanism that conditions how symbolic, hedonic, and social influence factors translate into luxury fashion brand preferences.

3.1. Discussion of research results

The findings corroborate the results of prior studies (Bai et al., 2021; Chen et al., 2025; Gao et al., 2026; Javornik et al., 2021; Luo et al., 2021; Naeem, 2026; Yoo, 2023; Zou et al., 2025) by confirming the significant roles of status motives, hedonism, social media influencers and cosmopolitanism in shaping luxury fashion brand preferences; however, unlike earlier research that examined these determinants in isolation, the present study

adopts a holistic analytical approach by simultaneously integrating multiple motivational and social drivers within a unified conceptual framework, thereby offering a more comprehensive understanding of Generation Z consumers' luxury brand preferences.

Consistent with theories of symbolic and conspicuous consumption, the results confirm that status motives play a significant role in shaping preferences for luxury fashion brands, highlighting the importance of prestige and social recognition in the consumption behavior of younger consumers. This finding aligns with prior research suggesting that luxury brands function as symbolic resources for identity construction and social positioning.

The significant effect of hedonism reinforces the relevance of hedonic consumption theory in the context of luxury fashion. The results suggest that emotional gratification, enjoyment, and experiential value are central drivers of luxury fashion brand preferences among Generation Z, emphasizing that luxury consumption extends beyond functional considerations and is closely tied to affective responses. This supports the view that experiential and pleasure-oriented motivations are particularly salient for younger, digitally native consumers.

Moreover, the positive influence of social media influencers underscores the growing importance of digital opinion leaders in shaping luxury fashion consumption. Drawing on source credibility and social influence theories, the findings indicate that influencers serve as effective mediators between luxury brands and Generation Z consumers by enhancing brand desirability and reducing psychological distance. This result confirms the pivotal role of influencer marketing in contemporary luxury branding strategies.

Importantly, the moderation analysis reveals that cosmopolitanism strengthens the effects of status motives, hedonism, and social media influencers on luxury fashion brand preferences. This suggests that globally oriented consumers are more responsive to symbolic, experiential, and digitally mediated stimuli, thereby highlighting cosmopolitanism as a key value-based mechanism in luxury consumption. By integrating motivational, social, and value-oriented perspectives, the study contributes to a more comprehensive understanding of luxury fashion consumption among Generation Z, particularly in emerging market contexts.

Conclusion

This study provides a comprehensive examination of luxury fashion brand preferences among Generation Z consumers by integrating status motives, hedonism, and social media influencer effects within a unified research framework, while explicitly accounting for the moderating role of cosmopolitanism. The originality of the research lies in its holistic approach, which combines motivational, experiential, and digital influence perspectives with a value-based moderator to explain luxury fashion consumption in an emerging market context. By focusing on Generation Z consumers in Serbia, the study extends existing

literature beyond developed markets and contributes novel empirical evidence to the growing body of research on luxury consumption among younger generations.

From a theoretical standpoint, the findings reinforce and extend established theories of symbolic and hedonic consumption by demonstrating their relevance within a digitally mediated environment. The results also enrich social influence and persuasion theories by highlighting the amplified role of social media influencers in shaping luxury brand preferences among Generation Z. Importantly, the study advances the literature by positioning cosmopolitanism not merely as a direct antecedent of consumption behavior, but as a key moderating mechanism that conditions how symbolic, emotional, and social stimuli translate into brand preferences. This integrative perspective offers a more nuanced understanding of luxury fashion consumption and contributes to theory development in the fields of consumer behavior and international marketing.

The practical implications of this research are particularly relevant for luxury fashion brand managers and marketing professionals. The findings suggest that effective marketing strategies targeting Generation Z should emphasize status signaling, experiential value, and influencer-based communication, while simultaneously accounting for differences in consumers' cosmopolitan orientations. Brands aiming to engage cosmopolitan segments of Generation Z may benefit from global positioning strategies, collaborations with internationally oriented influencers, and communication messages that highlight global lifestyles and cultural openness. These insights can support more targeted and effective branding decisions in highly competitive and digitally driven markets.

Despite its contributions, the study is subject to certain limitations. The research is based on data collected within a specific national context, which may limit the generalizability of the findings to other cultural and market environments. In addition, the use of self-reported data may introduce potential response biases. Furthermore, the study focuses on a selected set of determinants, while other relevant factors, such as income levels, brand loyalty, or sustainability orientation, were not included in the model.

Future research could address these limitations by adopting a cross-national or comparative research design to examine whether the proposed relationships hold across different cultural contexts. Longitudinal studies could also provide deeper insights into how luxury fashion preferences evolve over time as Generation Z consumers mature and their purchasing power increases. Additionally, future studies may expand the research model by incorporating additional psychological, social, or ethical variables, thereby further enriching the understanding of luxury fashion consumption in contemporary consumer markets.

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Optimization model of collective nutrition in the Serbian Armed Forces using linear programming and Python programming environment

Модел оптимизације колективне исхране Војске Србије заснован на линеарном програмирању и програмском окружењу Пајтон

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Summary

The aim of this paper is to develop an optimization model of collective military nutrition based on linear programming, to reduce the daily meal costs while meeting the energy, nutritional and logistical requirements of the Serbian Armed Forces. The research was conducted using linear programming, multi-criteria analysis and deterministic sensitivity analysis. The model was implemented in the Python programming environment, and the analysis covered 230 dishes from the Serbian Armed Forces Nutrition Plan, taking into account economic, nutritional, and organizational constraints, as well as price change scenarios. The research results show the optimization approach lowers daily meal costs compared to the existing normative model without compromising the defined nutritional standards. Furthermore, the model demonstrates satisfactory stability in different market conditions. The originality of this research lies in the development of an integrated model that unifies economic, nutritional, and logistical criteria into a single framework designed for the food system in the Serbian Armed Forces. The limitations of the research relate to the deterministic nature of the model, static nutritional parameters and the absence of full stochastic optimization.

Keywords: linear programming, nutrition in the Serbian Armed Forces, cost optimization, Python programming environment, Serbian Armed Forces.

JEL classification: C02, C60, M11, D12

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Сажетак

Циљ овог рада је да се развије оптимизациони модел колективне исхране војника заснован на линеарном програмирању, како би се смањили трошкови дневног obroka уз задовољавање енергетских, нутритивних и логистичких ограничења исхране у Војсци Србије. Истраживање је спроведено коришћењем линеарног програмирања, мулти-критеријумске анализе и детерминистичке анализе осетљивости. Модел је имплементиран у програмском окружењу Пајтон, а анализом је обухваћено 230 јела из Плана исхране у Војсци Србије, укључујући економска, нутритивна и организациона ограничења, као и сценарије промене цена. Резултати истраживања указују на то да оптимизациони приступ омогућава ниже трошкове дневног obroka у односу на постојећи нормативни модел, без кршења дефинисаних нутритивних стандарда, уз задовољавајућу стабилност модела у различитим тржишним условима. Оригиналност рада огледа се у развоју интегрисаног модела који комбинује економске, нутритивне и логистичке критеријуме у јединствени оквир прилагођен систему исхране у Војсци Србије. Ограничења истраживања односе се на детерминистички карактер модела, статичке нутритивне параметре и одсуство потпуне стохастичке оптимизације.

Кључне речи: линеарно програмирање, исхрана Војске Србије, оптимизација трошкова, програмско окружење Пајтон, Војска Србије.

JEL класификација: C02, C60, M11, D12

Introduction

Collective nutrition planning in the Serbian Armed Forces is a complex logistical and optimization problem that requires the harmonization of energy and nutritional needs of users with available financial resources, nutrition norms and organizational constraints of the food supply system (Jović, 2016). In addition to the economic aspects of food planning, food safety also plays an important role. Jović (2013) emphasizes its importance for preserving the health of the population, while Arsić (2014; 2025) points to the possibilities of improving the military food system in the Serbian Armed Forces by applying economic criteria. Martić et al. (1991) confirm that linear and integer programming models enable nutritionally and economically optimal menu planning. Doncore et al. (2023) state that modern nutrition optimization models integrate nutritional, economic, and organizational requirements into a single optimization framework. On the other hand, Rahbari et al. (2023) show that during the COVID-19 pandemic, robust optimization has played a significant role in the strategic management of canned food supply chains, enabling the selection of the most advantageous strategy and achieving significant savings with better capacity utilization.

The aim of this paper is to develop an optimization model of collective nutrition in the Serbian Armed Forces based on linear programming and implemented in the Python programming environment, which minimizes the cost of a daily meal while meeting the energy, nutritional and logistical constraints of the food system.

1. A brief overview of the relevant literature

Modern research in the field of collective nutrition indicates that menu planning is a multi-criteria problem that requires simultaneous satisfaction of nutritional, economic and organizational requirements. Traditional normative approaches are increasingly upgraded with methods of linear programming, robust optimization and sensitivity analysis for more rational use of resources and minimization of costs. In the domestic literature, special

importance is given to nutritionally adequate nutrition as a factor in preserving the health ability and operational efficiency of members of the military (Jović, 2016; Božić, 2005; Jokić & Tešanović, 2017). Arsić & Pamučar (2025) propose a methodology that reduces subjectivism and improves nutrition planning in the Serbian Armed Forces. The theoretical foundations of food system optimization come from Stigler's cost minimization problem, which was one of the key incentives for the development of linear programming (Dantzig, 1963). Modern research confirms that linear programming is an effective approach to shaping nutritionally and economically optimal nutrition models (Donkor et al., 2023; Gerdessen & Borgonjen-van den Berg, 2023). Robust optimization approaches designed to make decisions in conditions of changing market parameters and expressed uncertainty are of particular importance (Sadana et al., 2023; Rahbari et al., 2023). Budowle et al. (2023) suggest that approaches based on the principles of fairness and equity can contribute to addressing food insecurity in a more sustainable way, thereby expanding the traditional optimization framework based solely on economic criteria.

Modern military nutrition research shows that the quality of nutrition directly affects the physical performance, resistance of the body, and the operational readiness of military systems (Karl et al., 2021; McClung & Gaffney-Stomberg, 2016; Bayes et al., 2025; Scott & Deuster, 2024; Fallowfield et al., 2025). Wincewicz-Bosy et al. (2022) highlight the importance of logistics planning and resilient food supply chain models in collective food systems. Darmon et al. (2002) have shown that minimizing costs without nutritional restrictions can negatively affect the quality of nutrition. The importance of AI DSS systems, sustainability and adaptive optimization approaches is confirmed by research by Bordbar et al. (2026), Pinel et al. (2024) and Grosul & Balatska (2021).

2. Diet plan proposal

The introduction of compulsory military service in Serbia from 2026 imposes the need to define an economically optimal model of soldiers' nutrition that simultaneously meets energy and nutritional limitations and enables rational management of available resources. A number of factors affect the solution of this problem, including the prices of food products, the structure of meals and the representation of certain food groups in the overall diet. Therefore, before implementing the food preparation process, it is necessary to look at all the relevant parameters and apply the methods of multi-criteria analysis and mathematical optimization in order to make optimal decisions.

The basis for the formulation of the model was the data from the Diet Plan in the Serbian Armed Forces, which includes 230 recipes of different categories of dishes: breakfast, snack, soups, main courses for lunch and dinner, salads, cakes, fruit and compotes. Based on the available data, a linear programming model was formulated in which the goal function and the set of constraints are defined by linear relationships while taking into account the energy and nutritional requirements of the food system (Martić et al., 1991).

Set of dishes:

$$J=\{1,2,...,230\}$$

Parameters:

c_i – the price of the dish,

E_i – energy value of the dish,

P_i, f_i, CH_i – protein, fat and carbohydrate content and

$N = 353$ – the number of days in a year, because a canned food meal is provided only once a month.

Variables:

The basic decision variable x_j is the annual frequency of food j .

