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Motto

New Horizons *in Economics* and Business

The aim of the conference is to promote innovations, support research, and enhance development as means of competitiveness of enterprises in the regional, national, and global environment.

Faculty of Economics, Technical University of Liberec

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Preface

It is with great pleasure that we present the proceedings of the Liberec Economic Forum 2025. Over the years, the Forum has become a recognized international platform for scholarly exchange and critical discussion in the fields of economics, business, and management. By convening researchers, practitioners, and policymakers, the Forum provides a setting in which theoretical developments and practical challenges can be examined in dialogue. The motto of this year's conference, *"New Horizons in Economics and Business,"* captures its underlying ambition: to broaden perspectives, stimulate innovation, and contribute to knowledge production that enhances competitiveness at regional, national, and global levels.

The principal aim of the conference is to advance innovation, support rigorous research, and foster development as a foundation of competitiveness. In the contemporary context, competitiveness is determined not solely by productivity and efficiency, but increasingly by processes of digital transformation, institutional adaptability to global challenges, and the pursuit of sustainable solutions. The contributions gathered in this volume reflect these priorities and illustrate their relevance across diverse domains of economic and business inquiry.

The breadth of topics addressed in the proceedings demonstrates the scope and dynamism of contemporary research. Several studies focus on education and human capital, such as comparative analyses of tertiary education financing in the Czech Republic and other EU countries, and investigations into the financial literacy of Generation Z with its implications for future economic participation. Research on human resource management in biotech and deep-tech startups, as well as examinations of labor market functions in sustaining pension systems, underscores the centrality of human capital to long-term competitiveness.

Digital transformation and the diffusion of new technologies constitute another major theme of the conference. Contributions examine the implementation of artificial intelligence tools in small enterprises, barriers to digital marketing in the Czech business environment, and the risks of digital marketing for aging populations. Additional studies analyze the adoption of new media, the role of visual content in online consumer decision-making, and the traffic sources of waste management websites, highlighting the transformative impact of digitalization on communication, marketing, and consumer behavior. Research on FinTech innovations and digital insurance ecosystems further emphasizes the profound reconfiguration of financial and business models by technological change.

The proceedings also devote sustained attention to entrepreneurship, innovation, and investment. Papers address the role of social entrepreneurship in promoting sustainable municipal development, the assessment of risks in startups, cross-country adoption patterns of crowdfunding, and bibliometric analyses of leadership approaches. Together, these contributions highlight the significance of entrepreneurship and innovative management practices for fostering economic growth and advancing societal well-being.

Sustainability and energy transformation form another salient focus of this volume. Studies investigate pathways toward decarbonization in business logistics through electromobility, challenges associated with the development of low-carbon energy sources in India, and the integration of sustainability into tourism products and municipal finance through accommodation fees. Further contributions address intangible assets in accounting systems, as well as the dynamics of inflation and purchasing power in both public and private sectors, thereby situating sustainability within broader financial and institutional contexts.

Finally, the proceedings illustrate the increasing diversification of economic research. Papers on esports as a domain of economic analysis, the regulation of sharing economy platforms, and the development of specialized tourism services in the Ötztal ski resort demonstrate the adaptability of economic inquiry to emergent sectors and societal transformations. These studies affirm that new horizons in economics and business are defined not only by established industries, but also by emerging phenomena, niche markets, and innovative practices.

On behalf of the organizing committee, we extend our sincere appreciation to all authors for their valuable contributions and their commitment to advancing research. We are likewise indebted to the reviewers, whose careful and constructive evaluations ensured the scholarly quality of the proceedings. Our gratitude is also directed to the keynote speakers, conference participants, institutional partners, and sponsors, whose engagement and support have been indispensable to the success of the Forum.

It is our conviction that the proceedings of the Liberec Economic Forum 2025 will serve not only as a record of the conference, but also as a lasting source of scholarly knowledge and intellectual inspiration. By engaging with themes such as education, digitalization, entrepreneurship, sustainability, finance, and societal transformation, this volume embodies the guiding idea of *“New Horizons in Economics and Business”* and contributes to shaping research agendas and practical applications in the years to come.

Liberec, September 2025

Mgr. Tereza Semerádová, Ph.D.
On behalf of the Organizing Committee

Table of Contents

Karina BENETTI, Azizjon BOBOJONOV, Katarina IZAKOVA, Mansur ESHOV Insurance as a Digital Ecosystem: Exploring New Horizons of Digitalization, Smart Business, and Global Competitiveness	11
Taniya CHOUDHURY, Marek FURMANKIEWICZ, Manu THOMAS Challenges in the Development of Low-Carbon Energy Sources in India.....	25
Petr DOUCEK, Milos MARYSKA Comparison of Tertiary Education Financing in the Czech Republic with Selected EU Countries	41
Martina HEDVICKAKOVA, Tereza KARLOVA The Role of the Labor Market in Ensuring the Sustainability of the Pension System.....	53
Martin JAKUBIK , Petra MARESOVA, Kamil KUCA Not Just About the Money: How Investors Evaluate Startup Risks	61
Irena JINDRICHOVSKA FinTech Innovations and Their Impact on Financial Inclusion in Central Europe: Evidence from Czechia	67
Ghulam KALSOOM, Rasa SMALIUKIENE, Roman ZAMECNIK Servant Leadership: Bibliometric Analysis and Future Agenda	79
Tomas KRTICKA, Ivan SOUKAL Structural Determinants of Crowdfunding Adoption Across Countries.....	95
Martin KUCHTA, Raduz DULA, Roman LACKO Traffic source investigation of waste management websites: implications for institutional communication	107
Ludek KUHR, Petr JANECEK Collection of local accommodation fee in municipalities in the Hradec Kralove Region, the Czech Republic	119
Olga MALIKOVA, Pedro Henrique SOUZA DIMARIO, Guilherme CORREA FERNANDES Trends in Recognition and Valuation of Intangible Assets from the Financial Accounting Perspective: A Comparative Study of the Czech and Brazilian Accounting Systems.....	133
Monika MUCSKOVA, Peter MICAK, Karel NEMECEK Generation Z and Financial Literacy: A Comparative Analysis of Generational Competencies	149

Seric NEVEN, HOLEDOVA Julie, TRIFKOVIC Jovana

Creation and Development of a Specialized Tourist Product Based on the Features of Attractiveness, Originality, Authenticity, and Relevance of Content 161

Anezka NOVAKOVA, Liuba TURCHYN

Current Digital Technologies and Their Impact on Marketing: Qualitative Analysis of the Czech Business Environment..... 175

Jana NUNVAROVA

Adoption of Artificial Intelligence Tools in Small Enterprises in the EU and the Czech Republic: Barriers, Opportunities and Implications for Marketing Strategies 195

Chinyere Chidera OKECHUKWU, Pavel BACHMANN

Digital Marketing Risks for Aging Populations: The Threat of Online Scams to Older Adults 207

Martin PETRICEK, Stepan CHALUPA

Regulation of the So-Called Sharing Economy in Accommodation Services in the Context of Negative Externalities 219

Veronika PULPAN KRAUSE, Daniel OPELIK, Josef VORACEK, Klara KULHANKOVA

Sports Services of a Selected Academy in the Ötztal Ski Resort 225

Jan REJTHAR

Esports – an Avenue for the Future of Economic Research..... 235

Patrik RICHNAK

Decarbonisation of Business Logistics: The Role of Electromobility in the Machinery and Equipment Industry..... 243

Martin SANDA, Jan ZBORIL

Short- and Mid-Term View on the Purchasing Power of Employees Working in the Public and Private Sectors, Considering the Existence of a Minimum Wage and the Influence of Inflation..... 255

Denisa SOUKUPOVA, Pavel BACHMANN

The Power of Image: the Impact of Visuals on Online Consumer Decision Making 267

Frantisek SUDZINA, Antonin PAVLICEK, Lucie ROZMBERSKA

Risk Aversion, Age, and Gender as Predictors of New Media Adoption: Evidence from LinkedIn, Twitter, Skype, and Viber 277

Eliska VALENTOVA, Magdalena ZBRANKOVA

The Significance of Social Entrepreneurship for Sustainable Municipal Development 287

Jana ZAHRADKA ZAJFRTOVA, Petra MARESOVA

Human Resource Management in Biotech and DeepTech Startups - the Pilot Study 299

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Insurance as a Digital Ecosystem: Exploring New Horizons of Digitalization, Smart Business, and Global Competitiveness

Abstract

The insurance industry is undergoing a profound transformation driven by the integration of artificial intelligence (AI), big data analytics, the Internet of Things (IoT), blockchain, and cybersecurity frameworks. These innovations are not incremental improvements but are reconfiguring the insurance value chain into a digital ecosystem—an interconnected environment characterized by real-time data flows, algorithmic decision-making, and platform-based business models. Within this ecosystem, risk management is shifting from retrospective compensation towards predictive and preventive strategies, with telematics, wearables, and smart sensors enabling usage-based insurance. This paper examines the systemic impact of digitalization by analyzing the synergies among emerging technologies and their ethical, regulatory, and operational implications. AI enhances underwriting, fraud detection, and claims automation but raises concerns about bias and transparency. Big data expands predictive modelling and personalization while intensifying privacy and governance challenges. The study argues that digital transformation requires moving beyond isolated technology adoption towards the design of resilient and inclusive insurance ecosystems. By framing digitalization as a structural and societal paradigm shift, this paper contributes a comprehensive perspective for academics, practitioners, and policymakers seeking to understand and guide the future of insurance.

Key Words: Digital Ecosystem, Insurance Industry, Artificial Intelligence, Big Data Analytics, Blockchain

JEL Classification: G22, G28, O33

Introduction

The insurance industry's digital transformation fundamentally reshapes operational efficiency, risk assessment, and customer engagement. Emerging technologies such as artificial intelligence (AI), big data analytics, blockchain, and the Internet of Things (IoT) have enabled insurers to automate underwriting, streamline claims processing, and enhance fraud detection (Eling & Lehmann, 2018). While these innovations are essential, framing them as separate drivers of change underestimates the current systemic and structural reconfiguration. Insurance is evolving into a digital ecosystem, an interconnected socio-technical network where technologies, data flows, institutions, and consumers interact dynamically. This reframing moves beyond efficiency-driven narratives and positions digitalization as a paradigm shift in how insurance generates value, manages risks, and governs trust. These advancements offer personalized and dynamic pricing models, leveraging predictive analytics to assess policyholder behaviour and mitigate real-time risks (McKinsey & Company, 2023). AI-driven chatbots, for example, provide 24/7 customer service, reducing operational costs while enhancing the user experience (IBM Research, 2024). Blockchain technology further strengthens transparency and trust through secure, immutable transaction records, streamlining smart contracts in claims settlement (Anderson, 2023).

However, the digitalization of insurance also introduces critical challenges, including ethical AI concerns, cybersecurity risks, and regulatory compliance (LNCS Homepage, [http, 2024](http://)). The increasing reliance on AI in risk assessment raises concerns about algorithmic bias, prompting regulators to emphasize explainable AI (XAI) models for fair and transparent decision-making (World Economic Forum, 2024). Additionally, insurers must navigate complex data privacy regulations such as the General Data Protection Regulation (GDPR) to ensure consumer data security and prevent breaches (European Commission Report, 2024).