Function of the target:

$$\text{Min } F = \sum_{j=1}^n c_i \cdot x_j$$

Limitations:

Nutritional restrictions

$$P_i^{\min} \leq \sum_{j=1}^n a_{ij} \cdot x_j \leq P_i^{\max}, \quad i = 1, \dots, m$$

Meal restrictions

$$\sum_{j=1}^{30} x_j = 353 \quad (\text{breakfast})$$

$$\sum_{j=31}^{41} x_j = 245 \quad (\text{snack})$$

$$\sum_{j=53}^{129} x_j = 353 \quad (\text{main dishes for lunch})$$

$$\sum_{j=130}^{142} x_j = 353 \quad (\text{salads})$$

$$\sum_{j=143}^{157} x_j = 131 \quad (\text{sweets})$$

$$\sum_{j=158}^{166} x_j = 222 \quad (\text{fruits for lunch})$$

Dinner

$$\sum_{j=167}^{182} x_j = 123 \quad (\text{cooked meals})$$

$$\sum_{j=183}^{199} x_j = 122 \quad (\text{small dinners})$$

$$\sum_{j=200}^{206} x_j = 108 \quad (\text{cold dinners})$$

$$\sum_{j=220}^{227} x_j = 85 \quad (\text{fruit for dinner})$$

$$x_{228} + x_{229} + x_{230} = 37 \quad (\text{compotes})$$

Nutritional limits of the daily rations

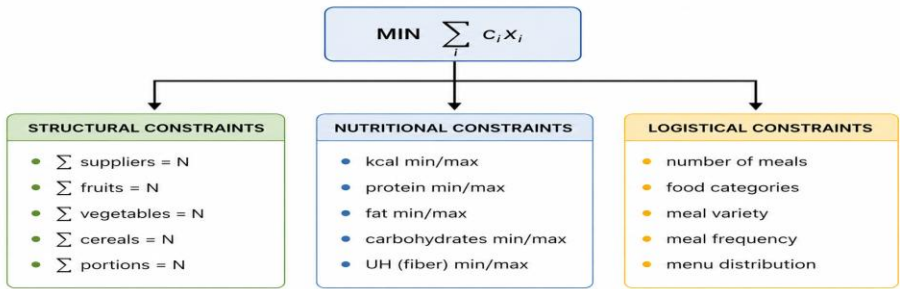
$$3300 \text{ kcal} \leq \text{Energy value} \leq 4200 \text{ kcal}$$

$$10\% \leq \text{Proteins} \leq 15\%$$

$$15\% \leq \text{Fats} \leq 30\%$$

$$55\% \leq \text{Carbohydrates} \leq 75\%$$

Figure1: Mathematical structure of the optimization model



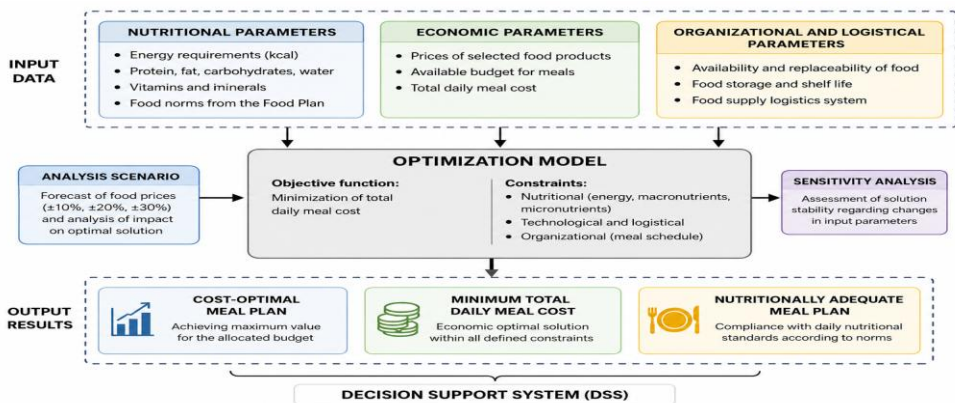
Source: Authors' processing

The presented mathematical scheme shows the relationship between the objective function and the structural, nutritional and logistical constraints of the model.

2.1. Programming the implementation of the optimization model in the Python programming environment

The optimization model was implemented in the Python programming environment using the pandas and NumPi libraries for processing the input data, while the linear programming problem was solved using the PuLP library and the built-in CBC (Coin-or Branch and Cut) solver. The optimization process of nutrition implemented in the Python programming environment consists of the phases shown in Figure 2.

Figure 2: Optimization process of soldier nutrition in the Python programming environment



Source: Authors' processing

2.1.1. Computational Complexity and Model Convergence

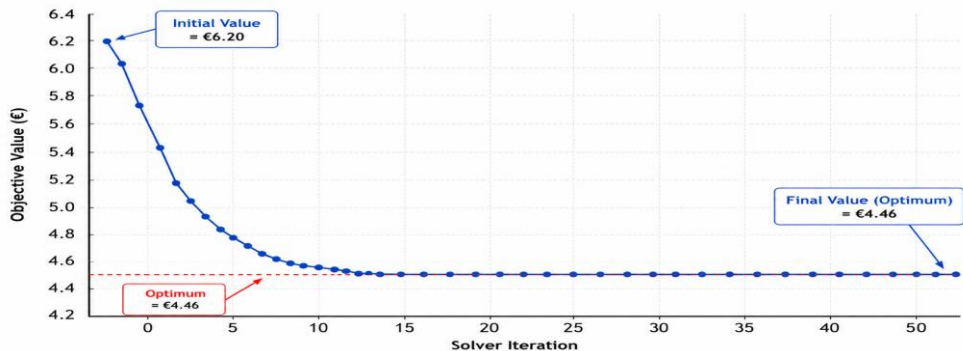
The formula includes 230 decision variables and a set of linear constraints. In the tested computer environment, the model execution time was less than one minute, with no identified numerical problems with instability or convergence.

Table 1: Basic characteristics of the optimization model and computer implementation

Characteristic	Value/Description
A type of optimization model	Integer Linear Programming (ILP)
Number of decision variables	230
Number of dishes analyzed	230
Objective function	Minimizing the cost of a daily meal
Type of restriction	Energy and nutritional restrictions
Number of major nutritional restrictions	4
Programming environment	Python
Used libraries	pandas, numpy, puLP
Optimization Solver	CBC (Coin-or Branch and Cut)
Type of variables	Integer variables
Output Result	The optimal frequency of application of dishes
Average Execution Time	< 1 minute
The Status of the Solution	Optimal solution found

Source: Authors' analysis

Chart 1: Convergence of the target function during the optimization process



Source: Authors' processing

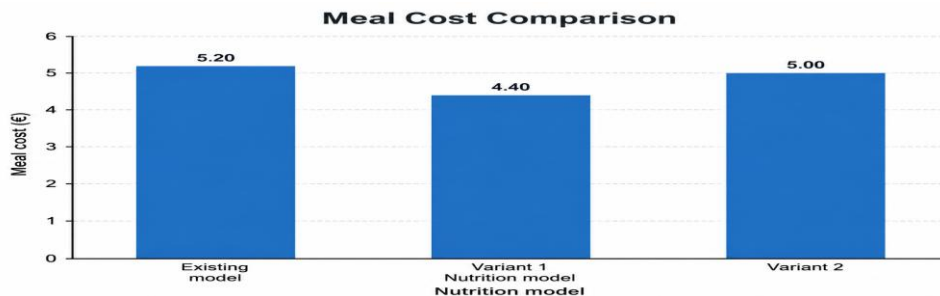
The presented results indicate the computational efficiency, numerical stability and practical applicability of the developed optimization model.

3. Results and discussion

Using the Python programming environment, multi-criteria analysis and linear programming, a mathematical model of nutrition in the Serbian Armed Forces was formulated with the aim

of minimizing the cost of a daily meal while meeting the defined energy and biological limits. The model uses two optimization variants to determine the optimal annual frequency of serving specific dishes across breakfast, lunch, dinner, and snacks. In the first variant, the optimal price of a daily meal is €4.46, while the second variant, with a higher proportion of expensive meals, is €5.06.

Chart 2: Comparison of the cost of a daily meal by dietary models



Source: Authors' processing

Compared to the existing nutrition model in the Serbian Armed Forces, the optimization model allows for savings of 0.2 to 0.8 € per daily meal. Chart 2 shows a comparison of the cost of a daily meal between the existing nutrition model in the Serbian Armed Forces and the optimized models obtained by applying linear programming and multi-criteria analysis.

4. Verification and validation of the optimization model

4.1. Cost Sensitivity Analysis

The sensitivity analysis was carried out by simulating the change in food prices ranging from -20% to +20%. In this way, it was examined how changes in input prices affect the total cost of a daily meal, as well as the relative savings compared to the existing model.

Table 2: Cost Sensitivity Analysis in the Context of Changes in Food Prices

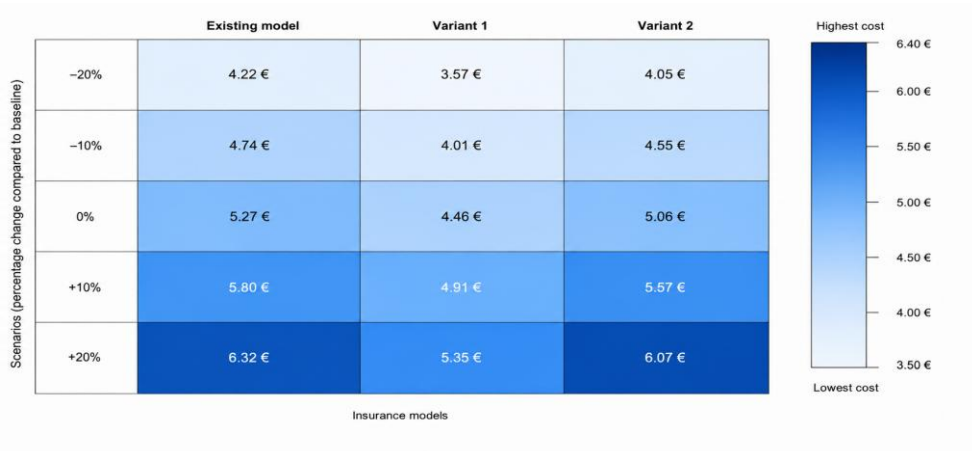
Price change scenario	Existing model (€)	Option 1 (€)	Savings V1 (€)	Option 2 (€)	Savings V2 (€)
- 20%	4.22	3.57	0.65	4.05	0.17
- 10%	4.74	4.01	0.73	4.55	0.19
0%	5.27	4.46	0.81	5.06	0.21
+10%	5.80	4.91	0.89	5.57	0.23
+20%	6.32	5.35	0.97	6.07	0.25

Source: Authors' analysis

The results confirm that the optimized variants maintain lower cost levels compared to the existing normative model in all analyzed scenarios, with variant 1 achieving the lowest

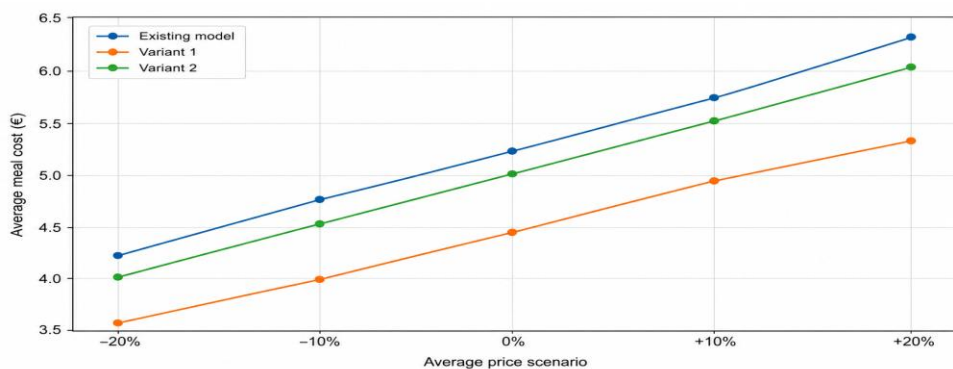
values of the target function. Chart 4 shows the change in the cost of a daily meal in different scenarios of food price changes.

Chart 3: Sensitivity Analysis of the Optimization Model Heat Map



Source: Authors' analysis based on the results of the optimization model simulation

Chart 4: Cost Sensitivity Analysis



Source: Authors' processing

4.2. Analysis of the stability scenario of the optimization model

In order to further verify the stability of the developed optimization model, deterministic sensitivity analysis was conducted through predefined scenarios of changes in food prices. Based on the scenario of change in prices of food products ranging from -20% to +20%, the

average cost values, standard deviation and sensitivity coefficient of the model were calculated. The obtained indicators enable a quantitative assessment of the model's behavior in response to fluctuating food prices.

Table 3: Descriptive stability indicators of the optimization model

Indicator	An existing model	Variant 1	Variant 2
Average price (€)	5.27	4.46	5.06
Average Savings (€)	—	0.81	0.21
Standard deviation	0.74	0.63	0.72
Sensitivity coefficient	1.00	0.85	0.93
Scope of deviation (€)	±0.18	±0.15	±0.17

Source: Authors' analysis

4.3. Analysis of deviations in nutritional parameters

Alongside the costs, the basic nutritional parameters were assessed for deviation from the set limits.

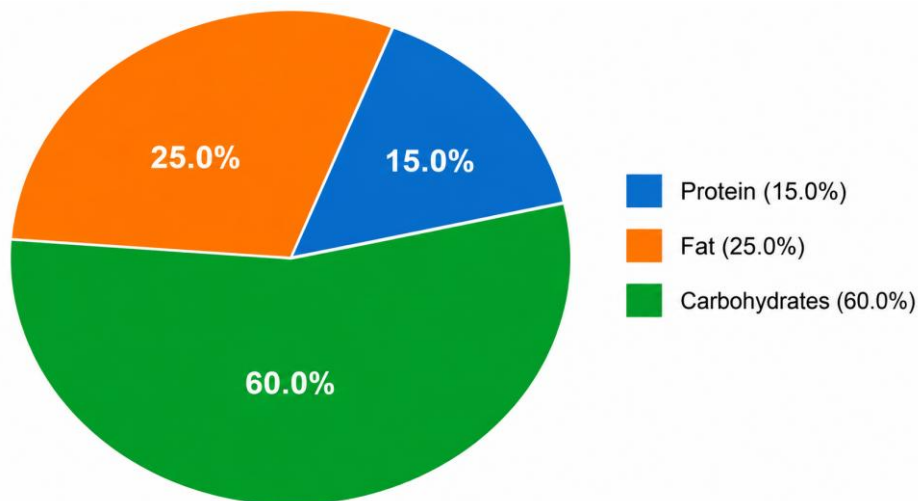
Table 4: Verification of compliance with the nutritional limits of the optimization model

Parameter	Lower limit	Upper limit	Variant 1	Variant 2	Rating
Energy	3300 kcal	4200 kcal	Within the limits	Within the limits	Acceptable
Proteins	10%	15%	Within the limits	Within the limits	Acceptable
Fats	15%	30%	Within the limits	Within the limits	Acceptable
Carbohydrates	55%	75%	Within the limits	Within the limits	Acceptable
Meal price	—	Minimum	€4.46	€5.06	V1 more economical, V2 more balanced

Source: Authors' analysis

The results indicate that cost reductions have not been achieved at the expense of compromising basic nutritional needs.

Chart 5: The Macronutrient Structure of an Optimized Daily Meal



Source: Authors' analysis

Chart 5 shows the optimal ratio of macronutrients in accordance with the nutritional standards of the Serbian Armed Forces.

4.4. Conceptual framework for robust optimization

In this paper, robust optimization is not performed as a separate stochastic model, but is presented as a conceptual extension of the basic linear optimization model. In real-world conditions, the prices of food products, the availability of groceries and logistics capacities may vary. The robust formulation of the model can be expressed as follows: minimize the total cost of a daily meal, provided that nutritional restrictions are met and in the event of adverse changes in prices and availability of products.

4.5. Formal formulation of robust optimization

To formalize a robust optimization approach, it is possible to define a robust target function based on minimizing the maximum expected costs under conditions of changes in input parameters. Unlike standard linear programming, where all parameters are assumed to be known and fixed, a robust optimization approach starts from the assumption that food prices can fluctuate within a defined set of uncertainties.

A robust formulation of the target function can be represented in the following form:

$$\min_{x \in X} \max_{c \in U} \sum_{i=1}^n c_i x_i$$

where:

x_i - frequency of application of dish i ,

c_i - the price i -dish,

U - set of food products price uncertainties.

X – a set of permitted solutions defined by nutritional and logistical constraints.

A set of uncertainties can be defined in intervals, assuming that the price of each food product may deviate from the nominal value within a predefined interval:

$$c_i \in [\bar{c}_i - \Delta_i, \bar{c}_i + \Delta_i].$$

Where it is located:

$\bar{c}_i$ - the nominal price of the product,

Δ_i – the maximum permissible deviation from the price.

In this way, a robust optimization approach not only minimizes costs in nominal terms, but also minimizes the most unfavorable possible costs within a defined set of uncertainties. In this paper, the robust optimization formulation is not implemented as a full stochastic model, but represents a theoretical and methodological framework for the future extension of the developed linear optimization system.

4.5.1. Scenario analysis

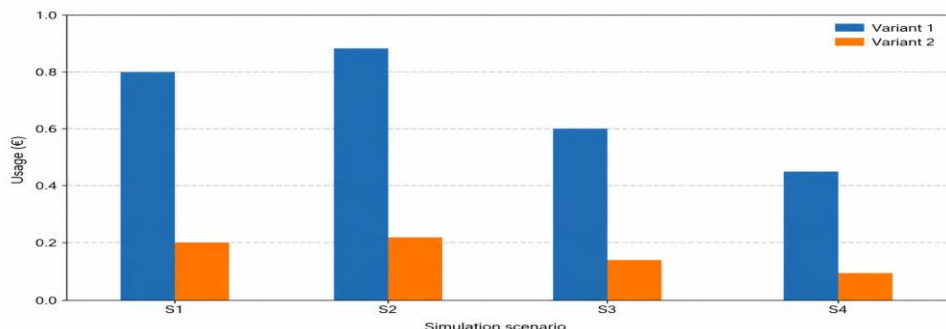
In order to further verify the behavior of the model under different conditions, four analytical scenarios were defined.

Table 5: Analysis of the behavior scenario of the optimization model in different market conditions

Scenario	Scenario description	The expected effect
S1 – Basic scenario	Prices and availability of products remain stable	The model achieves minimal costs
S2 – Inflation scenario	Increase in food product prices by 10-20%	Costs are increasing, but optimized variants remain more affordable
S3 – logistical disruption	Limited availability of certain foods	The model adjusts the structure of choice in favor of available dishes
S4 – quality scenario	The share of more expensive and varied dishes is increasing	The price is rising, but the acceptability of the menu is increasing

Source: Authors' analysis

Chart 6: Comparison of savings by simulation scenarios



Source: Authors' analysis

4.6. Comparison with actual historical cost data

In order to further verify the practical applicability of the developed optimization model, a conceptual comparison was made with historical data on food costs in the Serbian Armed Forces for a multi-year period. For each observed year, the input economic parameters were reconstructed on the basis of estimated market prices of food products, after which the optimization model was applied again to historical datasets.

Table 6: Comparative analysis of historical and optimized daily meal costs

Year	Existing model (€)	Optimized variant 1 (€)	Optimized variant 2 (€)	Estimated savings V1 (€)	Estimated Savings V2 (€)
2021	4.62	3.95	4.41	0.67	0.21
2022	4.88	4.13	4.63	0.75	0.25
2023	5.01	4.24	4.81	0.77	0.20
2024	5.18	4.39	4.96	0.79	0.22
2025	5.27	4.46	5.06	0.81	0.21

Source: Authors' analysis

The obtained results confirm that the optimized model in all analyzed years achieves lower projected costs of a daily meal compared to the existing normative approach, while maintaining the defined nutritional restrictions.

4.7. Comparison with alternative models

In order to further verify the feasibility of the proposed model, a conceptual comparison with alternative approaches to nutrition planning was performed.

Table 7: Comparison of the optimization model with alternative approaches to nutrition planning

Model	Basic characteristic	Advantages	Limitation
An existing normative model	Planning according to a valid diet plan	A well-established and operationally proven system	Does not reduce costs
Lowest price model	Selection of the cheapest dishes	Biggest savings	Risk of reduced diversity
Nutritionally balanced model	Priority nutritional structure	Good biological adequacy	Does not guarantee minimal costs
Proposed optimization model	price + nutritional restrictions + frequency of meals	Best Cost-Constraint Ratio	Requires up-to-date data and software support
Robust model	It involves the risk of changes in the price and availability of the product	Greater stability	More complex to apply

Source: Authors' analysis

4.8. Discussion of validation results

The obtained results confirm that optimization models improve the economic efficiency and nutritional adequacy of the food system (Karl et al., 2021; McClung & Gaffney-Stomberg, 2016; Wincewicz-Bosy et al., 2022; de Moor et al., 2024), while AI DSS systems support adaptive scheduling (Bordbar et al., 2026). Gerdessen & Borgonjen-van den Berg (2023) highlight the transparency and effectiveness of the MILP approach.

Conclusion

The results of the research indicate that the application of linear programming in collective nutrition planning in the Serbian Armed Forces enables the achievement of a more favorable relationship between costs and nutritional restrictions compared to the traditional normative approach. The scientific contribution of the paper is reflected in the formulation of an integrated MILP model that combines economic, nutritional and logistical criteria into a single optimization framework. The limitations of the research relate to the deterministic character of the model, the use of static nutritional parameters, and the absence of a full stochastic robust optimization formulation. Future research may be directed towards the development of stochastic and robust optimization models, the integration of simulation methods, and the application of adaptive algorithms for collective nutrition planning in complex logistics systems.

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Do Gender, Age, and Education Matter for Guest Loyalty in Four-Star Hotels in Serbia?

Да ли су пол, старост и образовање значајни за лојалност гостију хотела категорије четири звезде у Србији?

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Abstract

Purpose: This paper examines whether gender, age, and education level introduce systematic differences in post-purchase behaviour among guests of four-star hotels in the Republic of Serbia, with a focus on two distinct outcomes: revisit intention and positive electronic word-of-mouth intention (eWOM), both considered indicators of guest loyalty.

Methodology: Primary data were collected through a survey of 589 respondents who had previously stayed in a four-star hotel in Serbia. Differences between male and female respondents were examined using independent-samples t-tests, whereas differences across age and education groups were analysed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test. The practical significance of the observed differences was assessed using eta-squared (η^2).

Findings: Revisit intention does not differ significantly across gender, age, or education, suggesting that the propensity to return to the same hotel is broadly uniform across socio-demographic groups. Positive electronic word-of-mouth intention is significantly higher among male guests ($\eta^2 = 0.027$) and, in one specific pairwise comparison, among respondents with Bachelor/Higher degrees than among postgraduate degree holders ($\eta^2 = 0.021$), although both effects are small.

Originality/value: The paper provides original evidence on socio-demographic differences in guest loyalty in Serbia's four-star hotel sector and contributes to the debate on whether revisit intention and electronic word-of-mouth are driven by the same factors.

Practical implications: The findings suggest that socio-demographic characteristics alone are insufficient to explain guest loyalty, indicating the need for future research to investigate the contribution of other factors, such as service quality and customer satisfaction.

Limitations: The study relies on a non-probability sample with an overrepresentation of younger, female, and urban respondents, limiting the generalizability of the findings, particularly beyond the Serbian context.

Keywords: socio-demographic characteristics, revisit intention, eWOM, four-star hotels, Serbia.

JEL classification: M31, Z32

Сажетак

Циљ: Рад испитује да ли пол, старост и ниво образовања условљавају систематске разлике у посткуповном понашању гостију хотела категорије четири звезде у Републици Србији, са фокусом на

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два различita ishoda: nameru ponovne posete i nameru širenja pozitivne preporuke elektronskim sistemom komunikacije potrošača „od usta do usta“ (electronic word-of-mouth, eWOM), koji se smatraju indikatorima lojalnosti gostiju.

Методологија: Примарни подаци прикупљени су испитивањем 589 испитаника који су претходно боравили у хотелу категорије четири звезде у Србији. Разлике између мушкараца и жена испитане су применом t-теста за независне узорке, док су разлике између старосних и образовних група анализирани једнофакторском анализом варијансе (ANOVA), уз примену Tukey-евог post hoc testa. Практични значај утврђених разлика процењен је применом ета-квдрата (η^2).

Резултати: Намера поновне посете не разликује се статистички значајно у односу на пол, старост и ниво образовања, што у контексту социо-демографских карактеристика указује на уједначену склоност гостију да поново посете исти хотел. С друге стране, намера ширења позитивног eWOM-a статистички је значајно израженија код мушкараца ($\eta^2 = 0.027$) и код испитаника са завршеним основним академским или високим студијама у односу на испитанике са последипломским образовањем ($\eta^2 = 0.021$), при чему је разлика по образовању утврђена само између ове две групе, иако су оба ефекта мала.

Оригиналност/вредност: Рад пружа оригиналне емпијске доказе о социо-демографским разликама у лојалности гостију хотела категорије четири звезде у Србији и указује да намера поновне посете и намера ширења позитивног eWOM-a не морају бити условљене истим детерминантама.

Практична примена: Резултати указују да социо-демографске карактеристике саме по себи нису довољне за објашњење лојалности гостију, што упућује на потребу да будућа истраживања испитају значај других фактора, попут квалитета услуге и сатисфакције потрошача.

Ограничења истраживања: Истраживање се заснива на невероватносном домаћем узорку, у којем су млађи, женски и испитаници из урбаних предела били више заступљени, што ограничава могућност генерализације налаза, првенствено изван контекста Србије.

Кључне речи: социо-демографске карактеристике, намера поновне посете, eWOM, хотели четири звезде, Србија.

ЈЕЛ класификација: M31, Z32

Introduction

The hospitality sector operates in a highly competitive environment in which guest retention and positive word-of-mouth (WOM) are critical drivers of sustainable performance. In Serbia, the four-star hotel segment represents the largest and most strategically significant tier of the accommodation market, comprising 184 of the country's 432 registered hotels as of April 2024 (Ministry of Tourism and Youth of the Republic of Serbia, Sector for Tourism, 2024). Understanding the factors that influence guests' post-purchase behaviour in this segment is therefore both theoretically and managerially significant.

Consumer loyalty in the hospitality context is most measured through two complementary constructs: revisit intention (RI) and positive electronic word-of-mouth intention (eWOM). Both are recognised in the literature as reliable indicators of guest loyalty and as outcomes that directly affect hotel profitability and reputation (Serra-Cantalops et al., 2018). While revisit intention reflects the behavioural dimension of loyalty, positive eWOM captures the attitudinal and communicative dimension, specifically the guests' willingness to recommend the hotel through digital channels. Despite their conceptual overlap, existing evidence indicates that these two outcomes are not influenced by the same set of antecedents (Serra-Cantalops et al., 2020; Redditt et al., 2022), raising the question of whether they respond equally to socio-demographic differentiation as well. Whether this asymmetry between RI and eWOM extends to socio-demographic

characteristics, that is, whether the same guest attributes that differentiate one outcome also differentiate the other, remains an empirically open question.