This paper explores the transformative impact of digitalization on the insurance industry, analyzing key technological innovations, their implications, and the evolving regulatory landscape. This paper aims to identify the basic categories of digital transformation in insurance, evaluate their key findings, and identify potential threats and opportunities. By addressing threats and opportunities, this research aims to provide insights for industry professionals, policymakers, and academics to navigate the future of competent insurance.

1. Methods of Research

This study employs a mixed-methods research approach, integrating qualitative and quantitative data to analyze digital transformation in the insurance industry. The research draws upon an extensive literature review of academic sources, industry reports, and regulatory frameworks. Empirical data was collected through case studies of leading digital insurance firms to capture insights into technological innovations, challenges, and best practices.

Secondary data analysis involved thematic evaluation of qualitative responses and comparative assessment of case studies to identify trends in AI-driven underwriting, big data analytics, IoT applications, blockchain implementation, and cybersecurity. A triangulation approach ensured methodological rigor by combining multiple data sources, enhancing reliability and validity.

While this study provides valuable insights, certain limitations exist, including regional regulatory variations, restricted access to proprietary data, and the rapidly evolving nature of digital insurance. Despite these challenges, the methodology offers a robust framework for understanding digital transformation in the insurance sector, with implications for industry professionals, policymakers, and academics.

2. Results of the Research

The results of this study confirm that the digital transformation of the insurance industry is a systemic reconfiguration of its value chain and governance frameworks rather than an incremental technological change. Artificial intelligence has emerged as a core enabler of innovation, improving underwriting, fraud detection, and claims automation. Research indicates that AI-powered systems reduce fraudulent claims by up to 30%, increase underwriting efficiency by 25%, and accelerate claims processing by 40% (Deloitte Insights, 2024). These findings complement earlier analyses highlighting that digitalization fundamentally reshapes the insurability of risks and the overall insurance value chain (Eling & Lehmann, 2018). Beyond efficiency gains, AI-driven chatbots and service platforms provide continuous customer interaction, reducing administrative costs while enhancing user experience (IBM Research, 2024). Nevertheless, regulators increasingly stress the need for explainable AI to ensure transparency and accountability in automated decision-making processes (World Economic Forum, 2024).

Big Data analytics reinforces these developments by enhancing predictive modelling and enabling more granular risk assessments. Studies show that predictive models improve accuracy by up to 60% (European Commission, 2024). Telematics in auto insurance and wearable devices in health insurance illustrate the value of real-time data for reducing claims and personalizing policyholder engagement (Wang, 2023; Habiba, 2024). These approaches are consistent with industry reports emphasising customer-centric transformation and data-driven ecosystems' strategic importance (McKinsey & Company, 2023). Yet, they also intensify debates around data privacy and ownership, as large insurers accumulate vast datasets that risk monopolizing the market (Jones, 2024).

The Internet of Things further transforms insurance practices by embedding sensors and monitoring devices into everyday life. Telematics-based motor insurance has reduced accident claims by up to 50%, health monitoring devices have decreased hospitalization rates by 30%, and smart home sensors have reduced burglary-related claims by 25% (Radwan, 2019; MIT Technology Review, 2024; Habiba, 2024). While these outcomes demonstrate the value of preventive insurance, they also reveal vulnerabilities: the interconnectedness of IoT systems multiplies potential entry points for cyberattacks, creating risks of data breaches and ransomware incidents (Reuters, 2025).

Blockchain offers complementary solutions to these challenges by embedding trust and transparency into insurance processes. Results show that smart contracts automate claims settlements, reduce disputes, and shorten payment cycles (Anderson, 2023). Immutable ledgers further reduce fraudulent claims by up to 40% (PwC, 2024). Decentralized identity solutions support compliance with data protection frameworks and enhance security for policyholders (Harvard Business Review, 2023). Despite these advantages, scalability and interoperability issues remain major barriers, as do uncertainties in regulatory environments (World Economic Forum, 2024).

Cybersecurity has emerged as both a technological challenge and a governance priority. The results confirm that insurers are increasingly exposed to ransomware, data breaches, and vulnerabilities stemming from third-party vendors. The average cost of breaches in the insurance sector is among the highest in financial services, reflecting the sensitivity of data being processed (European Commission, 2024). To mitigate these risks, insurers deploy AI-driven anomaly detection systems and adopt zero-trust security frameworks, thereby enhancing resilience in a highly interconnected environment (Deloitte Insights, 2024; Jones, 2024). At the same time, insurers themselves must design products covering cyber risks, creating a dual responsibility that further underlines the systemic complexity of digital transformation.

The interplay of these technologies and governance mechanisms will be further elaborated in the Discussion (see Tab. 1, which highlights key findings, threats, and opportunities in each domain of digital transformation). One of the most profound changes in the industry is the integration of AI into underwriting, claims processing, and fraud detection. AI-driven analytics and machine learning algorithms enable insurers to assess risk more accurately, personalize policy pricing, and detect fraudulent claims in real-time. However, concerns regarding AI fairness and explainability remain significant. The risk of algorithmic bias, if not adequately addressed, can lead to ethical dilemmas and regulatory scrutiny. Insurers must, therefore, adopt Explainable AI (XAI) methodologies to enhance transparency and accountability in automated decision-making.

Big Data analytics has revolutionized predictive risk management, enabling insurers to anticipate customer needs and proactively manage risks. The integration of telematics in auto insurance and wearable devices in health insurance exemplifies how real-time data collection optimizes policyholder engagement and risk assessment. Data privacy concerns persist, with regulators emphasizing compliance with GDPR, CCPA, and emerging AI governance frameworks (European Commission, 2024; Baker Tilly, 2025). Insurers must balance data-driven insights with stringent privacy safeguards to maintain consumer trust (Jones, 2024).

Blockchain technology introduces significant advantages, particularly in claims settlement, fraud prevention, and identity management. Smart contracts automate claim approvals, reducing processing times and minimizing human intervention. Blockchain-based claim tracking mitigates fraudulent activities by ensuring that transactions are transparent and tamper-proof (PwC, 2024). Despite these benefits, challenges related to scalability, regulatory compliance, and interoperability with legacy systems must be addressed for widespread adoption in insurance (World Economic Forum, 2024).

IoT-driven insurance solutions, such as telematics-based auto policies and smart home sensors, have enhanced risk mitigation and dynamic policy pricing. However, IoT adoption also amplifies cybersecurity risks, with interconnected devices exposing insurers and policyholders to data breaches and ransomware attacks (Reuters, 2025). The industry's response has been to implement AI-driven threat detection systems and zero-trust security frameworks, yet the evolving nature of cyber threats necessitates continuous innovation in cybersecurity practices (Deloitte Insights, 2024).

Ethical and regulatory considerations remain pivotal in the digital insurance landscape. The need for algorithmic accountability, consumer data protection, and transparent AI governance has prompted regulatory bodies to introduce AI audits, bias testing, and strict compliance measures (The American College of Financial Services, 2025). Future regulatory developments will likely shape the trajectory of digital insurance, influencing how insurers develop and deploy emerging technologies (van Bekkum & Zuiderveen Borgesius, 2025).

In addition to these thematic results, the conceptual framework of digital transformation is further elaborated through a visual synthesis that illustrates the building blocks of the digital insurance ecosystem. This framework emphasizes the interplay of AI, Big Data, IoT, blockchain, and cybersecurity, integrated under regulatory and ethical oversight. Together, these building blocks form a dynamic, adaptive ecosystem in which data flows, technological infrastructures, and governance mechanisms converge to redefine risk management and customer engagement. To strengthen analytical interpretation, this framework is not presented here but discussed in detail in the following section (see Fig. 1).

Looking forward, the ecosystem view highlights significant ethical and socioeconomic implications. Digital exclusion threatens affordability and access for populations without connectivity, while data sovereignty determines who benefits from value creation—policyholders, insurers, or global technology platforms (van Bekkum & Zuiderveen Borgesius, 2025). Fragmentation across regulatory jurisdictions risks producing uneven levels of consumer protection worldwide. Projecting towards 2035, the insurance industry may evolve into a self-regulating, autonomous ecosystem where policies adapt dynamically, claims are executed automatically through smart contracts, and compliance is continuously monitored. Insurers will shift from being risk compensators to orchestrators of a wider digital environment.

In summary, the results of this study show that digitalization offers transformative potential but requires insurers to navigate complex technological, regulatory, and ethical landscapes. By adopting responsible AI practices, enhancing cybersecurity, and implementing robust compliance mechanisms, insurers can unlock the benefits of digital transformation while safeguarding transparency and fairness. A critical insight is that digital transformation cannot be reduced to the adoption of discrete technologies. Instead, insurance is evolving into a digital ecosystem defined by convergence and interaction. This ecosystem is characterized by interconnectivity, platformization, predictive prevention, algorithmic governance, and value co-creation. Customers actively contribute to value creation through their data, regulators embed oversight into

technological systems, and insurers assume the role of orchestrators within interconnected platforms. The recognition of these dynamics confirms that the findings align with the conceptualization of insurance as a digital ecosystem, as outlined in the abstract and reinforced in the conclusion. This explicit connection underscores that digitalization is not a series of isolated innovations but a structural transformation of the industry's value creation, governance, and ethical responsibilities.

The interplay of these technologies and governance mechanisms reveals that digital transformation in insurance cannot be understood as isolated innovations. Instead, each technological domain contributes specific opportunities and risks that only gain their full meaning when situated within a systemic perspective. To avoid redundancy, the detailed comparative overview (Tab. 1) and the conceptual ecosystem framework (Fig. 1) are integrated into the Discussion section, where they provide the analytical basis for interpreting the broader implications of the findings. This ensures that the transition from empirical results to conceptual synthesis is explicitly structured and analytically robust.

3. Discussion

The findings of this study suggest that digital transformation in insurance represents not only a technological evolution but also a systemic restructuring of the industry. While the integration of AI, Big Data, IoT, and blockchain generates measurable efficiency gains, it simultaneously raises ethical, regulatory, and socioeconomic challenges.

To enhance the analytical depth of this study, Tab. 1 and Fig. 1 are presented in the Discussion rather than in the Results. Table 1 provides a structured overview of the key technological domains of digital transformation in insurance, summarizing their main findings, potential threats, and opportunities. Fig. 1 complements this evidence by synthesizing these domains into a conceptual architecture of the digital insurance ecosystem. Taken together, the table and the figure are not redundant but mutually reinforcing: the table disaggregates technological changes into discrete categories, while the figure integrates them into a systemic model that highlights interdependencies, governance mechanisms, and ethical dimensions.

Tab. 1: Key Findings in Individual Categories of Digital Transformation in the Insurance Industry

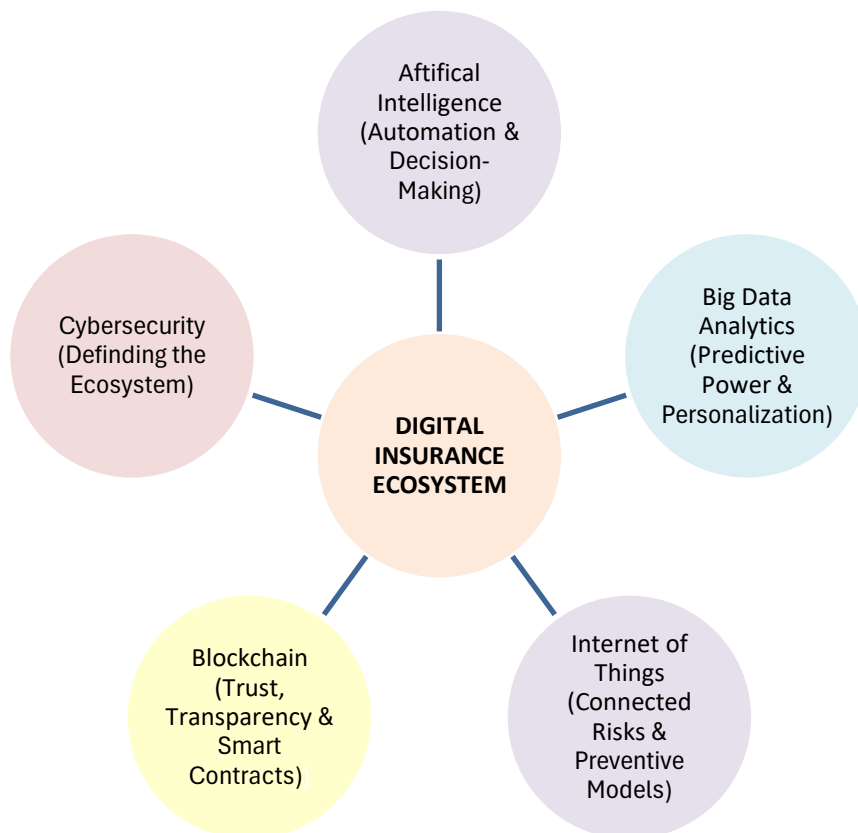
Category	Key Findings	Potential Threats	Opportunities
Artificial Intelligence (AI)	AI enhances fraud detection (30% reduction), personalized underwriting (25% efficiency increase), and automated claims processing (40% faster). Integration of natural language processing for unstructured claims data, computer vision for	Bias in models, risks to personal data protection, need for continuous retraining and governance frameworks to	Combining AI with blockchain can create immutable, explainable decision logs to meet regulatory scrutiny; improved transparency and

Category	Key Findings	Potential Threats	Opportunities
	damage assessment, and wearable device analytics for health risk profiling. Advanced models such as TabNet significantly improve claims prediction accuracy; deep learning ensembles enhance fraud detection efficiency.	avoid model obsolescence.	trust; accelerated claims settlement and product personalization.
Big Data Analytics	Predictive modeling improves risk assessment accuracy (by 60%). Integration with InsurTech platforms enables more precise customer segmentation and cross-selling. Emerging “small data” strategies improve model interpretability and reduce overfitting risk while maintaining accuracy.	Data misuse risks, monopolization of data by large insurers, regulatory constraints (GDPR, CCPA).	Collaborative data-sharing frameworks can enhance industry-wide risk modeling while protecting privacy; support proactive product innovation and targeted marketing.
Internet of Things (IoT)	Enables dynamic policy pricing and real-time risk assessment. Sensors and telematics reduce accident claims by up to 50%, wearables reduce hospitalization rates by 30%, smart home security systems reduce burglary claims by 25%. Multi-sensor fusion from vehicles, homes, and personal devices allows contextualized risk scores updated in near real-time.	Cybersecurity vulnerabilities, inaccurate data leading to disputes, unequal access for customers with poor connectivity.	Predictive maintenance alerts reduce claim frequency and severity; synergy with blockchain ensures IoT data integrity and auditability.
Blockchain Technology	Automates claims settlement through smart contracts, reduces fraud by 40%, and enables decentralized identity management. Can also support decentralized insurance pools and provide transparent regulatory reporting.	Scalability issues, lack of standardized protocols, regulatory uncertainty, interoperability challenges with legacy systems.	Integration with IoT for automated, condition-triggered claims; use of smart contract templates to speed up deployment of new insurance products; improved auditability for compliance.
Cybersecurity	Growth of digital insurance increases risks – data breaches (average loss \$3.3 million),	Increasing sophistication of attacks,	Implementation of Zero Trust frameworks,

Category	Key Findings	Potential Threats	Opportunities
	ransomware (+35% YoY). Advanced threat detection systems use AI, including zero-day threat identification.	vulnerabilities in third-party vendor ecosystems, supply chain as an attack vector.	deployment of agile cloud-native security solutions, and joint industry cyber-resilience exercises to strengthen preparedness.
Ethical and Regulatory Considerations	Bias in AI underwriting, data privacy issues, and opaque decision-making. Explainable AI (XAI) is becoming a regulatory expectation; state-level regulations (e.g., Colorado SB 21-169) define the permissible scope of AI use.	Global differences in AI regulation, compliance complexity for multinational insurers, risk of algorithmic discrimination.	Proactive compliance programs and bias-auditing tools; engagement with policymakers to shape fair, innovation-friendly regulation while ensuring consumer protection.

Source: by authors

Fig. 1: Building Blocks of the Digital Insurance Ecosystem



Source: by authors

A first issue concerns AI fairness and explainability. Although AI-driven underwriting, pricing, and fraud detection improve accuracy and efficiency, unresolved problems of algorithmic bias and opacity persist (van Bekkum & Zuiderveen Borgesius, 2025; The American College of Financial Services, 2025). If left unaddressed, these challenges may undermine consumer trust and trigger regulatory scrutiny. Insurers must therefore integrate Explainable AI (XAI) methodologies to ensure transparency, fairness, and accountability. As highlighted in Tab. 1, AI provides measurable efficiency gains (e.g., fraud reduction and faster claims processing) but simultaneously raises concerns about bias and model governance. Fig. 1 situates AI at the core of the ecosystem, embedded within ethical and regulatory oversight that is essential to mitigate these risks.

Second, data governance and privacy remain crucial. The increasing reliance on customer data from telematics, IoT sensors, and wearable devices generates new opportunities for risk prevention, but also exacerbates privacy concerns (Jones, 2024; European Commission, 2024). Effective frameworks must reconcile innovation with GDPR, CCPA, and forthcoming AI regulations to prevent misuse of sensitive data. Tab. 1 identifies the monopolization of data and risks of misuse as critical threats. Fig. 1 places Big Data within the broader ecosystem where regulatory mechanisms determine how value is distributed and consumer trust is maintained.

Third, cybersecurity vulnerabilities intensify with interconnected digital infrastructures. Blockchain, IoT, and cloud computing expand the attack surface for cybercriminals (Reuters, 2025; Deloitte Insights, 2024). While insurers are adopting zero-trust frameworks and AI-driven threat detection, evolving ransomware and state-sponsored attacks pose persistent risks that require ongoing vigilance. In Tab. 1, cybersecurity emerges both as a technological challenge and as a governance imperative. Fig. 1 reinforces this by showing cybersecurity as a cross-cutting foundation of the entire ecosystem, shaping the resilience of all other building blocks.

Fourth, regulatory harmonization emerges as a decisive factor in shaping the trajectory of digital insurance. Fragmented legal frameworks across jurisdictions complicate compliance for global insurers (World Economic Forum, 2024; Baker Tilly, 2025). Regulatory divergence risks slowing innovation and creating uneven consumer protection. Cross-border coordination and the adoption of interoperable standards are therefore essential. Tab. 1 points to fragmented regulation as a barrier to innovation, while Fig. 1 illustrates how regulatory and ethical frameworks must encompass all technological domains to ensure interoperability and fairness at the ecosystem level.

A comparative perspective highlights regional divergences in the adoption of digital insurance. In the European Union, strict regulatory frameworks such as GDPR and upcoming AI regulations prioritize consumer protection and data governance, often slowing the pace of innovation but ensuring accountability. In contrast, the United States displays a more market-driven approach, with rapid adoption of InsurTech solutions but fragmented state-level regulation. Asia, particularly China and Singapore, shows a hybrid model, characterized by state-led innovation agendas and strong public-private partnerships driving large-scale implementation of digital ecosystems. These differences

underline that digital transformation trajectories are shaped not only by technology but also by institutional, cultural, and regulatory contexts.

Finally, the move toward a digital ecosystem model redefines the role of insurers as orchestrators of value rather than mere financial intermediaries. This transition emphasizes interconnectivity, predictive prevention, algorithmic governance, and value co-creation (see Table 1; Figure 1). While this ecosystem model offers transformative opportunities, it also risks creating digital exclusion for populations without connectivity and reinforces concerns about global data sovereignty. The orchestration role becomes evident when Tab. 1 and Fig. 1 are read together. The table highlights micro-level efficiencies and risks of each technology, whereas the figure synthesizes them into a macro-level ecosystem that insurers must design, govern, and sustain. Limitations of the study must be acknowledged. First, the analysis is based primarily on secondary data, conceptual literature, and illustrative case studies, meaning that results are exploratory rather than statistically generalizable. Second, the temporal scope of the study is limited to literature from 2018–2025, which may quickly become outdated given the rapid pace of technological and regulatory change. Third, jurisdictional differences in regulation and market maturity restrict the applicability of findings across regions.

Future research directions should build on these insights. Empirical and longitudinal studies could evaluate the real-world impacts of digital insurance solutions, such as AI-driven underwriting or blockchain-enabled claims settlement, on efficiency, fairness, and consumer trust. Comparative research across regions (EU, USA, Asia) would shed light on regulatory divergences and their market effects. Finally, interdisciplinary studies could examine the broader socioeconomic implications of digital ecosystems, especially their impact on financial inclusion and consumer empowerment.

Conclusion

The insurance industry is undergoing an unprecedented digital revolution fueled by advancements in AI, big data analytics, IoT, blockchain, and cybersecurity. These technologies have redefined traditional business models, enhancing efficiency, customer experience, and risk assessment. However, as insurers increasingly rely on digital tools, they must address the associated challenges, including AI bias, data privacy risks, cybersecurity threats, and regulatory compliance. AI has significantly improved underwriting, claims processing, and fraud detection, enabling insurers to offer more personalized and efficient services. However, ethical concerns regarding algorithmic fairness and transparency necessitate regulatory oversight and the adoption of Explainable AI (XAI) frameworks. Likewise, big data analytics has empowered insurers with predictive insights yet concerns about data privacy and consumer protection remain at the forefront of regulatory discussions.

Blockchain technology has introduced a paradigm shift in claims processing and fraud prevention, ensuring transparency and trust through smart contracts and decentralized identity management. Despite its potential, the adoption of blockchain in insurance faces hurdles such as scalability, interoperability with legacy systems, and regulatory ambiguity. Strategic collaborations between insurers, regulators, and technology

providers will be key to overcoming these barriers. The IoT revolution has enabled insurers to offer usage-based insurance models, integrating real-time data from telematics devices, smart home sensors, and wearable technologies. While these innovations enhance risk mitigation and policy personalization, they expose insurers to heightened cybersecurity vulnerabilities. The growing number of cyberattacks on digital insurance platforms underscores the need for robust encryption protocols, real-time threat detection, and comprehensive risk management frameworks.