A persistent debate in consumer behaviour research concerns the extent to which socio-demographic characteristics, specifically gender, age, and education level, moderate post-purchase behaviour: the available evidence is mixed and context-dependent. Studies across various service sectors report both significant and non-significant effects of these variables on RI and eWOM (Sun & Qu, 2011; Yen & Tang, 2019), and the hotel hospitality context in Central and Eastern European markets remains under-investigated. This gap is particularly evident in Serbia, where empirical research on guest post-purchase behaviour is limited (Blešić et al., 2014; Vujić et al., 2019). This paper addresses the gap by examining whether gender, age, and education level systematically differentiate revisit intention and positive eWOM intention among guests of four-star hotels in Serbia. In doing so, the paper contributes empirical evidence to the debate on whether RI and eWOM are driven by the same factors and offers a nationally specific baseline for future research on loyalty segmentation in the Serbian hospitality market.

To date, no study has simultaneously examined gender, age, and education as potential moderators of both revisit intention and positive eWOM in the four-star hotel segment in Serbia, leaving open the question of whether these two loyalty outcomes respond to socio-demographic differentiation in the same way. This research question is deliberately bounded: the paper does not investigate the structural antecedents of loyalty, such as service quality or satisfaction, as part of its central inquiry. Instead, it focuses exclusively on the socio-demographic moderation of two loyalty outcomes in a nationally specific context.

The paper is structured as follows: Section 1 reviews the theoretical background on RI and eWOM as loyalty indicators and on socio-demographic influences in post-purchase behaviour; Section 2 presents the methodology; the Results and Discussion section reports and interprets findings for each hypothesis; and the Conclusion synthesises the main contributions, managerial implications, and limitations.

1. Theoretical background

The post-purchase phase of the service consumption cycle is conceptually grounded in the disconfirmation paradigm (Oliver, 1980), which posits that consumers compare the perceived performance of a service against their prior expectations. When perceived performance meets or exceeds expectations, positive post-purchase outcomes are more likely. In hospitality research, two such outcomes have received consistent empirical attention: revisit intention and positive eWOM intention.

Revisit intention is defined as the consumers' expressed likelihood of returning to the same hotel on a future occasion (Um et al., 2006; Ugwuanyi et al., 2021). It represents the behavioural dimension of loyalty and is recognised as one of the most commercially valuable outcomes for hotel enterprises, since the cost of acquiring new guests consistently

exceeds that of maintaining existing relationships (Mat Som et al., 2012; Nazarian et al., 2023). Empirical studies consistently confirm that perceived service quality, mediated by satisfaction, positively affects revisit intention (Maroco & Maroco, 2013; Nugroho et al., 2021). While this line of inquiry has generated a substantial and methodologically mature body of evidence, comparatively little attention has been paid to the role of guest socio-demographic characteristics as potential moderators of post-purchase loyalty outcomes.

Positive eWOM intention refers to consumers' willingness to share favourable experiences with other users via digital platforms such as TripAdvisor, Booking.com (in the tourism context), or social media networks (Jalilvand et al., 2011; Serra-Cantalops & Salvi, 2014). Unlike revisit intention, eWOM has an outward communicative character, extending the influence of a single consumer experience to a potentially wide digital audience (Litvin et al., 2008; Ye et al., 2009). Empirical evidence shows that positive eWOM drives meaningful growth in hotel bookings (Serra-Cantalops et al., 2018) and shapes the expectations of future guests before their first visit. The role of online recommendations in shaping tourist decision-making has also been documented in the Serbian context, where digital word-of-mouth was found to influence travel choices even during periods of severe market disruption such as the COVID-19 pandemic (Marić et al., 2024).

Despite their common conceptual basis in guest loyalty, RI and eWOM do not necessarily respond to the same drivers with the same intensity. In most studies satisfaction is a strong predictor of both outcomes, but its effect on revisit intention tends to be more robust and consistent across studies, while the activation of eWOM appears to require additional conditions beyond satisfaction, such as the presence of emotionally distinctive experiences, altruism, technology acceptance, digital competencies, and others (Serra-Cantalops et al., 2020; Redditt et al., 2022). This asymmetry motivates the present study's interest in testing whether socio-demographic characteristics produce similar divergences. The following section examines what the existing literature reveals about the moderating role of gender, age, and education on post-purchase behaviour in hospitality contexts.

Research on the influence of socio-demographic characteristics on post-purchase behaviour in hospitality has produced a body of evidence that is neither consistent nor conclusive. Gender, age, and education level have all been proposed as potential moderators, yet findings vary considerably across study contexts, methodological approaches, and outcome variables. Gender has been proposed as a moderator of post-purchase behaviour because male and female consumers may differ in their digital communication patterns, their propensity to share experiences online, and the weight they assign to service encounters when forming loyalty intentions. However, some studies find no significant gender effect on either RI or eWOM in hotel contexts (Sun & Qu, 2011; Wen et al., 2018; Yen & Tang, 2019). Age has similarly been proposed as a moderator, based on the premise that different generational cohorts may hold distinct service expectations, process hospitality experiences differently, and vary in their willingness to engage with digital review platforms, while education level has received comparatively less attention as a standalone predictor of loyalty outcomes. In eWOM research, higher education has sometimes been associated with more frequent online activity (Marić et al., 2022). Conversely, more educated consumers may apply higher critical standards when evaluating

service quality, which could either increase or decrease the likelihood of generating positive eWOM depending on whether those standards were met. The direction and magnitude of this effect are therefore theoretically ambiguous.

The inconsistency of findings across these variables motivates the present study. If socio-demographic characteristics systematically differentiate RI and eWOM among guests of four-star hotels in Serbia, this would have implications for segmented loyalty management. Conversely, if they do not, this would indicate the need for future research to investigate the contribution of other factors, such as service quality and customer satisfaction. Against this backdrop, the present study tests these competing possibilities empirically, using a sample of four-star hotel guests in Serbia as its analytical context.

2. Methodology

Primary data were obtained through a structured online questionnaire administered between 2025 and 2026. The sample comprised adult guests who had previously stayed at four-star hotels in Serbia. A non-random convenience sampling approach was employed, supplemented by a snowball technique to enhance geographic and demographic diversity. In total, 608 completed questionnaires were collected. Following data cleaning, which involved removing incomplete responses and identifying outliers using Mahalanobis distance, 19 cases were excluded, resulting in a final sample of 589 participants. The socio-demographic characteristics of the sample are presented in Table 1.

Table 1: Socio-demographic characteristics of the sample (n=589)

Characteristic	Category	n	%
Gender	Male	236	40.1
	Female	353	59.9
Age	18-20 years	151	25.5
	21-29 years	160	27.3
	30-39 years	103	17.6
	40-49 years	92	15.5
	50+ years	83	14.1
Education	Primary	21	3.8
	Secondary	249	41.8
	Bachelor/Higher	170	29.4
	Master/PhD	149	25.0
Employment	Pupil	19	3.1
	Student	208	34.2
	Employed	281	46.2
	Unemployed	9	1.5
	Retired	38	6.3
	Employer	53	8.7
Residence	Urban	406	66.8
	Rural	112	18.4
	Suburban	90	14.8

Length of stay	< 4 days	353	58.1
	4-7 days	214	35.2
	> 7 days	41	6.7

Source: Author's research

Based on the theoretical framework outlined above, the following research hypothesis was proposed:

- *H₁: Guest loyalty differs significantly according to socio-demographic characteristics among guests of four-star hotels in Serbia.*

To test the main hypothesis, the following auxiliary hypotheses were developed:

- *H_{1a}: Revisit intention differs significantly between male and female respondents.*
- *H_{1b}: Revisit intention differs significantly across age groups.*
- *H_{1c}: Revisit intention differs significantly across education levels.*
- *H_{1d}: Positive electronic word-of-mouth intention differs significantly between male and female respondents.*
- *H_{1e}: Positive electronic word-of-mouth intention differs significantly across age groups.*
- *H_{1f}: Positive electronic word-of-mouth intention differs significantly across education levels.*

Revisit intention (RI) and positive electronic word-of-mouth (eWOM) intention were each assessed using three-item scales ranging from 1 (strongly disagree) to 5 (strongly agree), adapted from established instruments in prior hospitality research. The reliability of both scales was confirmed: the RI scale yielded Cronbach's alpha (CA) = 0.737 and composite reliability (CR) = 0.850, while the eWOM scale produced CA = 0.811 and CR = 0.856. Average Variance Extracted (AVE) values exceeded 0.50 for both constructs, supporting convergent validity.

The following hypotheses were examined: H_{1a} (RI differs by gender), H_{1b} (RI differs by age group), H_{1c} (RI differs by education level), H_{1d} (positive eWOM differs by gender), H_{1e} (positive eWOM differs by age group), and H_{1f} (positive eWOM differs by education level). Group differences were analysed using independent-samples t-tests for binary groups (gender) and one-way ANOVA for multiple groups (age, education). When ANOVA indicated a significant overall effect, pairwise comparisons were conducted using Tukey's HSD post hoc test. The magnitude of statistically significant effects was assessed using eta-squared (η^2), following Cohen's (1988) guidelines: $\eta^2 = 0.01$ indicates a small effect, $\eta^2 = 0.06$ a medium effect, and $\eta^2 = 0.14$ a large effect.

3. Results and Discussion

The Results and Discussion section presents the statistical findings for each hypothesis in sequence and interprets them considering the existing literature reviewed in Section 1. The order follows the structure of the analytical tables: Table 2 addresses gender effects (H_{1a},

H_{1d}), Table 3 addresses age effects (H_{1b}, H_{1c}), and Tables 4 and 5 address education effects (H_{1c}, H_{1f}).

Table 2 presents the results of the independent-samples t-test comparing RI and positive eWOM between male and female respondents. For revisit intention, the difference between male (M = 4.048, SD = 0.652) and female (M = 3.961, SD = 0.849) respondents was not statistically significant (t = 1.398, p = 0.163). Hypothesis H_{1a} is therefore not supported. For positive eWOM, the difference was statistically significant (t = 4.018, p = 0.001), with male respondents reporting a notably higher mean (M = 3.726, SD = 0.941) than female respondents (M = 3.366, SD = 1.225). Hypothesis H_{1d} is supported, although the effect size is small ($\eta^2 = 0.027$).

Table 2: Independent-samples t-test: revisit intention and positive eWOM by gender

Variable	Gender	n	M	SD	t	p	Decision
Revisit Intention	Male	236	4.048	0.652	1.398	0.163	H _{1a} not supported
	Female	353	3.961	0.849			
Positive eWOM	Male	236	3.726	0.941	4.018	0.000	H _{1d} supported $\eta^2 = 0.027$
	Female	353	3.366	1.225			

Note: p < 0.05 indicates a statistically significant difference. η^2 reported for significant results only. Effect size benchmarks (Cohen, 1988): 0.01 = small, 0.06 = medium, 0.14 = large.

Source: Author's research

The non-significant gender difference in revisit intention is consistent with findings from hospitality research positioning satisfaction and service quality as dominant predictors of loyalty (Maroco & Maroco, 2013; Nugroho et al., 2021). Both male and female guests in the sample expressed comparably high revisit intentions (both means above 3.9 on a five-point scale), suggesting that the intention to return to a four-star hotel of comparable quality is broadly shared across gender groups.

This finding resonates with Sun & Qu (2011), who showed that gender may influence how service quality translates into WOM behaviour, though its moderating role is neither universal nor unconditional. The small effect size observed here ($\eta^2 = 0.027$) indicates that, while the difference is statistically real, its practical importance for hotel marketing management should not be overstated: gender alone explains less than 3% of the variance in eWOM intention.

Table 3 displays the one-way ANOVA results examining whether revisit intention and eWOM differ across five age groups (18-20, 21-29, 30-39, 40-49, and 50+ years). For revisit intention, the omnibus F-test did not reach statistical significance (F = 1.416, p = 0.227), and hypothesis H_{1b} is rejected. Group means ranged narrowly from 3.844 (40-49 age group) to 4.084 (30-39 age group), indicating minimal differentiation. For positive eWOM, the omnibus test also failed to reach significance (F = 1.789, p = 0.129), and hypothesis H_{1c} is rejected. The age group 40-49 reported the highest mean eWOM value (M = 3.760), but the difference from other groups was not statistically significant.

Table 3: One-way ANOVA: revisit intention and positive eWOM by age group

Variable	Age group	n	M	SD	F	p	Decision
Revisit Intention	18-20	151	4.044	0.787	1.416	0.227	H _{1b} not supported
	21-29	160	4.002	0.900			
	30-39	103	4.084	0.679			
	40-49	92	3.844	0.711			
	50+	83	3.955	0.666			
Positive eWOM	18-20	151	3.439	1.131	1.789	0.129	H _{1c} not supported
	21-29	160	3.393	1.271			
	30-39	103	3.514	1.081			
	40-49	92	3.760	0.998			
	50+	83	3.582	1.029			

Note: Post hoc analysis not conducted given the absence of significant omnibus effects. $p < 0.05$ indicates statistical significance.

Source: Author's research

The uniformity of post-purchase intentions across age groups suggests that chronological age, in isolation, carries limited explanatory power in this context and that the variation observed in the data is more plausibly attributable to factors that cut across demographic boundaries rather than to age itself. Service quality is a plausible explanation of this pattern: Lu et al. (2015) argue that in higher-tier hotel segments, where the service offer is broadly standardised across properties, sustainable competitiveness depends on delivering experiences that resonate with guests regardless of their demographic background. Should service quality indeed operate as such a cross-demographic driver of post-purchase intentions, the suppression of age-based differentiation observed here would be an expected rather than surprising outcome. Empirically disentangling this interpretation, however, requires a design that simultaneously models perceived service quality, satisfaction, and age: a task that exceeds the scope of the present study.

Table 4 presents the ANOVA results for education level, which included four groups: primary education, secondary education, Bachelor/Higher education, and Master/PhD level. For revisit intention, no significant differences were found across education groups ($F = 0.723$, $p = 0.539$), and hypothesis H_{1c} is rejected. Mean values ranged from 3.941 (secondary) to 4.047 (primary), a range so narrow as to be substantively negligible.

Table 4: One-way ANOVA: revisit intention and positive eWOM by education level

Variable	Education	n	M	SD	F	p	Decision
Revisit Intention	Primary	21	4.047	0.450	0.723	0.539	H _{1c} not supported
	Secondary	249	3.941	0.867			
	Bachelor / Higher	170	4.031	0.685			
	Master / PhD	149	4.040	0.752			

Positive eWOM	Primary	21	3.920	0.546	4.239	0.006	H _{1f} supported* $\eta^2 = 0.021$
	Secondary	249	3.451	1.177			
	Bachelor / Higher	170	3.707	0.969			
	Master / PhD	149	3.326	1.247			

Note: * $p < 0.01$. Post hoc results for the significant eWOM omnibus effect are presented in Table 5.

Source: Author's research

For positive eWOM, the omnibus ANOVA reached significance ($F = 4.239$, $p = 0.006$), providing empirical support for hypothesis H_{1f}. Table 5 presents the Tukey HSD post hoc results, which reveal that the only statistically significant pairwise comparison is between the Bachelor/Higher education group ($M = 3.707$) and the Master/PhD group ($M = 3.326$), with a mean difference of 0.381 ($p = 0.014$; 95% CI: [0.056, 0.706]). All other pairwise comparisons were non-significant. The effect size is small ($\eta^2 = 0.021$).

Table 5: Tukey HSD post hoc comparisons: positive eWOM by education level

Group 1	Group 2	Mean diff.	p	95% CI	Decision
Bachelor/Higher	Master/PhD	0.381	0.014	[0.056; 0.706]	Significant
Primary	Secondary	0.470	0.256	[-0.189; 1.128]	Not significant
Primary	Bachelor/Higher	0.213	0.846	[-0.457; 0.883]	Not significant
Primary	Master/PhD	0.594	0.107	[-0.081; 1.269]	Not significant
Secondary	Bachelor/Higher	-0.257	0.100	[-0.545; 0.031]	Not significant
Secondary	Master/PhD	0.125	0.708	[-0.175; 0.425]	Not significant

Source: Author's research

Marić et al. (2022) found that eWOM is used most frequently by younger, highly educated, employed individuals, suggesting that education level is positively associated with participation in online review activity. The finding that postgraduate respondents expressed lower eWOM intentions than those with Bachelor/Higher qualifications is therefore substantively interesting and partially counterintuitive. A plausible interpretation is that postgraduate guests apply more demanding quality benchmarks when evaluating hotel experiences and are consequently less inclined to generate positive eWOM unless the experience clearly exceeded their expectations: a possibility that warrants direct empirical investigation in future research. In any case, the small effect size ($\eta^2 = 0.021$) limits the practical significance of this finding, and education level should not be treated as a reliable standalone predictor of eWOM behaviour in this context.

Across all three socio-demographic variables, a consistent asymmetry emerges: revisit intention is statistically invariant with respect to gender, age, and education, while eWOM shows selective sensitivity to gender and education. This asymmetry has theoretical implications: it suggests that the propensity to return to a hotel is driven by factors that cut across demographic boundaries most plausibly, the quality of the service experience itself, while willingness to publicly share that experience through digital channels is somewhat more susceptible to individual-level characteristics. This is consistent with the broader

argument in the literature that RI and eWOM, despite both being loyalty indicators, are activated through partially distinct psychological pathways (Serra-Cantalops et al., 2020).

Taken together, the results for H_{1a} through H_{1f} provide only partial support for H_1 . Socio-demographic characteristics introduce significant differentiation exclusively in eWOM intention (H_{1d} and H_{1f}), while revisit intention remains statistically invariant across all three variables. H_1 is therefore partially supported, with the effect confined to one of the two loyalty outcomes examined.

Conclusion

This study examined whether gender, age, and education level differentiate revisit intention and positive electronic word-of-mouth (eWOM) intention among guests of four-star hotels in Serbia. The primary empirical finding is an asymmetry between the two loyalty outcomes: revisit intention remained consistent across all three socio-demographic variables, whereas positive eWOM demonstrated selective, though modest, sensitivity to gender and education level. Male guests and those with Bachelor/Higher qualifications reported slightly higher eWOM intentions than female guests and postgraduate respondents, respectively. Although these differences were statistically significant, they accounted for only 2-3% of the variance in eWOM, highlighting the limited explanatory power of socio-demographic characteristics as standalone predictors.

Although most of the tested hypotheses were not supported, the findings carry practical relevance precisely because of what they do not show: socio-demographic characteristics alone are insufficient to explain differences in guest loyalty among four-star hotel guests in Serbia. The practical implications are twofold. First, the absence of significant age, gender, and education effects on revisit intention suggests that the propensity to return is broadly uniform across demographic groups. This points toward other factors, most plausibly service quality and customer satisfaction as the primary drivers of repeat visitation. It indicates that investment in consistent service delivery is likely a more effective retention strategy than demographic-targeted programming: a direction that warrants direct empirical investigation in future research. Second, the selective gender and education effects on eWOM, though small in magnitude, suggest that digital advocacy is somewhat more prevalent among male guests and those with Bachelor/Higher qualifications. Hotels seeking to strengthen their positive digital reputation could consider directing review generation efforts toward these segments (for example, through post-stay communication channels) while remaining aware that socio-demographic targeting alone is unlikely to be sufficient without an underlying foundation of service quality that motivates guests to share positive experiences in the first place.

However, several limitations should be noted. The sample was constructed using non-probability methods, resulting in overrepresentation of younger, female, and urban respondents, which limits generalisability. Additionally, the study is geographically confined to Serbia, and findings may not apply to other cultural or regulatory contexts. Future research would benefit from larger, probability-based samples drawn across multiple Central and Eastern European markets, as well as from moderated mediation analyses that

simultaneously model the roles of service quality, satisfaction, and socio-demographic characteristics in shaping revisit intention and eWOM. Future research could also shift attention from age as a demographic label to the ways in which specific service quality attributes are evaluated across age groups. Evidence from Wuest et al. (1996) indicates that mature hotel guests in the United States prioritised assurance and reliability above all other service dimensions. Although this evidence derives from a US sample and may not translate directly to the Serbian context, it nevertheless suggests that age shapes attribute-level evaluations without necessarily differentiating downstream behavioural intentions. Whether comparable attribute-level priorities exist among guests of four-star hotels in Serbia, and whether such priorities propagate into differential revisit and eWOM intentions once satisfaction is controlled for, remains an open empirical question.

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The Impact of Modern Technologies and Methods on the Management of Key Logistics Activities

Утицај модерних технологија и метода на управљање
кључним логистичким активностима

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Abstract

Purpose: This paper examines the impact of modern technologies and methods on the management of key logistics activities, with a particular focus on warehousing and transportation. The aim is to assess how innovative logistics solutions contribute to improving the speed, efficiency, safety, and sustainability of logistics operations.

Methodology: The study is based on a review of relevant academic and professional literature, supported by case studies of leading global companies, including Amazon, Alibaba, JD.com, Walmart, DHL, UPS, IKEA, and Alphabet. The analysis covers modern warehousing and transportation technologies, including robotics, automation, artificial intelligence, drones, and Hyperloop solutions.

Findings: The findings indicate that the adoption of modern logistics technologies significantly improves operational efficiency, reduces logistics costs, accelerates order processing and delivery, enhances warehouse space utilization, and contributes to more sustainable logistics systems. At the same time, successful implementation requires substantial initial investments, workforce upskilling, and organizational adaptation.

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Originality/value: The paper provides an integrated overview of the most important contemporary logistics technologies and methods by examining their practical implementation in leading global companies, highlighting their advantages, limitations, and implications for the future development of logistics systems.

Practical implications: The findings may assist logistics managers and decision-makers in selecting and implementing modern logistics solutions to improve competitiveness, service quality, and operational efficiency.

Limitations: The paper is based on a literature review and case study analysis rather than empirical research. Consequently, the conclusions represent a synthesis of existing knowledge and provide a foundation for future empirical studies.

Key words: storage, transportation, innovative technologies, drones, inventory.

JEL classification: L91, M11, O33

Сажетак

Циљ: Овај рад анализира утицај савремених технологија и метода на управљање кључним логистичким активностима, са посебним освртом на складиштење и транспорт. Циљ рада је да сагледа на који начин иновативна логистичка решења доприносе унапређењу брзине, ефикасности, безбедности и одрживости логистичких процеса.

Методологија: Истраживање је засновано на анализи релевантне научне и стручне литературе, као и студија случаја водећих светских компанија, укључујући Amazon, Alibaba, JD.com, Walmart, DHL, UPS, IKEA и Alphabet. Анализиране су савремене складишне и транспортне технологије, укључујући роботизацију, аутоматизацију, вештачку интелигенцију, дронове и Hyperloop концепт.

Резултати: Резултати указују да примена савремених логистичких технологија омогућава значајно повећање оперативне ефикасности, смањење логистичких трошкова, бржу обраду и испоруку робе, бољу искористиеност складишног простора и унапређење одрживости логистичких система. Истовремено, имплементација ових технологија захтева значајна почетна улагања, развој нових компетенција запослених и прилагођавање постојећих пословних процеса.

Оригиналност/вредност: Рад пружа обједињени преглед најзначајнијих савремених логистичких технологија и метода кроз анализу њихове практичне примене у водећим светским компанијама, указујући на њихове предности, ограничења и потенцијални утицај на будући развој логистичких система.

Практична примена: Резултати рада могу послужити менаџерима логистике и доносиоцима одлука као основа за избор и имплементацију савремених логистичких решења у циљу повећања конкурентности, унапређења квалитета услуге и смањења оперативних трошкова.

Ограничења истраживања: Рад се заснива на анализи постојеће литературе и доступних студија случаја, без спровођења емпијског истраживања, због чега закључци представљају синтезу постојећих сазнања и могу представљати основу за будућа емпијска истраживања.

Кључне речи: складиштење, транспорт, иновативне технологије, дронови, залихе.

ЈЕЛ класификација: L91, M11, O33

Introduction

Without the wide application of logistics activities such as storage and transportation, modern human life as we know it today would not be possible. In fact, most of the products we consume have been stored and transported at some point. Storage and transportation help overcome the time and space gap between production and consumption. In previous decades, the global logistics system was continually disrupted by geopolitical crises - such as the COVID-19 pandemic, the Russia-Ukraine war, and the conflict between Israel and Iran - which caused significant delays and spiked transportation costs (Nuševa et al., 2023). However, advancements in methods and technology facilitate the navigation of logistical challenges and contribute to reduced costs. Innovative stock replenishment methods,

advanced storage solutions, and modern transport concepts - such as drones and hyperloop capsules – offer significant advantages. These include lower storage and transportation costs, faster replenishment times, faster transportation, safer storage and transportation, and more environmentally sustainable logistics operations.

The first chapter of the paper, titled "Modern Understanding of Storage and Transport", begins by elaborating on the basic principles of storage, such as fundamental stock replenishment models and optimal storage space arrangement. The second part explains the basic modes of transport, covering their common uses, advantages, and disadvantages. The second chapter of the paper titled "Innovative Technologies and Methods of Optimization of Storage and Transport" explains innovative solutions that have been practically applied by companies from different categories such as online trading companies, brick-and-mortar trading companies, large logistics companies and certain global manufacturers of durable consumer goods. In this way, the authors intended to highlight the impacts of implementing modern storage and transport solutions. Specifically, they aimed to define the current standing of modern logistics systems and predict their future development. The aim of this paper is to assess the current state of the modern logistics system and analyze how modern logistics solutions impact service speed, cost, and sustainability, ultimately highlighting proven best practices.