Regulatory bodies are increasingly active in shaping the digital insurance landscape. Compliance with GDPR, CCPA, and evolving AI regulations is paramount to safeguarding consumer rights and responsible data usage. Implementing AI audits, bias mitigation techniques, and transparent algorithmic governance will foster trust and accountability in digital insurance practices. Looking ahead, the successful digital transformation of insurance will require a balanced approach that embraces innovation while mitigating associated risks. Insurers must invest in ethical AI frameworks, strengthen cybersecurity infrastructure, and proactively engage with regulators to navigate the evolving compliance landscape. Collaboration between industry stakeholders, policymakers, and technology leaders will be instrumental in shaping a resilient and inclusive digital insurance ecosystem.

Ultimately, while digitalization presents numerous opportunities, insurers must prioritize responsible innovation, ethical considerations, and regulatory compliance to ensure a sustainable and consumer-centric future. By doing so, the industry can unlock the full potential of digital insurance while maintaining trust, transparency, and fairness in an increasingly data-driven world. Policy implications emerging from this study point to the need for more targeted regulatory and industry initiatives. Regulators should establish clear compliance frameworks for explainable AI, mandate regular algorithmic audits, and encourage the adoption of interoperable cybersecurity standards. Industry associations can play a role in developing collaborative data-sharing models that balance innovation with privacy protection, while public-private partnerships can accelerate the development of trustworthy digital ecosystems. These measures would create a more resilient, consumer-centric insurance landscape by aligning compliance obligations with innovation incentives.

Synthesizing the findings, it becomes clear that the technological efficiencies documented throughout this study—fraud reduction, faster claims processing, and more accurate risk assessment—carry profound socioeconomic and ethical consequences. Enhanced personalization can increase consumer welfare but risks reinforcing inequalities if digital exclusion persists. Similarly, data-driven ecosystems create opportunities for co-creation of value but also raise sovereignty questions over who ultimately benefits from consumer data. The broader implication is that digital insurance must be governed not only as a technological system but also as a social contract, balancing efficiency with fairness, innovation with accountability, and growth with inclusivity.

Reframing insurance as a digital ecosystem offers a deeper understanding of digitalization not merely as technological adoption but as structural transformation. The convergence of AI, IoT, big data, and blockchain creates emergent dynamics that reshape the industry's

value creation, governance, and ethical responsibilities. To unlock the full potential of this transformation, insurers must adopt ecosystem thinking: building inclusive, interoperable, and fair systems that balance innovation with accountability. Regulatory bodies and academics must likewise develop frameworks that anticipate ecosystem-level risks, from data sovereignty disputes to digital exclusion. Ultimately, the future of insurance will be determined not by isolated digital innovations but by how effectively the industry designs, governs, and sustains its role as a digital ecosystem. This vision requires collaboration across stakeholders to ensure that digital insurance evolves as technologically advanced, ethically robust, and socially sustainable.

In line with the objectives of this study, the article has identified the main technological drivers of digitalization, evaluated their implications for efficiency, fairness, and regulation, and framed them within the broader concept of the digital ecosystem. This provides both scholars and practitioners with a structured lens for understanding the convergence of technological and regulatory dynamics in insurance. For practitioners, the findings underscore the need to invest in responsible AI, cybersecurity, and data governance. For regulators, the results highlight the importance of harmonizing frameworks across jurisdictions and embedding algorithmic accountability into oversight. For academics, this study opens avenues for future research, including longitudinal assessments of digital insurance adoption, cross-regional comparisons of regulatory impact, and interdisciplinary analyses of financial inclusion and consumer trust. In doing so, the article contributes to shaping a foundation for sustainable, fair, and innovative digital insurance.

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Challenges in the Development of Low-Carbon Energy Sources in India

Abstract

India is undergoing an energy transition driven by the dual imperatives of continuing economic growth and the urgent need for climate change mitigation. This article analyzes the planning documents, achievements and future challenges of developing low-carbon energy sources (LCESs) in India. Our considerations are based on the latest statistical data on LCESs development and major government policy documents. India has made significant progress in developing LCESs, focusing on solar, wind, and nuclear power to support economic growth and to mitigate climate change. Between 1990 and 2023, renewable energy production in India increased by 1900 times, from 437 TJ to 830227 TJ. Solar energy has become the cornerstone of India's low-carbon strategy, with aggressive expansion supported by government policy. However, dependence on fossil fuels, especially coal, remains high, increasing from 55% to nearly 63% of the energy production during the same period. The weakness of many planning documents and policies is the lack of measurable goals and dates for their planned implementation, as well as poor analyses of realistic ways to achieve these goals. Key barriers include limited funds for investment, limited energy storage infrastructure, improper energy grid modernisation, regulatory inconsistencies, socioeconomic disparities, and slow policy implementation. A more balanced focus is essential on decentralised energy systems, improved energy efficiency, and just transition strategies.

Key Words: Low-Carbon Economy, Sustainable Development, Energy Sector, Energy Transition, National Policy, India

JEL Classification: O13, P28, Q48

Introduction

According to United Nations (UN) estimates, India overtook China in terms of population in 2023 and became the world's largest country. Economic and population growth, coupled with an improved quality of life, will generate a steady increase in the demand for electricity. This raises an important question: how can economic growth be achieved while avoiding a massive increase in the use of fossil fuels in energy production, which negatively impacts air quality and generates carbon dioxide (CO₂) emissions, thereby increasing the average global temperature?

India was not far behind other large countries in setting a target to reduce CO₂ emissions by approximately 33% between 2005 and 2030 (Fragkos et al., 2021). However, studies on India's development indicate that the share of renewable energy sources (RES) has decreased and CO₂ emissions have increased because energy production growth was based mainly on coal-fired power plants (Ortega-Ruiz et al., 2020; Singh et al. 2023; Uche et al., 2023). These trends contradict national goals and the recommendations of global climate scientists to reduce greenhouse gas emissions (GHG). These data underscore the difficulty in achieving economic development and improving the quality of life of Indian citizens using low-carbon energy sources (LCESs).

This study focuses on the development of LCESs in India, encompassing all energy sources that do not emit CO₂. This includes both renewable and nuclear energy sources. Although the long-term goal should be to achieve a modern circular economy without the use of fossil fuels, the use of non-renewable nuclear energy during the period of energy transition seems necessary owing to the limitations of renewable technologies (the main problem being instability and dispersion). The main goals of this study are as follows:

- To critically analyse the trajectory of India's current LCESs development policies.
- Briefly analyse the current planning documents of the Indian central government related to the development of LCESs

Our analyses and conclusions can be helpful in evaluating existing energy policies in developing countries and shaping future policies.

1. Methods of Research

We primarily rely on the available statistical data on the energy sector's development to date and a qualitative analysis of India's government's strategic documents. Our analysis was divided into two stages. The first examines the real changes in India's energy sector (Section 3). For long-term comparisons (1990-2023), we used data from the International Energy Agency (IRENA, 2025). The year 1990 was selected as a baseline because significant international agreements were negotiated in the 1990s. (such as the UN Framework Convention on Climate Change in 1992 and the Kyoto Protocol in 1997), mentioning the importance of shifting away from fossil fuels as they release greenhouse

gases, especially CO₂. Moreover, a reliable and standardised dataset has been made available from this year (IRENA, 2025). To analyse the regional variation in LCEs capacity, we used the latest statistical data on RES (as of March 2025) published by the Government of India, Ministry of Statistics and Programme Implementation (MSPI, 2025) and data on nuclear power plants (as of June 2025) published by the Nuclear Power Corporation of India Limited (NPCI, 2025). In the analysis of RES, we aggregated small and large hydroelectric sources, which are reported separately in Indian government statistics. We used the QGIS Desktop program (version 3.40.9) to visualise the regional data. In the second stage of the analysis (Section 4), we conducted a concise qualitative analysis of the current strategic, planning, and legal documents prepared by the Indian central government:

1. **Energy Conservation Act (ECA, passed in 2001, last revised in 2022)**: It regulates energy consumption in various sectors, promotes energy efficiency, and lays the groundwork for a domestic carbon market.
2. **National Electricity Plan (NEP, notified in 2007, last revised in 2023)**: This outlines India's strategy for electricity generation, transmission, and distribution from 2023 to 2032.
3. **National Action Plan on Climate Change (NAPCC, 2008)**: This outlines India's approach to addressing climate change, including the energy economic sector.
4. **National Offshore Wind Energy Policy (NOWEP, 2015)**: This aims to provide a framework for the development of the offshore wind sector in India.
5. **Long-Term Low-Carbon Development Strategy (formal acronym LT-LEDS; submitted to the UN in 2022)**: This outlines a path towards low-carbon development, aiming to decouple economic growth from emissions and foster a sustainable, low-emission economy.
6. **National Green Hydrogen Mission (NGHM, 2023)**: It describes India's approach to developing the use of clean hydrogen energy.

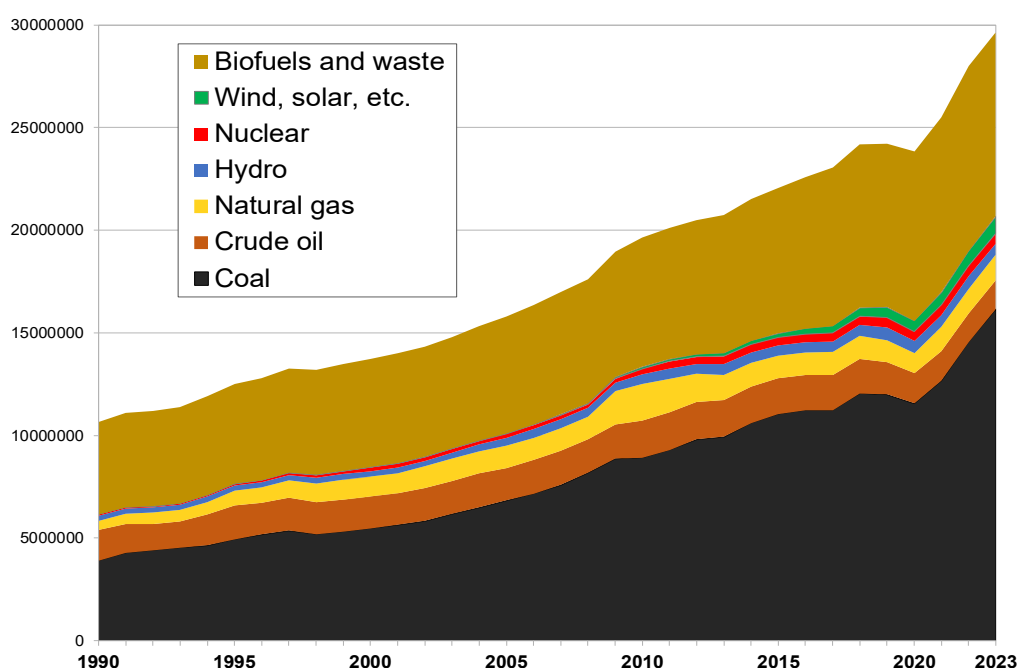
In this stage, we focused on finding records in the above-mentioned documents regarding the development of LCEs. To discuss our findings, we used opinions and analyses from other authors, supported by the SCOPUS AI tool, which analyzes abstracts of papers inventoried in the SCOPUS database. We obtained the AI-proposed articles in their full versions and analysed their content in detail, considering only the articles whose content most closely matched our analysis (considering the limit of 20 references in this publication). Articles that could not be obtained because of copyright issues were excluded from the analyses.

2. The Development of LCEs in India

Economic growth, combined with India's growing population, has significantly increased energy demand. Between 2000 and 2023, domestic energy production nearly tripled (Figure 1). However, this growth was predominantly driven by the consumption of coal. According to the International Energy Agency (IRENA, 2025), the share of coal in energy

production increased from 34.7% to 54.5% in the years 1990-2023, while the share of renewable energy (RE) decreased from 44,7% to 34,8% (Figure 2). However, RE is dominated by bioenergy from burning wood and waste, which is not an optimal solution for achieving a low-carbon economy in the long term. India is greatly dependent on traditional bioenergy sources for cooking and heating, especially in rural regions. This energy is derived from firewood, crop residues, dried leaves, and animal dung (considered as biofuels in statistics). This is not a sustainable practice and contributes to air pollution, deforestation, black carbon emissions, and health hazards.

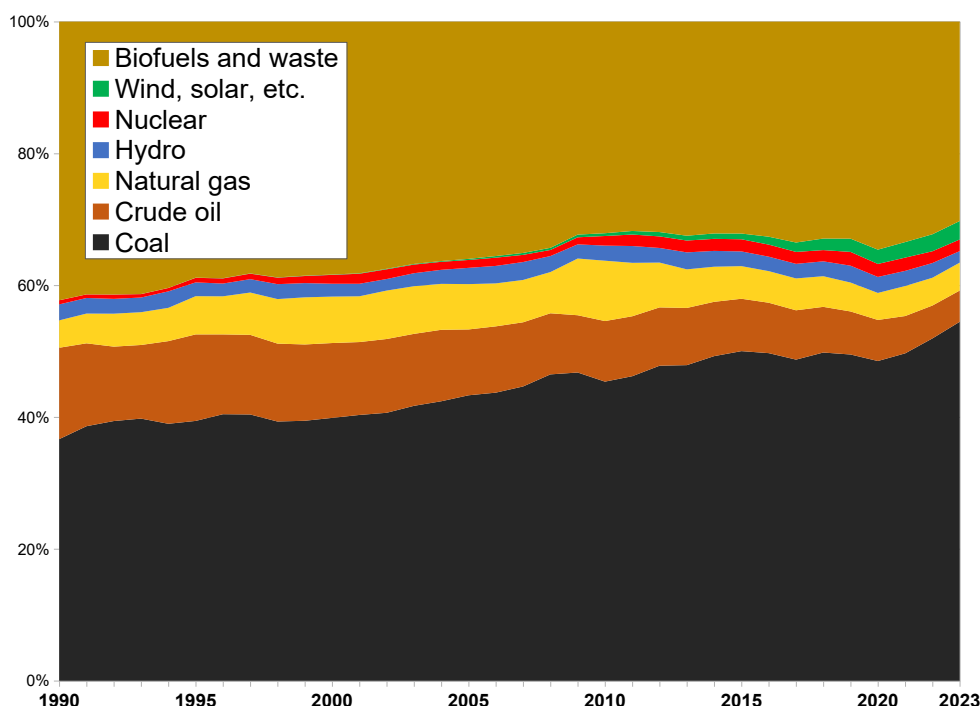
Fig. 1: Growth in energy production in India between 1990 and 2023 (TJ) and acceleration of investment after 2021.



Source: own work, data from the International Energy Agency (IRENA, 2025)

Recently, India has made notable achievements in development of modern LCESs. In the RE sector, the country has experienced rapid growth, with a significant increase in renewable generation, especially solar and wind plants, from approximately 436 TJ in 1990, to 830227 TJ in 2023. According to the IEA, India ranked fourth globally in terms of overall installed RE capacity in 2023 (after China, the USA, and Brazil). Government support through favourable policies and incentives has attracted foreign investment, positioning India as a global leader in clean energy. Furthermore, the RE sector is emerging as a key driver of job creation, contributing to economic development and enhancing the energy security.

Fig. 2: Share of sources in national energy production in India (1990–2023).
 A significant increase in the role of coal is evident, despite the development of modern RES (wind, solar, etc.), which still have a negligible percentage share.

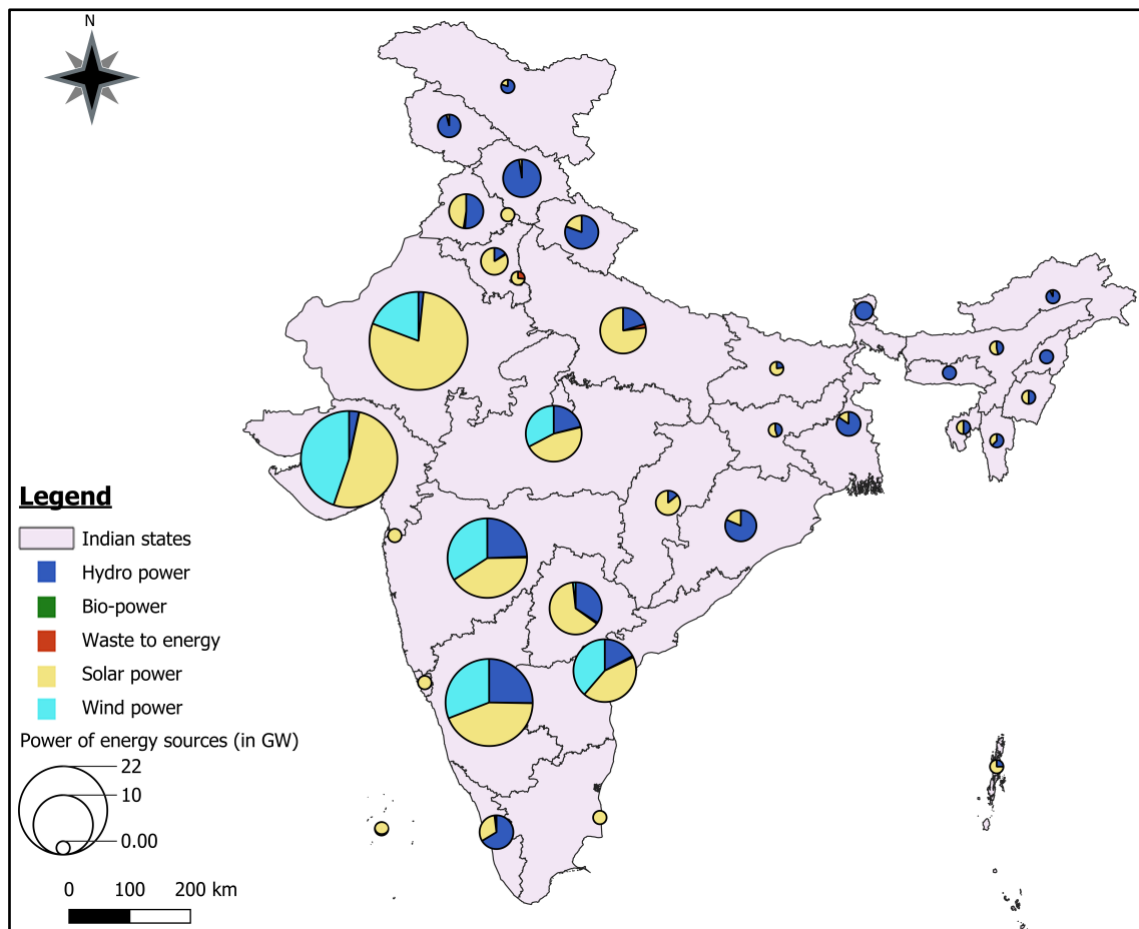


Source: own work, data from the International Energy Agency (IRENA, 2025).

In terms of installed RE capacity in 2024, according to data from the Government of India (MSPI, 2025), solar energy had the greatest importance (81.8 GW of installed capacity, that is, 46.8% of RE), followed by wind energy (45.8 GW, 26.2%), and hydropower (36.1 GW, 20.7%), with solar energy sources experiencing the most dynamic growth. Solar farms mainly operate in western India (Figure 3), with the highest capacities in Rajasthan (21.3 GW), Gujarat (13.5 GW), and Karnataka (8.5 GW).

The largest wind farm capacities were installed in Gujarat (11.7 GW), Karnataka (6.0 GW), and Tamil Nadu (10.6 GW). The largest combined capacities of small and large hydroelectric plants were installed in Karnataka (4.9 GW), Himachal Pradesh (3.9 GW), and Maharashtra (3.7 GW). Bioenergy was dominated in Maharashtra (2.6 GW), Uttar Pradesh (2.1 GW) and Karnataka (1.9 GW). The burning of waste for energy purposes was the highest in Delhi (but only 84 MW). In the northern part of the country, RES are less developed.

Fig. 3: Installed RES capacity in Indian states in 2024. There is a visible concentration of investment in the four western Indian states.

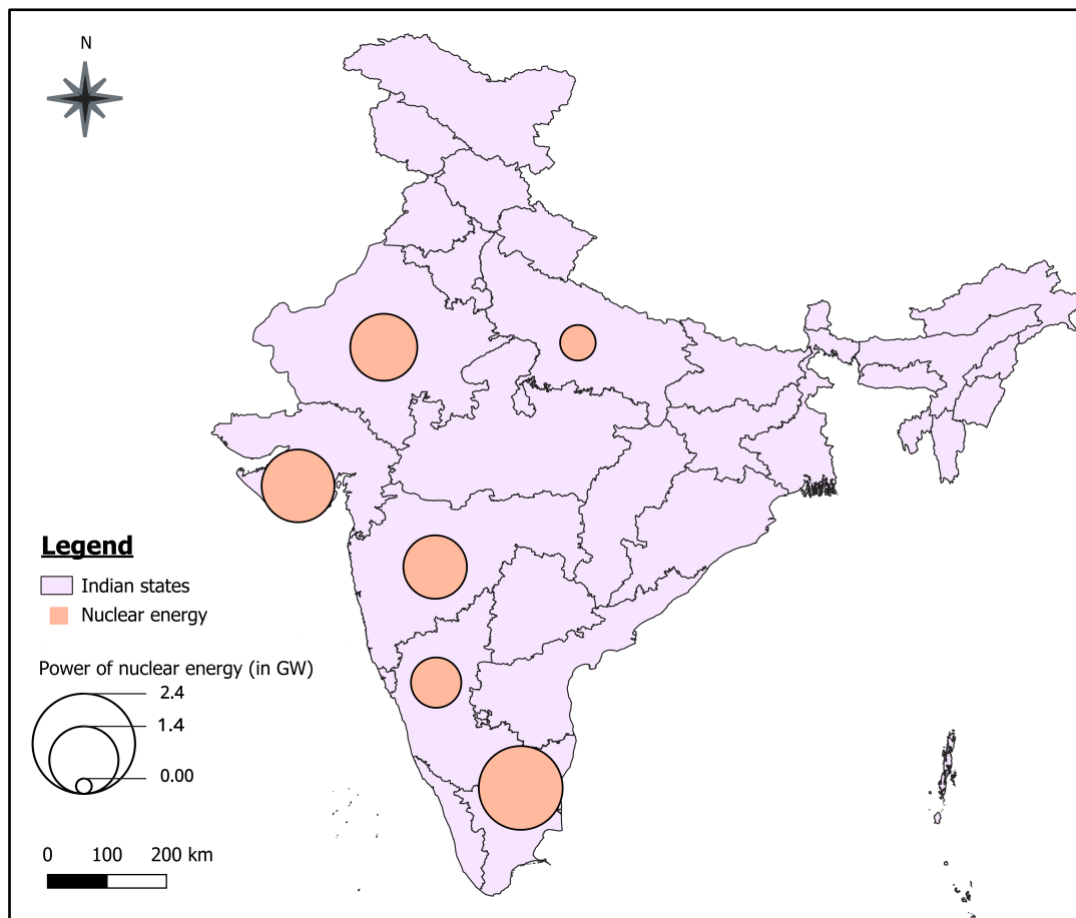


Source: own work, data from (MSPI, 2025)

In the nuclear energy sector, India has 25 reactors in operation in eight nuclear power plants located in six states (Figure 4). Their capacity was 8.9 GW as of June 2025, which is a very low figure in relation to India's energy needs. Nuclear power produced 57 TWh in the fiscal period 2024/2025¹, contributing to approximately 3% of the total power generation in India. Eleven reactors are under construction, with a combined generation capacity of 8.7 GW.