1. Literature Review

The optimization of storage and transport activities is a subject of growing interest among researchers. In recent years, there has been a steady increase in scientific articles addressing optimization of inventory replenishment, warehouse space, and transportation. Seothan states that optimizing warehouse layouts is critical for improving fulfillment efficiency, particularly as e-commerce demand continues to grow. His paper analyzes case studies of successful warehouse optimizations to demonstrate how strategic warehouse design not only improves operational efficiency but also enhances customer satisfaction (Seothan, 2025). Authors such as Ibrahim Mohamud and Abdul Kafi have also analyzed "the role of warehouse layout and operations in warehouse efficiency" aiming to investigate how these attributes affect warehouse efficiency (Mohamud et al., 2023). Then, when it comes to new warehouse technologies, Halawa & Daoud examined the impact of Real Time Location System (RTLS) on the warehouse safety and operational efficiency using data from a US warehouse (Halawa et al., 2020). Mabotja researched the need for automation and robotization in South African steel manufacturing firms. Mabotja emphasized that the enhancement of warehouse operations, particularly through the adoption of formal picking methods, could markedly diminish operational inefficiencies and elevate customer satisfaction (Mabotja, 2025).

Many authors examined technology influence on efficiency through case studies of largest retail companies. Li carried out research on application of AI in Amazon warehouse management. Author concluded that "by leveraging AI algorithms for demand forecasting, inventory optimization, and transportation planning, Amazon has improved efficiency,

reduced costs, and increased customer satisfaction" (Li, 2024). Goyal examined the impact of Enterprise Resource Planning (ERP) systems on operational efficiency at Amazon. He aimed to understand ERP's role in Amazon's supply chain and logistics by analyzing its impact on key performance indicators such as cost reduction, order accuracy, and process automation in order to identify potential best practices (Goyal, 2025). In addition, Cao's research focused on optimizing logistics cost management of JD.com. He utilized charts to break down JD.com's logistics costs and identify areas of inefficiency (Cao, 2025). Additionally, numerous other papers examine warehouse and transport technologies. In recent years, many of them have examined the implementation of drone and hyperloop technologies. Doppelbauer (2025) examined the potential of hyperloop tubes for commercial transportation, highlighting their ability to reduce both travel time and costs. However, there are few specific scientific papers that directly compare different warehouse and transportation practices across retail and logistics companies. In the sense that this paper does. Therefore, the authors hope this research will help fill this existing gap.

2. Modern understanding of storage and transport

In modern economic theory, logistics activities are considered as inevitable, which must be undertaken in order to overcome the temporal (storage) and spatial (transport) divergence of production and consumption. Since the time and place of production rarely align with those of consumption, logistics is an absolute necessity. However, modern storage and transportation technologies bridge this gap. For example, the widely known "just-in-time" procurement concept allows companies to drastically reduce warehousing as a logistics activity. Developed by Toyota and applied today by Dell, this concept aims to operate without keeping excess stockpiles of inputs (materials, parts, etc.) and outputs (goods, finished products). Ultimately, JIT minimizes inventory holding costs, improves product quality, increases flexibility, and strengthens relationships with suppliers (Ferrer, 2025).

However, the implementation of this concept is demanding. It requires complete data synchronization between the manufacturing plant and input suppliers, with instantaneous updates. Therefore, choosing an adequate ERP system is essential for success. Critics of the "just-in-time" concept state that while the strategy works well for high-value or highly specific products like cars or computers - where consumers are willing to wait – it is nearly impossible to apply to the massive volume of Fast-moving consumer goods (FMCG).

2.1. Modern understanding of storage

Warehousing as a logistics activity includes the design of the physical warehouse and the choice of replenishment methods. Rob O'Byrne believes that any warehouse should be designed to meet the four principles of flow, availability, capacity, and traceability (O'Byrne, 2025). Effective flow allows products to move easily and quickly through the warehouse, which is why many theorists believe a one-way flow is the most efficient design. Availability means easy access to products inside the warehouse with easy maneuvering of forklifts and other storage equipment. Capacity refers to the maximum

utilization of warehouse space, while traceability refers to the ability to physically track products in the warehouse in real time. The choice of inventory (replenishment) method usually boils down to choosing between periodic and continuous inventory systems. Under the periodic method, orders are placed at fixed time intervals. The order size is calculated by taking the difference between the amount of product already in inventory and sales from the previous period. ERP in this sense plays a key role by providing these two data. Using a periodic inventory replenishment system, the company restocks its inventory at set intervals (e.g., weekly, monthly, yearly). A continuous inventory replenishment system, on the other hand, utilizes a determined stock threshold to automatically trigger purchase orders (Božić & Aćimović, 2016).

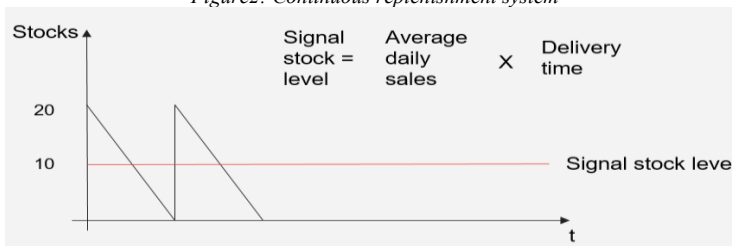
Figure1: Example of a periodic replenishment system

Periodic stock replenishment system									
Maximum	20	20	20	20	20	25	25	20	20
Current stocks	5	7	10	0	0	23	21	5	10
	Tuesday	Tuesday	Tuesday	Tuesday	Tuesday	Tuesday	Tuesday	Tuesday	Tuesday
Next order	15	13	10	20	25	2	0	15	10

Source: Authors

Figure 1 shows an example of a periodic replenishment system. In this case, the warehouse generates a new order every Tuesday up to the level of 20 units of the product. The quantity of 20 units is obtained based on the historical sales data of the given product. In other words, the potential software would, based on sales from the previous period, determine the level to which the inventory will be replenished. In this case, sales in previous periods were close to, but never exceeded, 20 units. However, on the fourth and fifth Tuesdays, sales reached exactly 20 units, and actual demand likely would have been higher had the product been available in stock. Consequently, a new benchmark of 25 units was set for subsequent periods. A well-designed ERP system should detect such demand fluctuations and respond proactively.

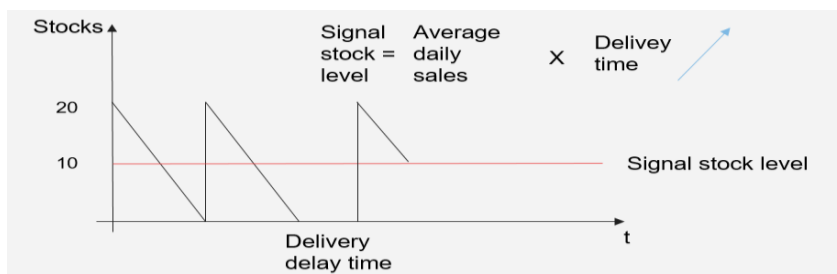
Figure2: Continuous replenishment system



Source: Authors

Figure 2 shows a model of a continuous stock replenishment system. In this model, inventory depletes from a certain initial level (this level is not fixed, but the volume of the order is) over time until it reaches the signal level of stock replenishment. In this case, the level is set at 10 units of the product based on average daily product sales and the time (number of days) for which the supplier can deliver a new quantity of the product. In this case, the ERP system would determine the signal level of inventory by calculating the average daily product sales (or material consumption if it is a matter of production), while the data on the required delivery time of the product (or material) would be manually stored in the software database.

Figure3: Effect of delivery delay on the continuous replenishment model



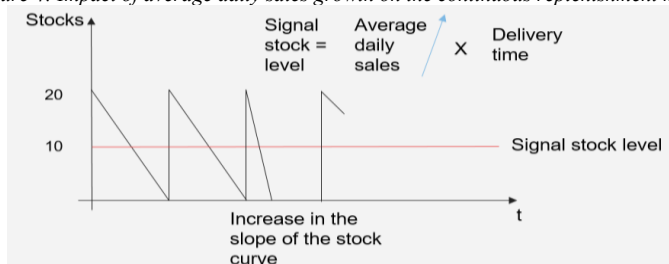
Source: Authors

Figure 3 shows a situation where a supplier of a product or material is late in delivery. Let's take for example the situation where the stock signal level is obtained as follows:

$$\text{Signal stock level (10)} = \text{Average daily sales (5)} \times \text{Delivery time (2)}$$

In this case, a supplier delay of just one day would mean missed sales of 5 units of product (or missed production of 5 units of product in the case of manufacturing). The software can react in this case by moving the stock signal level to a higher level, for example 15 units or by specifying a larger order volume (the order volume is fixed only in the short term).

Figure 4: Impact of average daily sales growth on the continuous replenishment model



Source: Authors

Figure 4 shows a situation where average daily sales increase significantly between two delivery periods. If the signal level of the stock was obtained in the previously mentioned way ($10=5X2$), and the average daily sales increased to 10 units of the product in the meantime, then the company is completely out of stock on the first day following the last delivery. Since the company operates for a whole day without inventory, it realizes a missed sale of 10 units of the product.

Significant changes in sales can be influenced by numerous factors, such as advertising campaigns, new trends, changing consumer tastes, and fads. Sometimes these shifts are predictable, but at other times, they are completely unpredictable (e.g., COVID-19 pandemic). Therefore, a company should maintain a certain level of safety stock to prevent such situations. To act more proactively, advanced software solutions can predict consumer trends. For example, the software could anticipate higher demand for canned and frozen fish during fasting days and suggest larger orders of these products. Naturally, this type of prediction requires additional master data that must be entered into the software. On the other hand, the sales are affected by a huge number of factors simultaneously in different directions and with different strength, which makes predictions of this type quite complex. It is impossible to account for every variable. For instance, the majority of residents in our supply areas may not be religious.

2.2. A modern understanding of transport

"Most economic processes, from going to work, through the delivery of raw materials and energy, to the delivery of finished products to customers, are directly related to transport. Transport plays an irreplaceable role in the social sphere. It allows people to meet, communicate and exchange ideas" (Dostal & Adamec, 2015).

The company's transport decisions depend primarily on the type of goods being transported. Table 1 shows the specific characteristics of certain types of transport, detailing the common use, advantages and disadvantages of each.

Table 1: Comparison of the specificities of individual types of transport

Type of transport	Common use	Advantages	Disadvantages
Road	Door to door shipping. Ideal for mixed loads. It is usually used for the first and last stages of transport.	The most flexible form of transport. Relatively cheap.	Limited to continental transport. Subject to traffic, customs and other delays.
Rail	Domestic, continental and intercontinental transportation.	Ideal for mass transport over long distances. Cheaper than air and road transport.	Potentially inflexible routes with limited availability of certain destinations.
Air	Fast transport over long distances.	Fast and safe.	Expensive. Restrictions on weight and size of cargo.

Maritime	Transportation of bulk and heavy cargo. Transportation of cargo that suffers from long delivery times.	Highly standardized shipping containers. Cheaper than air and road transport.	Inflexible routes. Long delivery time. Inflexible shipping times (ships will not wait for missing containers).
Pipeline	Transfer of liquid and gaseous cargo over long distances.	The possibility of transporting basic energy raw materials (oil and gas) to remote locations.	Infrastructure requires constant maintenance. Risks of leaks and endangering the environment. Susceptible to sabotage and terrorism.

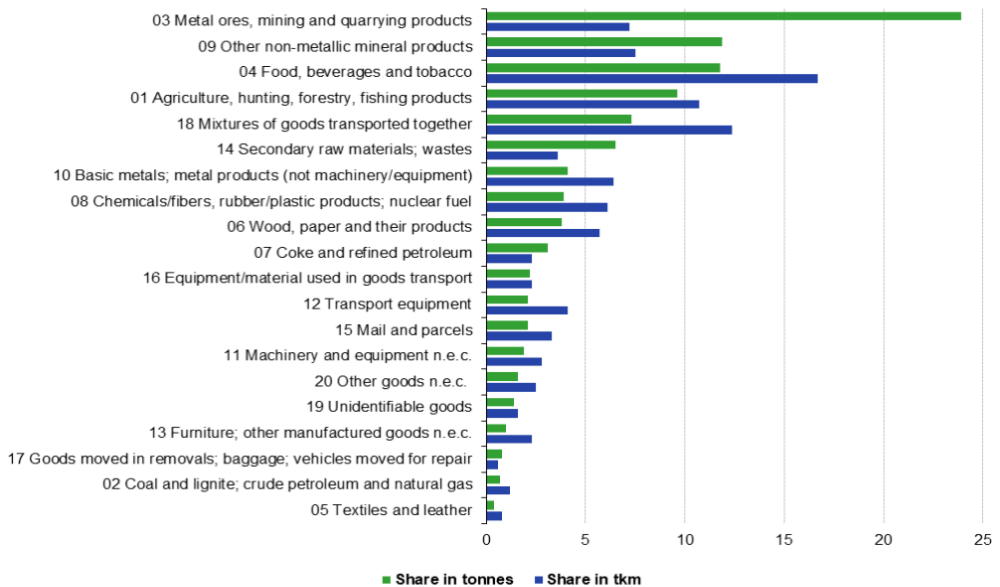
Source: Ivanov & Schonberger, 2017.

These 5 modes of transport are considered traditional and form the basis for transporting most goods. However, a wide array of alternative transportation modes are currently under development, such as drones, hyperloop tubes, and magnetic trains. Some companies, like SpaceX, are considering the possibility of space transport to move goods and people via rockets between different cities on Earth.