¹ In India, the government's financial year (financial period), often used in statistics, runs from 1 April to 31 March the following year.

Fig. 4: Nuclear energy installed capacity in Indian states in 2025. Nuclear power plants are located in only six states in India, which hinders energy distribution.



Source: own work, data from (NPCI, 2025)

3. The Analysis of Documents Related to Energy Policy in India

India's transition to a low-carbon energy economy is guided by a series of national rules, plans, and strategies, such as the Energy Conservation Act (ECA), National Electricity Plan (NEP), National Action Plan on Climate Change (NAPCC), National Offshore Wind Energy Policy (NOWEP), Long-Term Low-Carbon Development Strategy (formal acronym LT-LEDS), and National Green Hydrogen Mission (NGHM).

The Energy Conservation Act (ECA) drives India's energy structure towards a low-carbon trajectory. It defines the regulatory and institutional framework of the Carbon Credit Trading Scheme (CCTS, last detailed regulations in 2024), which offers companies financial incentives to invest in clean technologies. To ensure accurate measurement of carbon emissions and energy consumption, this act introduced energy auditor professionals to verify and evaluate commercial units, appliances, industries, academic institutions, residences and vehicles for carbon trading certificates. Alongside market-

based mechanisms, this amendment also mandates the Energy Conservation and Sustainable Building Codes (ECSBC, last detailed regulations in 2024), a responsibility of both the central and state governments. This strategy empowers audit agencies and imposes penalties for non-compliance. Stringent energy norms and strict financial retribution are applied in cases of failure to meet the mandatory regulations. Furthermore, the State Energy Conservation Fund and financial budget planning support local energy initiatives. Strengthening intergovernmental collaboration is another objective of enhancing project efficiency. Together, these measures will help India join the global climate movement by advancing greener practices. However, the Act fails to address small-scale enterprises and household energy efficiency. From a low-carbon economy perspective, it supports all energy sources simultaneously, whereas the slow adaptation of market-based mechanisms may constrain progress.

The National Electricity Plan (NEP), under the Ministry of Power, outlined a 15-year roadmap for electricity generation, forecasting a demand of 277 GW by the Indian fiscal period 2026/2027 and 366 GW by 2031/2032. The ministry is strategically planning to generate additional electricity to meet future energy requirements of the country. A large part of this mission is devoted to demand-side management (DSM) to reinforce low-carbon policies across various sectors, led by the Bureau of Energy Efficiency (BEE). It includes emission laws to decarbonise fossil fuel-based power plants by implementing cleaner technologies, such as fuel-gas desulfurisation. The total generation capacity is expected to increase through a diversified mix of renewable and nuclear sources by 2027-2032, aiming for 80% of capacity from clean sources. The improvement of battery and pumped hydro storage is prioritised to reduce the dependency on conventional sources. The plan also supports low-emission technological research, including waste-to-energy, stabilised grids, demand management and knowledge transfer. However, it lacks incentives for private-sector investment in low-carbon projects.

The National Action Plan on Climate Change (NAPCC) is closely linked to sustainable development goals (SDGs), including poverty alleviation (SDG 1) and climate action (SDG 13). India acknowledges its shared responsibility to address climate change through global cooperation, framed under the 'common but differentiated responsibilities' of the United Nations Framework Convention on Climate Change (UNFCCC) for equitable mitigation of climate change. The NAPCC launched eight National Missions for climate-resilient, low-carbon economic development without environmental harm: (1) the National Solar Mission to boost solar energy uptake; (2) the National Mission for Enhanced Energy Efficiency to strengthen energy security; (3) the National Mission on Sustainable Habitat to plan urbanisation and waste management; (4) the National Water Mission for water resources conservation; (5) the National Mission for Sustaining the Himalayan Ecosystem to protect natural habitats and glaciers; (6) the National Mission for a Green India to safeguard biodiversity; (7) the National Mission for Sustainable Agriculture to build climate resilience in agriculture; and (8) the National Mission on Strategic Knowledge for Climate Change to advance research. Together, these offer a platform for India to meet its environmental goals, protect vulnerable communities, promote market-based tools, and build a low-carbon economy with international partnerships. However, the NAPCC sets no carbon reduction target, lacks strong central-

state coordination, faces funding shortfalls in some sub-missions, and suffers from limited outcome reporting. Solar energy has shown the fastest growth, although the distributed solar potential remains underdeveloped.

The National Offshore Wind Energy Policy (**NOWEP**) attempts to utilise the country's 7600 km coastlines to produce cost-effective, sustainable renewable energy. The goal is to promote the establishment of offshore windfarms along the Exclusive Economic Zone (**EEZ**) through Foreign Direct Investments, public-private partnerships, and international collaborations. In accordance with this strategy, the Ministry of New and Renewable Energy would serve as India's key ministry for the development of offshore wind energy and collaborate closely with other governmental organisations to develop and utilise maritime space. However, the government document on this policy, beyond generally formulated goals, does not contain any specific analyses, measurable goals, or dates for achieving them. According to preliminary assessments, eight locations in Gujarat and Tamil Nadu have been identified as possible offshore zones for the development of offshore wind energy, which is estimated to generate approximately 71 GW. However, by mid-2025, no offshore wind farms had been built.

In 2022, the Government of India submitted a Long-Term Low-Carbon Development Strategy (**LT-LEDS**) to the UN. This document outlines a vision to expand low-carbon energy pathways by emphasising both renewable and nuclear power as critical pillars of its transition strategy. LT-LEDS reaffirms the target of achieving 50 % of installed power capacity from non-fossil sources—primarily renewables—by 2030, alongside a 45 % reduction in the emission intensity of GDP from 2005 levels. This renewables push builds on substantial growth in solar, wind, hydro, and bioenergy, supported by massive capacity additions and policy-support mechanisms. Simultaneously, this strategy underscores the long-term potential of nuclear energy to provide firm, carbon-free, baseload power. It envisions leveraging India's three-stage nuclear programme to bolster energy security and decarbonisation. The approach considers nuclear and renewable sources as complementary: renewables offer rapid scalability, whereas nuclear energy delivers reliability and deep decarbonisation. Collectively, these energy pathways form a dual strategy designed to meet India's development needs while aligning with its net-zero by 2070 goal. Nuclear power is a significant pillar of the long-term energy transition in India's Union Budget and has ignited hope for India's low-carbon development. It complements the RES and is suitable for factory-based manufacturing and provides grid stability. The Nuclear Power Corporation of India Limited (**NPCIL**) aims to generate 500 GW of clean energy by 2030. The Nuclear Energy Mission for '*Viksit Bharat*' (**Developed India**) seeks to make India a nuclear leader by increasing capacity from 8180 MW to 22480 MW (**by 2031/2032**) and 100 GW by 2047. Ten additional reactors will be built in Gujarat, Rajasthan, Tamil Nadu, Haryana, Karnataka, and Madhya Pradesh, and construction of the previously approved ten has already begun. The Prototype Fast Breeder Reactor at Kakrapar and the Jaduguda uranium deposit are notable advances. High hopes are pinned on the R&D of small modular reactors (**SMR**), with indigenous SMRs planned in remote areas by 2033. The government encourages public-private partnerships through legislative changes. Safety remains the top priority, supported by stringent nuclear policies in the country. While SMR commercialisation and thorium

reactor development remain in the early stages of research, falling RE costs may heighten competition. Past nuclear disasters have raised concerns, and community acceptance remains challenging. Despite these hurdles, the mission aims to strengthen domestic nuclear capacity and boost energy efficiency in India.

The National Green Hydrogen Mission arose from India's goal to be Net Zero by 2070 and energy efficient by 2047. Its aim is not only energy independence but also surplus generation for export, helping to shift from carbon-intensive energy to clean fuels. Governed by the Ministry of New and Renewable Energy (MNRE), the mission has a standardised regulatory framework to ensure efficiency, interoperability, and global alignment, promoting cross-border trade. A national portal will monitor the efficacy, safety certifications, and regulatory clearances. Coordination among governments, businesses, academia, and international partners is encouraged, with private sector involvement to overcome market barriers being necessary. Green hydrogen can be crucial for decarbonising steel, fertilisers, and heavy industries, with a 2030 target of five million metric tons annually. Cost reduction is pursued via pipelines, electrolyzers, small hydro systems, rooftop solar systems, and wastewater electrolysis. International R&D collaboration supports electrolyser development. Phase one (2022–2026) focuses on infrastructure, pilots, compliance, investment risk assessment, policy improvement, and safety. Phase two (2026–2030) expands adoption to carbon-intensive sectors, mandates consumption under the ECA, develops skills, transitions the workforce, promotes partnerships, and raises public awareness. Despite progress, achievements are unassessable due to the early research phases, high production costs, and limited hydrogen technology.

4. Discussion

Despite the ambitious goals and policy frameworks listed in national documents, energy transition faces several critical challenges. Policies often fail to achieve their intended targets. For example, according to the Ministry of New and Renewable Energy, in the Indian rooftop solar initiative, 'PM Surya Ghar Muft Bijli Yojana' (2024/2025), only about 613,000 people out of 4,700,000 applicants received government-provided subsidies. This is an example of a policy gap between planning and execution, resulting from a lack of sufficient funds for this type of investment. Despite significant achievements in RES investments, India's current efforts towards a low-carbon economy have not been sufficient to reduce CO₂ emissions. The growing energy demand is also driving the use of traditional energy sources based on the combustion of non-renewable energy sources.

The authors listed several social, political, and economic barriers to the development of LCEs (Lawrenz et al., 2018). The main social barrier is poverty, which prevents investment in energy efficiency and distributed energy sources at the local level. The coal mining and energy sectors employ over 400,000 people. These employees and their families constitute an important political lobby that supports this economic sector. In the nuclear sector, the major social obstacle is public opposition stemming from safety

concerns, especially in light of past industrial disasters, such as the Fukushima nuclear accident in Japan (Vidhyarthi, 2015). Societal resistance and stringent regulations continue to delay project implementation and reduce public trust in nuclear energy as a viable low-carbon solution (Selvam et al., 2025). Challenges in nuclear waste management, regular uranium supply, and the complexity of regulatory approval processes further slow down progress. These issues are compounded by the difficulty in fully realising RE goals, indicating the need for more aggressive and coherent policy execution. Both nuclear energy and RE require huge capital expenditures, which are lacking in India's budget. Inadequate storage facilities, underdeveloped technology, grids, and infrastructural energy transmission to rural areas are considerable problems for RE development. In this sector, a significant gap remains between the estimated potential, national goals, and actual deployment of technologies. Factors such as inadequate dissemination strategies, technological limitations, and inconsistent implementation hinder progress (Chandrasekar and Kandpal, 2007). Without strong measures to curb coal use, the rapid adoption of renewable technologies may still fall short of the carbon reduction targets required to meet climate goals by 2050 (Barbar et al., 2023). Effective decision support systems are required for RES development, for example, by effectively assessing the feasibility of locations for RES (Kazak et al., 2023). There is also the potential to increase waste-to-energy generation in India, but this is controversial from an environmental perspective, and it is recommended to reduce the amount of waste and recycle it rather than incinerating it.

Furthermore, India continues to grapple with an energy crisis characterised by unreliable power supply, transmission losses, and increasing demand, particularly in the rapidly growing building sector (Joshi and Pathak, 2014). Although increasing RE is vital, its rapid integration into India poses significant challenges to the existing coal-based infrastructure and has major socio-economic implications for the country. There are also opinions that express concerns about abandoning traditional fossil fuels too quickly. Pandey and Kumar (2025) believe that if India moves away from coal too quickly, there could be several serious economic risks, including threats to energy security, the creation of stranded assets, loss of livelihoods, technological complexities of transitioning to low-carbon technologies, an increase in import dependency, and significant financial losses to the government's exchequer. Therefore, policy must adopt a holistic socio-technical approach at the local and central levels that supports flexible coal-fired power plant operations, invests in new technologies, and manages the transition justly to mitigate potential disruptions (Debnath et al., 2021). However, excessive climate change caused by CO₂ emissions could trigger even more costly and disruptive changes in the future. However, these changes are difficult to predict. Consequently, the development of nuclear infrastructure is crucial for decarbonising India's power sector (Selvam et al., 2025).

Efforts to achieve a low-carbon economy cannot be confined to national energy policies that focus solely on large-scale production. Equally intensive action is needed to improve energy efficiency in the economy and households. Using current technologies, single-family households in most parts of India can become annual producers rather than consumers of energy. However, this requires financial backing for grassroots initiatives, as residents often lack resources for relatively costly energy efficiency investments.

Research in some countries shows that local communities dependent on traditional household energy sources (e.g. fossil fuel stoves) are often not strongly inclined to develop RE sources (Furmankiewicz et al., 2021). Therefore, development must consider both centralised and locally distributed energy sources while maximising energy efficiency in industry, agriculture, services, and households, alongside societal education.

A comparison of the projected reduction in CO₂ emissions associated with investments in LCEs suggests less favourable outcomes for India than for many other countries. Compared to 2015 levels, emissions are anticipated to fall across many countries by 2050, except India. Projections indicate that developing nations, such as Brazil, China, India, and Indonesia, will see a sharp rise in greenhouse gas emissions, whereas developed nations, such as Canada, Japan, and the United States, are expected to experience relative stabilisation (Fragkos et al., 2021). The European Union is an exception because emissions in this area could continue to decline through 2050 (Fragkos et al., 2021; Manowska et al., 2024). Under a low-emission pathway, many countries are projected to cut emissions from reference levels, with reductions ranging from approximately 10% in Brazil to over 60% in Canada, the EU, and the USA. However, the emphasis on developing particular types of energy varies from country to country, depending on financial and technological resources, natural conditions, and national policies. Labour-intensive RE projects favour emerging economies such as India, but in mature markets like Germany, future RE growth can be more difficult due to high saturation (Murgan et al. 2025).

Conclusion

Despite its significant achievements in the development of LCEs (Singh et al., 2023), India continues to increase its consumption of fossil fuels that emit CO₂. Presumably, without the development of nuclear energy, reducing the role of fossil fuels will not be possible over a long period. Based on the analyses presented, we can identify three main recommendations for India's energy policy at the national, federal, state, and local (districts and municipalities) levels.

(1) At the national level: The central government should define quantifiable LCEs development goals for all national and state energy plans to improve monitoring and accountability. It should also address nuclear energy concerns, such as safety and nuclear waste management. Central subsidies should be designed to encourage activity, for example, by offering bonuses in subsidies to the most active states. Mandating rooftop solar installations for new building construction can be included as a policy measure. Extending the deadline of the Production-Linked Incentive (PLI) scheme up to 2030 is required to encourage the private sector to invest in the production of high-efficiency PV modules, as the development did not meet expectations. India must support public-private partnerships in the energy sector, and facilitate access to individual bank credits or subsidies for decentralised RES installations in households and medium-sized enterprises. Significant efforts are needed to modernise energy grids to integrate RES into

the existing system. The future development of Small Modular Reactors (SMRs) is also an opportunity.

(2) At the state level: States should be required to prepare regional strategies and plans for the development of LCEs in accordance with their physical and geographical conditions, considering measures to save energy, not just produce it.

(3) At the local level: Initiatives for developing urban low-emission development strategies (Staden et al., 2014) should be further expanded, and energy saving should be promoted. Greater emphasis should be placed on modern, dispersed RE sources, energy efficiency, and recycling rather than waste incineration. In the event of problems with the development of the energy network, local off-grid systems with battery storage should be supported. It is also necessary to educate residents on behaviours that promote low-carbon economies.

Finally, coordination between the central and state governments must be improved. Greater attention should be paid to increasing energy efficiency, particularly in industries and households. Traditional economic development focuses on energy development and supply, generating profits for energy companies. However, energy efficiency can significantly reduce the increase in energy demand, thereby contributing to the achievement of sustainable development goals.

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Comparison of Tertiary Education Financing in the Czech Republic with Selected EU Countries

Abstract

This article deals with a comparative analysis of tertiary education financing in the Czech Republic and selected European countries in the period 2012-2021. It uses harmonised Eurostat data, which have been converted into purchasing power units (PPS) to ensure international comparability. It focuses on key indicators - total and public expenditure on education, its share in GDP, expenditure per student and student-teacher ratio. The results show significant differences between countries. Germany and Sweden stand out with high investment and a favourable student-teacher ratio. Turkey, despite lower GDP, devotes a significant share of public funds to tertiary education but faces teacher overload. The Czech Republic is below average in international comparison, both in absolute expenditure and in relation to GDP. Nevertheless, there has been an improvement in expenditure per student and a reduction in the student-teacher ratio in recent years. Finally, the study emphasises the need for a strategic approach to tertiary education financing. The Czech Republic needs to increase public investment and stabilise academic staff if it wants to move towards advanced European systems and ensure the long-term competitiveness of its education sector.

Key Words: Tertiary Education, Public Expenditure, International Comparison, Student-Teacher Ratio, Eurostat

JEL Classification: I22, H52, O57

Introduction

Education is one of the key pillars for the development of a knowledge-based economy and sustainable national competitiveness. Tertiary education has a special role to play in this context, not only providing professional knowledge and skills, but also promoting research, innovation and social progress. However, the effectiveness and sustainability of the higher education system depends on a range of factors, from the level and structure of financial investment to the quality and availability of academic staff.

Given the increasing pressure on public budgets and changing demographic and social conditions, the allocation of resources to tertiary education is a subject of professional and political debate across Europe. In this context, the Czech Republic faces challenges related to the long-term lower expenditure on education relative to GDP and the tight structure of the academic labour market. Comparisons with selected European countries can provide valuable insights into the relative position of the Czech Republic and identify strengths and weaknesses in the development of tertiary education. This paper focuses on a systematic comparison of selected indicators of tertiary education in the Czech Republic, surrounding Central European countries, Sweden as a country with a high standard of living and a country with a different development trajectory - Turkey, which from the perspective of economic indicators is very interesting for comparison. Unfortunately, it was not possible to make a comparison with the EU28 countries in the paper as the time series of average values for each year was not complete.

1. Methods of Research

To ensure the scientific validity of the analysis, a quantitative approach based on secondary processing of structural data from harmonised European statistics was chosen. All datasets used come from a single source (Eurostat, 2025a; Eurostat, 2025b) to ensure methodological consistency and comparability across countries. The indicators observed relate exclusively to tertiary education (ISCED 5-8) and include both financial and personnel dimensions. The analysis is based on harmonised Eurostat data for the period 2012 to 2021 and focuses mainly on financial expenditure, its structure and the capacity of academic staff. The aim is to contribute to a better understanding of the Czech Republic's position in the European context and to provide a basis for an informed debate on the strategic direction of tertiary education. From a data perspective, data extraction was carried out for the following thematic areas, which we consider key for comparing the situation in tertiary education with other selected countries.

1. total expenditure on education,
2. the structure of public and private expenditure, both in total and per student,
3. share of tertiary education spending in total GDP,
4. statistics on teaching and academic staff

The next step was to harmonise the units and convert the indicators into a format that allows direct comparison between countries - for example, by converting absolute per capita or per student expenditure, or by expressing them as a percentage of gross domestic product (GDP). For all indicators, the time dimension was retained in order to track developments over the period under review, and the values were converted to the Purchasing Power Standard (PPS, defined in the following paragraph). Data expressed in financial units are in EUR PPS (Purchasing Power Standard). PPS is the purchasing power standard. It is an artificial currency unit. Theoretically, one PPS can buy the same amount of goods and services in each country. However, price differences across borders mean that different amounts of national currency units are needed for the same goods and services depending on the country. PPS are derived by dividing any economic aggregate of a country in national currency by its respective purchasing power parities. (Eurostat, 2025) Descriptive statistical analysis was performed on the adjusted and harmonized

data. It included calculation of basic characteristics of the distribution (**arithmetic mean, median, quartiles, standard deviation**) and detection of trends using time series. To illustrate differences between countries and trends over time, results were presented using graphical and tabular outputs.

The processing was carried out using Microsoft Excel tools and the Python programming language, especially the Pandas and Matplotlib libraries.