According to data from the European Commission for Mobility and Transport, the total number of tkm achieved by all modes of transport in 2020 was 3.76 trillion tkm. European Commission data refer to transport between member states and do not include transport from member states to non-EU countries. The share of road transport was the largest and amounted to 49.9% of all realized tkm, which testifies to the mutual continental connection of these countries and the developed road infrastructure of these countries. Maritime transport had a share of 31.7%, railway 11.1%, river 4.2%, pipeline 3.0%, while air transport had a share of only 0.1% of the total number of tkm (European Commission: Mobility and Transport, 2021).

According to data from the European Commission, the transport and services sector employs 14.2 million people, which is a share of 5.6% of the total number of employees in the Union. The largest share of employees is in land transport with a share of 50% (road, rail and pipeline transport), 2% are employed in air transport, while 5% are employed in maritime and river transport. About 28% of employees are employed in storage and auxiliary transport jobs (loading, unloading, etc.), while the other 16% work in postal and courier companies (European Commission: Mobility and Transport, 2023).

Figure5: The share of certain categories of goods in the transport of the European Union in 2023



Source: Eurostat, 2024.

Figure 5 shows that, in EU transport, the most dominant categories by share of total transported tonnage are "Metal ores, mining and quarrying products", "Other non-metallic mineral products", and "Food, beverages and tobacco". However, when it comes to the share in the total number of tkm, the categories "Food, beverages and tobacco", "Mixtures of goods transported together" and "Agriculture, hunting, forestry, fishing products" dominate. According to Eurostat data, about 1.5 billion tons of food, beverages and tobacco, 127 million tons of furniture and 50.9 tons of textile and leather products were transported in 2023.

3. Innovative technologies and methods of optimization of storage and transport

With the growth of e-commerce - especially since the COVID-19 pandemic - storage and transport systems are evolving rapidly. Global trade and distribution giants like Amazon are implementing a high degree of robotization and automation in their warehouse systems.

For example, Amazon's new distribution center in Shreveport, Louisiana is powered by eight interconnected robotic systems (Greenawalt, 2025). Amazon's "Sequoia" system uses AI and computer vision systems to consolidate inventory and free up warehouse space, thereby facilitating faster order transactions closer to customers. According to some estimates, Sequoia allows Amazon to process orders as much as 75% faster. This system

uses robots that transport supplies to employees directly at their workplace in the area between the thighs and chest, thus avoiding the need for the employee to crouch or stand up to reach the product for delivery. According to estimates, this reduces employee injuries by 15% compared to non-robotized warehouses. "Sequoia" uses robots named "Hercules" and "Titan". "Hercules" transports shelves with products weighing about 567 kg (1250 pounds), while itself weighs about 136 kg (300 pounds). "Titan" robots have twice the capacity and are used to transport bulky products such as home appliances or entire pallets of food. In addition to these, Amazon's warehouses also use the so-called "Vulcan pick", Amazon's first touch-sensitive robot with integrated artificial intelligence. This robot easily manipulates products on warehouse shelves and can pick products from the highest and lowest shelf levels. The "Vulcan pick" has been in official use since 2025 and was originally implemented in Germany. "Sparrow," another Amazon robotic system, supports employees who pack items for customer orders. "Sparrow" collects items from the shelves into special boxes that employees will use when packing orders for consumers. After the robot system "Sparrow" delivers the products to the employees, the employees use automatic packaging technology. Automatic packaging enables extremely precise packaging of orders regarding product dimensions, in this way the consumption of packaging material is precisely measured. The automatic packaging system was first launched in Ohio in 2023 and has the capacity to pack up to several hundred thousand orders per week. The system originally made packages from plastic materials, and later that practice was replaced by paper packages in order to implement sustainability factors in distribution. "Robin", Amazon's robotic system introduced in 2022 in Florida, picks up packages and moves them on toward the shipping dock. The entire process is completed by the "Cardinal" and "Proteus" robotic systems. "Cardinal" picks up packages shipped by "Robin" and gently lowers them onto shipping carts that "Proteus" will ship to trucks and other delivery vehicles. Estimates are that the entire robotic system of Amazon will increase the productivity of Amazon's "fulfillment centers" by up to 25%. The introduction of Amazon's robotic systems is not intended to replace employees, but to provide additional support to employees in their daily activities (Greenawalt, 2025).

After Amazon, numerous trade and logistics companies started automating and robotizing their warehouses. Cainiao Network, "Alibaba's" company for optimizing logistics processes, presented a new warehouse concept by opening a fully automated customs warehouse in Hangzhou. This warehouse is supported by autonomous mobile robots ("AMRs") similar to those used by Amazon (such as the "Hercules" and "Titan" robots). In addition to robots, the automation of the storage processes of this warehouse includes a central warehouse management system ("WMS") as well as autonomously guided vehicles ("AGVs"). The technology of this warehouse is especially important during holidays like "Double 11" when additional warehouse efforts are needed in order to process orders (Baker, 2022).

JD.com, another Chinese giant, launched the "Asia No.1" initiative in the first half of the last decade to automate its warehouses in cities, such as Shanghai, Guangzhou, Wuhan and Shenyang. Initially, in early 2018, a warehouse was built in Shanghai with about 200,000 m² of storage space, fully automated when it comes to the stages of

receiving, storing, sorting and packing orders. The warehouse order processing system uses technology such as artificial intelligence, cloud computing, sensitive sensors, transfer robots, automatic packaging machines and others. This warehouse has the ability to process up to 16,000 orders per hour, with an accuracy of 99.99% (JD.com, 2014). In 2024, JD.com initiated a new project named "Zhilang GTP System" and implemented it at Beijing Airport Garment Warehouse. This warehouse covers 2,500 m² of storage space and adopts an integrated modular solution for storage and data collection. The "Zhilang" project was supposed to respond to challenges such as optimization of warehouse space, labor costs and variety of storage units (known as SKU - Stock Keeping Unit). The warehouse is equipped with 7,700 storage containers, supports high storage density and flexible assortment management, which enables a quick return on investment (less than 2 years). The main advantage of this type of warehouse is higher productivity, which is supported by 45 "Zhilang" robots as well as 38 workstations designed for human-robot collaboration. In addition to productivity, this type of warehouse achieves a better optimization of storage space through superior vertical storage solutions that enable up to 2.5 times better compaction of products in the warehouse compared to traditional storage methods. All this contributes to the reduction of storage operational costs and a better flow of products through the warehouse, which results in a higher and faster ROI (Zhang, 2025).

Even brick-and-mortar chains like Walmart are not far behind e-commerce retailers in terms of new warehouse and transport technologies. Walmart has automated a large number of its US warehouses over the past 2 years. A product warehouse in Brooksville, Florida, stands out as an example. In this warehouse, which has been operating since 1991, most of the processes, such as receiving pallets from trucks, were carried out using manual forklifts. Today, this procedure has been completely replaced by automatic robotic forklifts that are controlled remotely. All other processes, such as sorting products, stacking products on warehouse shelves, packing products on pallets for delivery, stretch-wrapping, and loading pallets onto shipping trucks, are also automated. During this process, Walmart made efforts to retain most of the workers who were employed in the warehouse before automation, as evidenced by the fact that out of several tens of thousands of employees, only a few hundred left after the automation process. Most of the employees were offered a certain type of improvement of technical skills in order to adapt to new work positions (through a six-week training). However, employees' perceptions when comparing their old, more manual job with the new one, more mentally demanding job, differ from case to case. Some employees believe that their new job develops their mental skills and benefits them physically. Because they are less exhausted after work, they feel they can spend more quality time with their families. On the other hand, some employees stated that they liked the simplicity of their previous job more and that it allowed them more regular physical activity, which they now have to compensate for in other ways. About 900 employees said they were skeptical about the transition that had taken place in their warehouse, while some even said they were afraid of new technologies and new roles (Gray, 2024).

Some logistics companies, like the German DHL, have also implemented these technologies. DHL is implementing "Edge AI" technology, which includes smart

warehouses with AI-powered robots and autonomous vehicles. "Edge AI" technology enables data analysis at the point of origin without relying on cloud servers. In other words, instead of sending data to a remote server, "Edge AI" enables instant data analysis on a specific device. Some of the advantages of this technology include optimized warehouse automation, as robots and autonomous vehicles can process data on-site to reduce inefficiencies in warehouse operations (such as collision avoidance, unnecessary robot movements, etc.), as well as improved cargo monitoring, since sensors that track temperature, humidity, and vibration levels can detect changes that may affect perishable products or equipment. By processing all this data locally, DHL employees can react promptly and proactively without waiting for analysis from the cloud system. A similar technology called "SenseAware" is used by the company "FedEx". "SenseAware" is an advanced IoT system for tracking sensitive shipments especially used to track Covid-19 vaccines during the pandemic. The system monitors the temperature, location and environmental conditions of these shipments and sends this data for processing every two seconds. The main advantage of technologies like "Edge AI" and "SenseAware" is reduced latency, i.e. the time between data collection and the corresponding reaction based on that data (Embedur.ai, 2025).

In addition to giant electronic retailers, large retail chains, and large logistics companies, new technologies in storage and transportation are also being adopted by manufacturers of durable consumer goods. A good example is IKEA, which implemented robotic technology in its warehouse in Zagreb in order to optimize the process. IKEA's small radio-controlled robots for picking up containers loaded with products can store 4 times more products in the same space compared to normal IKEA storage racks. These robots are also energy efficient - for example, ten of these robots consume the same amount of energy as a standard vacuum cleaner (Ingka.com, 2021).

Table 2: Presentation of innovative warehouse and transportation solutions of some of the largest global companies

Company	Key warehouse and transport innovations
Amazon	Robotics, drones, Sidewalk IoT
Walmart	Symbolic robotics, AI, drone delivery
IKEA	AS/RS, urban fulfillment, circular logistics
DHL	AMRs, digital twins, green warehousing
Alibaba	Cainiao AI, blockchain
Target	Store hubs, sortation centers
Maersk	Smart containers, digital logistics
Nike	RFID, green fulfillment
McDonald's	AI forecasting, kitchen robotics

Source: Authors from available data

An increasing number of companies use drones to deliver lighter packages over short or medium-long distances. Commercial drones are capable of transporting packages weighing up to about 2.7 kg at distances of no more than 16 km. Wing, which is owned by Alphabet (Google), has so far made 100,000 drone deliveries in the city of Logan, Australia, carrying food, medicine, coffee, etc. In addition to Wing, companies like Walmart,

Amazon, UPS, and Walgreens (which is one of the largest pharmacy retail chains), stand out in drone technology. Amazon Prime Air says it has developed advanced drones that can transport shipments weighing up to 5kg over distances of up to 30km in less than 30 minutes. In this way, even 75% of all Amazon shipments can be transported by drones. Some experts in this field believe that by using drones for the final delivery of packages to consumers, transportation costs would be significantly reduced from about 6 USD for standard delivery methods to about 0.05 USD for delivery by drones (Interestingengineering.com, 2025).

According to experts, drones may be assisted by artificial intelligence in the future; however, such applications are currently restricted to automated acrobatics using drones in the sky at various events. Artificial intelligence would be a potential solution to numerous problems that have already appeared in practice during the commercial use of drones. For example, Alphabet had problems with drone deliveries in Canberra, Australia, as the drones were constantly attacked by crows and other birds. Also, in the early stages of using drones, some companies faced problems with landing drones, as some drones did not distinguish between the water surface of a swimming pool and a solid surface like a lawn. Also, some drones have mixed dogs with people, making delivery more risky, these and similar issues have been cited by Amazon (Interestingengineering.com, 2025). Of course, practice is full of examples of drones hitting electrical infrastructure, poles, trees, and even glass buildings. A good part of these problems could be overcome by the use of artificial intelligence. A drone could use AI to estimate wind speeds, compare them against permitted limits, and proactively assess delivery safety.

Thus, although the potential benefits of drone delivery are great, some consumers have expressed concern about having orders delivered via drones due to fears of product damage, on the one hand, and hacking attacks on the other. Drones are often highlighted as a delivery method due to several advantages, including reduced road congestion and avoidance of urban traffic, a positive environmental impact through lower CO₂ and gas emissions, shorter delivery times (typically under 30 minutes), and a lower risk of package damage (Interestingengineering.com, 2025). In other words, the positive effects of drone delivery are most recognized in megacities, where cross-city travel has become a multi-hour challenge. Nevertheless, it is in large urban areas where drones face the greatest risks, due to the dense concentration of buildings, antennas, and telecommunications infrastructure. When it comes to delivering orders over longer distances, companies like "Zipline" and "Swoop Aero" can serve as representative examples. Since 2020, these companies have been using drones to deliver medicines, vaccines and bags filled with blood to more remote places that do not have a developed road infrastructure. The impact of the "Zipline" project in Rwanda has helped to completely transform the health system in terms of the number of patients whose treatment has been facilitated with the help of drug delivery via drones (Ackerman & Koziol, 2019).

Table 3: Number of commercial drone deliveries from 2018 to 2023

Year	Number of commercial drone deliveries
2018	6.000
2019	34.000
2020	164.000
2021	507.000
2022	874.000
2023	1.044.000

Source: Drones.r.Africa, 2024.

When it comes to drone deliveries, Asia, Africa, and South America stand out as the leading regions by sheer volume of packages delivered. The vast majority of these deliveries were for medical supplies (medicines, vaccines, etc.), FMC products from retail stores, and food from restaurants and cafes, respectively.

Another type of modern transport that is more in the stage of invention rather than innovation is "hyperloop" transport. Hyperloop capsules represent a technology that uses magnetic levitation together with air pressure in order to achieve revolutionary speeds when it comes to transportation. It is estimated that people and goods could be transported in these capsules at speeds of up to 700 miles per hour (1127 km/h). In that case, this transport technology would directly compete with high-speed rail and high-speed air transport, since high-speed rail transport almost never exceeds a speed of 500 km/h (400 km/h in ideal conditions), while commercial flights move at speeds in the range of 885 to 965 km/h. In addition to speed, this type of transport offers several major advantages. First, it completely avoids traffic congestion typical of highways. Second, it alters long-distance cost dynamics, significantly reducing the price per kilometer traveled. Third, it improves safety by operating in an extremely controlled environment free from obstacles and other vehicles. Finally, it is highly energy-efficient because it relies on renewable rather than non-renewable energy sources. The main disadvantage of this type of transport is the limited capacity of passengers and products that can be transported in a single trip. This disadvantage is particularly evident when compared to rail or air transport (Novatr.com, 2023).

A significant number of companies have already started developing Hyperloop projects. The Canadian company TransPod has begun designing Hyperloop tubes that would connect Toronto and Montreal, emphasizing that this mode of transportation would be cheaper, faster, and more sustainable compared to alternatives. For comparison, the company estimated that such a journey would take 45 minutes, highlighting that it currently takes up to 4 hours by plane to cover the same distance (Novatr.com, 2023).

Dr. Josef Doppelbauer, one of the leading researchers on this topic, defines "hyperloop" as "horizontal elevator, with acceleration like a rocket, but without intermediary stops" (Doppelbauer, 2025). In his paper, Dr. Josef cites some intercity routes with estimated transportation times using this new technology as examples of the effectiveness of this technology.

Table 4: Time required for the transport of people and products between certain city routes

Routes	Distance (km)	Time spent in transport (min.)
Bratislava – Vienna	55	5
Dubai – Abu Dhabi	130	9
Helsinki – Stockholm	400	22
Los Angeles – San Francisco	560	30

Source: Doppelbauer, 2025.

The development of "hyperloop" transport technology was initiated by many companies, including "Boring Company", "Virgin hyperloop", "HyperloopTT", the mentioned "TransPod", "Zeleros Hyperloop", "DP World", "Hardt Hyperloop", "DGW Hyperloop" and many others. Led by "DP World" in cooperation with "Virgin Hyperloop", the project aims to build a "hyperloop" system to connect Dubai and Abu Dhabi, with an estimated speed of about 1000 km/h. In cooperation, these two companies carried out the world's first transport of people in the "hyperloop" system at a distance of only 500 meters (Novatr.com, 2023). However, "hyperloop" technology is only in the initial testing phase, and it will take some time before this technology can safely and efficiently transport passengers and products.

Conclusion

By analyzing the logistics practices of the largest trade and logistics companies in the world, we gain insight into the most modern trends in storage and transportation. Robotization and warehouse automation, like that implemented by Amazon or JD.com, will become imperative for the rest of the industry as competitiveness is now built on technology. Will automation and robotization displace labor from warehouse activities?

The answer to this question is both yes and no. A forklift driver as an occupation will probably disappear along with other related jobs, but practice has so far proven that technology almost always creates new jobs. Technologies such as drones or "hyperloop" capsules represent a revolution in transportation, especially in the field of transportation speed, but also in the fields of safety and sustainability. Initial investments in such systems are large and for now belong to the domain of venture capital, but the benefits of successful implementation of these systems are potentially enormous.

New storage systems will enable prevention of shortages, reduction of unnecessary stocks, reduction of breakages and other defects and storage incidents. New transportation systems enable less traffic congestion, less emissions of harmful gases and more efficient transportation. In recent years, there has been a fierce race to implement these solutions, because one thing is clear: a company that succeeds in doing so secures a significant competitive advantage that will be hard to match.

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Ljubojević, T.K. (2000a).
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Strakić, F., Mirković, D., Boškov, T., Ljubojević, K., Tanasijević, V., Dimitrijević, M., et al. (2003). Metadata in data warehouse. *Strategic Management*, 11, 122-132.

➔ **Magazine article**

Strakić, F. (2005, October 15). Remembering users with cookies. *IT Review*, 130, 20-21.

➔ **Newsletter article with author**

Dimitrijević, M. (2009, September). MySQL server, writing library files. *Computing News*, 57, 10-12.

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VBScript with active server pages. (2009, September). *Computing News*, 57, 21-22.

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Dimitrijević, M. (2007). *Customer relationship management* (6th ed.). Subotica: Faculty of Economics.

➡ **Book, two authors**

Ljubojević, K., Dimitrijević, M. (2007). *The enterprise knowledge portal and its architecture*. Subotica: Faculty of Economics.

➡ **Book, three to six authors**

Ljubojević, K., Dimitrijević, M., Mirković, D., Tanasijević, V., & Perić, O. (2006). *Importance of software testing*. Subotica: Faculty of Economics.

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Mirković, D., Tanasijević, V., Perić, O., Jovanov, N., Boškov, T., Strakić, F., et al. (2007). *Supply chain management*. Subotica: Faculty of Economics.

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Web user interface (10th ed.). (2003). Subotica: Faculty of Economics.

➡ **Group, corporate, or government author**

Statistical office of the Republic of Serbia. (1978). *Statistical abstract of the Republic of Serbia*. Belgrade: Ministry of community and social services.

➡ **Edited book**

Dimitrijević, M., & Tanasijević, V. (Eds.). (2004). *Data warehouse architecture*. Subotica: Faculty of Economics.

➡ **Chapter in an edited book**

Boškov, T., & Strakić, F. (2008). Bridging the gap: Complex adaptive knowledge management. In T. Boškov & V. Tanasijević (Eds.), *The enterprise knowledge portal and its architecture* (pp. 55-89). Subotica: Faculty of Economics.

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Mirković, D. (2006). History and the world of mathematicians. In *The new mathematics encyclopedia* (Vol. 56, pp. 23-45). Subotica: Faculty of Economics.

C. Unpublished Works

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Ljubojević, K., Tanasijević, V., Dimitrijević, M. (2003). *Designing a web form without tables*. Paper presented at the annual meeting of the Serbian computer alliance, Beograd.

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Boškov, T., Strakić, F., Ljubojević, K., Dimitrijević, M., & Perić, O. (2007. May). *First steps in visual basic for applications*. Unpublished paper, Faculty of Economics Subotica, Subotica.

➔ Doctoral dissertation

Strakić, F. (2000). *Managing network services: Managing DNS servers*. Unpublished doctoral dissertation, Faculty of Economics Subotica, Subotica.

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Dimitrijević, M. (2003). *Structural modeling: Class and object diagrams*. Unpublished master's thesis, Faculty of Economics Subotica, Subotica.

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Faculty of Economics. (2008, March 5). *A new approach to CRM*. Retrieved July 25, 2008, from <http://www.ef.uns.ac.rs/papers/acrm.html>

➔ Article from an online periodical with DOI assigned

Jovanov, N., & Boškov, T. A PHP project test-driven end to end. *Management Information Systems*, 2(2), 45-54. doi: 10.1108/06070565717821898.

➔ Article from an online periodical without DOI assigned

Online journal articles without a DOI require a URL.

Author, A. A., & Author, B. B. (Publication date). Title of article. *Title of Journal, volume number*. Retrieved from <http://www.anyaddress.com/full/url/>

Jovanov, N., & Boškov, T. A PHP project test-driven end to end. *Management Information Systems*, 2(2), 45-54. Retrieved from <http://www.ef.uns.ac.rs/mis/TestDriven.html>.

2. Reference Quotations in the Text

➤ Quotations

If a work is directly quoted from, then the author, year of publication and the page reference (preceded by “p.”) must be included. The quotation is introduced with an introductory phrase including the author’s last name followed by publication date in parentheses.

According to Mirković (2001), “The use of data warehouses may be limited, especially if they contain confidential data” (p. 201).

Mirković (2001), found that “the use of data warehouses may be limited” (p. 201). What unexpected impact does this have on the range of availability?

If the author is not named in the introductory phrase, the author's last name, publication year, and the page number in parentheses must be placed at the end of the quotation, e.g.

He stated, “The use of data warehouses may be limited,” but he did not fully explain the possible impact (Mirković, 2001, p. 201).

➤ Summary or paraphrase

According to Mirković (1991), limitations on the use of databases can be external and software-based, or temporary and even discretion-based (p.201).

Limitations on the use of databases can be external and software-based, or temporary and even discretion-based (Mirković, 1991, p. 201).

➤ One author

Boškov (2005) compared the access range...

In an early study of access range (Boškov, 2005), it was found...

➤ When there are **two authors**, both names are always cited:

Another study (Mirković & Boškov, 2006) concluded that...

➤ If there are **three to five authors**, all authors must be cited the first time. For subsequent references, the first author’s name will cited, followed by “et al.”.

(Jovanov, Boškov, Perić, Boškov, & Strakić, 2004).

In subsequent citations, only the first author’s name is used, followed by “et al.” in the introductory phrase or in parentheses:

According to Jovanov et al. (2004), further occurrences of the phenomenon tend to receive a much wider media coverage.

Further occurrences of the phenomenon tend to receive a much wider media coverage (Jovanov et al., 2004).

In “et al.”, “et” is not followed by a full stop.

➤ Six or more authors

The first author's last name followed by "et al." is used in the introductory phrase or in parentheses:

Yossarian et al. (2004) argued that...

... not relevant (Yossarian et al., 2001).

➤ Unknown author

If the work does not have an author, the source is cited by its title in the introductory phrase, or the first 1-2 words are placed in the parentheses. Book and report titles must be italicized or underlined, while titles of articles and chapters are placed in quotation marks:

A similar survey was conducted on a number of organizations employing database managers ("Limiting database access", 2005).

If work (such as a newspaper editorial) has no author, the first few words of the title are cited, followed by the year:

("The Objectives of Access Delegation," 2007)

Note: In the rare cases when the word "Anonymous" is used for the author, it is treated as the author's name (Anonymous, 2008). The name Anonymous must then be used as the author in the reference list.

➤ Organization as an Author

If the author is an organization or a government agency, the organization must be mentioned in the introductory phrase or in the parenthetical citation the first time the source is cited:

According to the Statistical Office of the Republic of Serbia (1978), ...

Also, the full name of corporate authors must be listed in the first reference, with an abbreviation in brackets. The abbreviated name will then be used for subsequent references:

The overview is limited to towns with 10,000 inhabitants and up (Statistical Office of the Republic of Serbia [SORS], 1978).

The list does not include schools that were listed as closed down in the previous statistical overview (SORS, 1978).

➤ When citing **more than one reference from the same author**:

(Bezjak, 1999, 2002)

➤ When several **used works by the same author were published in the same year**, they must be cited adding a, b, c, and so on, to the publication date:

(Griffith, 2002a, 2002b, 2004)

➤ **Two or more works in the same parentheses**

When two or more works are cited parenthetically, they must be cited in the same order as they appear in the reference list, separated by a semicolon.

(Bezjak, 1999; Griffith, 2004)

➡ **Two or more works by the same author in the same year**

If two or more sources used in the submission were published by the same author in the same year, the entries in the reference list must be ordered using lower-case letters (a, b, c...) with the year. Lower-case letters will also be used with the year in the in-text citation as well:

Survey results published in Theissen (2004a) show that...

➡ **To credit an author for discovering a work**, when you have not read the original:

Bergson's research (as cited in Mirković & Boškov, 2006)...

Here, Mirković & Boškov (2006) will appear in the reference list, while Bergson will not.

➡ **When citing more than one author**, the authors must be listed alphabetically:

(Britten, 2001; Sturlasson, 2002; Wasserwandt, 1997)

➡ **When there is no publication date**:

(Hessenberg, n.d.)

➡ **Page numbers must always be given for quotations**:

(Mirković & Boškov, 2006, p.12)

Mirković & Boškov (2006, p. 12) propose the approach by which "the initial viewpoint...

➡ **Referring to a specific part of a work**:

(Theissen, 2004a, chap. 3)

(Keaton, 1997, pp. 85-94)

➡ **Personal communications, including interviews, letters, memos, e-mails, and telephone conversations**, are cited as below. (These are *not* included in the reference list.)

(K. Ljubojević, personal communication, May 5, 2008).

3. Footnotes and Endnotes

A few footnotes may be necessary when elaborating on an issue raised in the text, adding something that is in indirect connection, or providing supplementary technical information. Footnotes and endnotes are numbered with superscript Arabic numerals at the end of the sentence, like this.¹ Endnotes begin on a separate page, after the end of the text. However, journal **does not recommend the use of footnotes or endnotes**.



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