2. Results and Discussion

Based on revised data on annual spending on tertiary education in eight European countries for the period 2012 to 2021, there are significant differences in the level of investment between countries. The figures are expressed in PPS EUR per student and include both public and private sources of funding. As mentioned in the Introduction of this paper, we do not purposely provide EU27 or EU28 averages in the analyses because the quality of the data available in the data sources is not sufficient. The following facts have led to this conclusion:

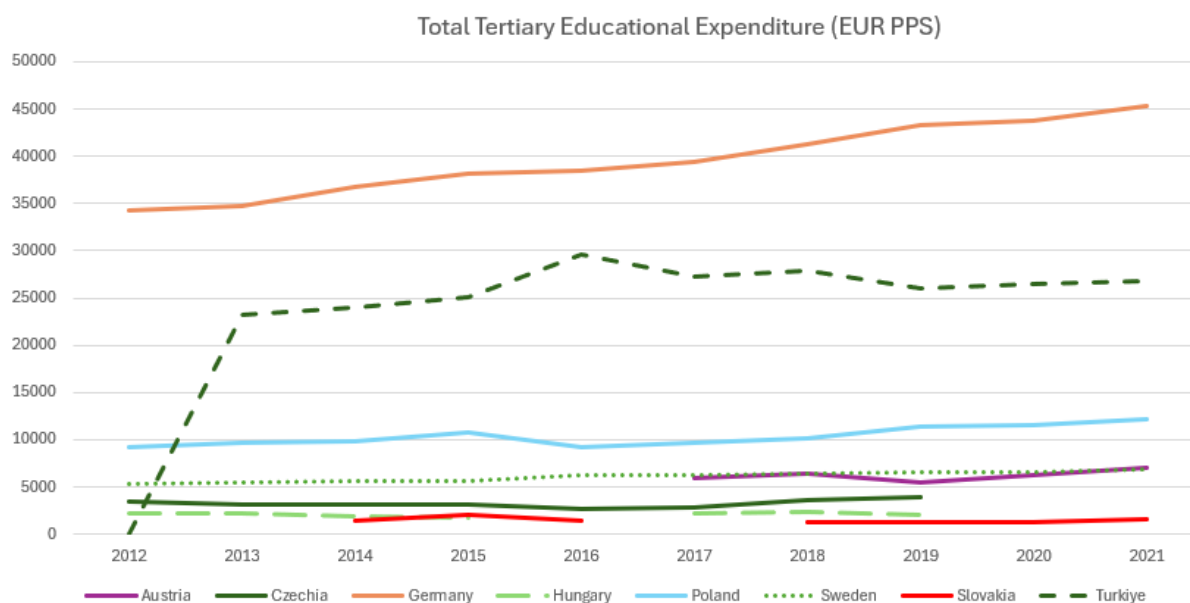
1. Average values are not filled in for all years included in the analysis,
2. The number of countries in the EU changes over time and this is not sufficiently reflected in the data.

2.1 Total Tertiary Educational Expenditure

The first analysis focuses on Total Tertiary Educational Expenditure in EUR PPS and aims to compare the value of this indicator between the countries included in the comparison. By far the highest average is **Germany**, with an average annual investment of over €39,500, which is on a steady upward trend. This figure confirms the strong support for the tertiary education system in the context of a mature and stable economic framework over the period under review. In second place is **Turkey**, with a significantly lower but still high average of around EUR 23 600. The significant increase in spending in the initial period in Turkey is followed by a gradual increase during the period under review, which is accompanied by a slight oscillation around the aforementioned rising average.

This development can be interpreted as a strategic orientation of the country towards strengthening higher education as a tool for modernisation and social upliftment. In terms of the Central European region, **Poland** has the highest average value, with average annual expenditure exceeding €10,000. This indicates relatively strong support for the higher education sector compared to other countries in the region. **Austria** and **Sweden** show a similar level of spending, slightly above EUR 6 000 per year, with both countries showing a stable and slightly increasing trend over the period under review.

Fig. 1: Total Tertiary Educational Expenditure (EUR PPS)



Source: authors, data from (EUROSTAT, 2025a)

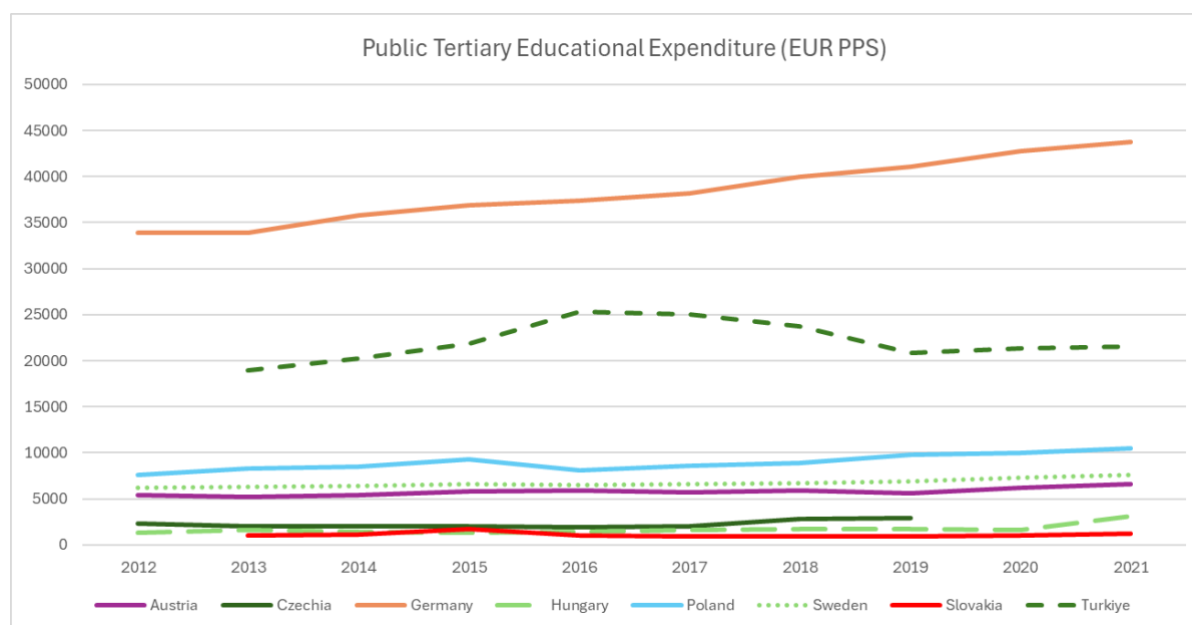
The Czech Republic, Hungary and Slovakia are at the lower end of the spectrum in this analysis. The Czech Republic has slightly fluctuating values between EUR 2 600 and EUR 3 900, with no significant upward trend. Hungary and Slovakia record significantly lower values, often accompanied by gaps in the data, which makes reliable interpretation difficult. These countries thus remain below average in terms of investment in tertiary education compared to most of the countries analysed.

The results confirm considerable variation in the approach of European countries to higher education funding. While some countries allocate high levels of resources steadily and over the long term, others lag behind or show irregular trends, which may reflect, for example, different policy priorities or different levels of private co-funding, which are analysed in the following text.

2.2 Public Tertiary Educational Expenditure

The following analysis focuses on public spending on tertiary education. Public expenditure is a key component of tertiary education funding and its evolution reflects the level of government commitment to higher education policy. The data analysed confirms that there is considerable variation across European countries not only in the overall level of investment but also in the weight that public funding carries in this expenditure.

Fig. 2: Public Tertiary Educational Expenditure (EUR PPS)



Source: authors, data from (EUROSTAT, 2025a)

The highest average public spending over the period was recorded in **Germany**, at around **€38 360 per student per year**. This level is only 3% below the average value of total expenditure, confirming that the German higher education system is predominantly publicly funded. A similarly high share of public expenditure was observed in **Turkey**, where the average value is around **€22,100**, i.e. around 93% of the total expenditure from the previous analysis. This confirms that even in emerging economies the state plays a crucial role in supporting higher education.

In the **Central European context**, **Poland** has the best profile, with an average public expenditure of almost **€8,950**, equivalent to around 86% of the total. This figure suggests a solid level of public support combined with a likely lower share of private co-financing. **Sweden** has an average public expenditure of **EUR 6 720**, accounting for more than 90% of total expenditure, which can be described as a model based on education provided through publicly subsidised education.

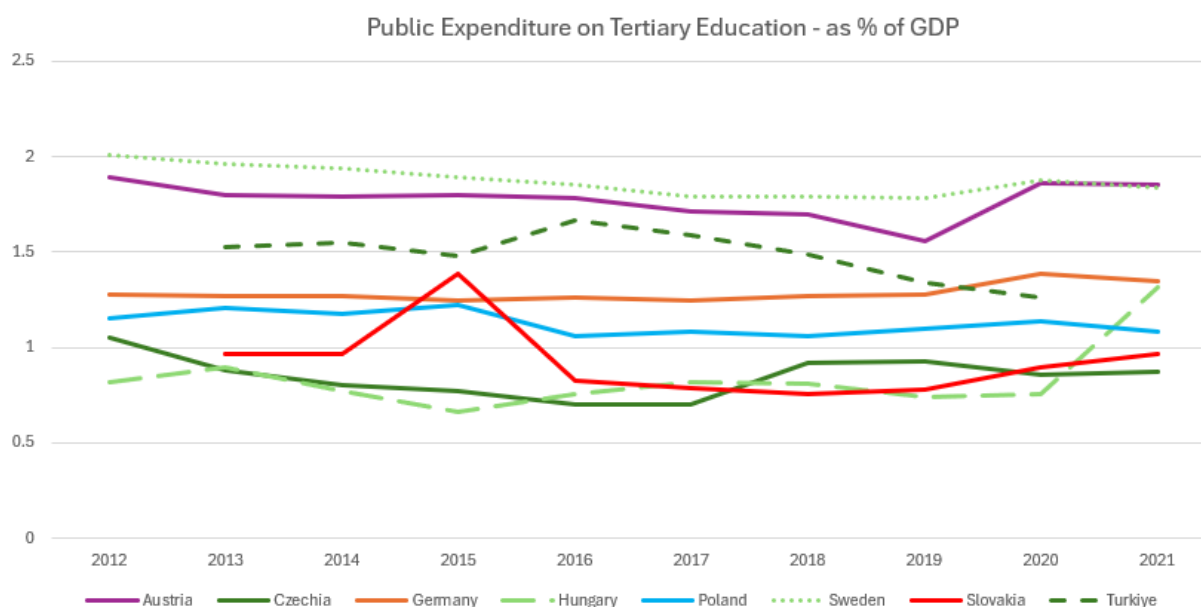
Austria is also in a similar range at EUR 5 770, with a minimal difference to total expenditure. Thus, in both cases, the public sector dominates the financing of tertiary education. In the case of **the Czech Republic, Hungary and Slovakia**, the observed expenditure structure is different and complicated by the frequent occurrence of incomplete data. Nevertheless, the available data show that public expenditure accounts for the vast majority of total spending in the Czech Republic, although the absolute level remains low. Public funding in these countries is not even half the German or Swedish level, even when converted to PPP (News, 2018; Eurostat, 2025c). A comparison of **total** and **public** expenditure shows that in most of the countries analysed, public resources account for the vast majority of tertiary education funding - most often between 85-95%.

Exceptions may be countries with a stronger private sector or with higher levels of household or business co-financing, which would be the subject of further analysis.

2.3 Public Expenditure on Tertiary Education as % of GDP

Another interesting perspective is the share of tertiary education spending in GDP. Relative tertiary education spending, expressed as a percentage of GDP, shows the share of national product that countries allocate to the higher education sector. This metric allows comparisons between countries regardless of their economic size or price level. The data show that **Sweden** and **Austria** systematically allocate the highest share of public support of their GDP to tertiary education. **Sweden** averages **1.87%**, while **Austria** follows with an average of **1.77%**. In both cases, this is a stable and consistent long-term support for public education, confirming the Swedish and Austrian socially oriented public service model. **Turkey** ranks third with **1.49% of GDP**, which, given its lower GDP per capita, confirms a particularly strong focus on tertiary education development. This figure builds on previous findings of high absolute and public expenditure and underlines the strategic importance of the tertiary sector in Turkish national policy. **Germany** is below these countries with an average share of **1.29% of GDP**, but still represents an above-average level of public funding relative to its strong economic base. It is important to stress here that Germany's absolute spending is by far the highest in the sample, so the lower relative share is due to the size of the economy rather than a lack of support.

Fig. 3: Public Expenditure on Tertiary Education as % of GDP



Source: authors, data from (EUROSTAT, 2025a)

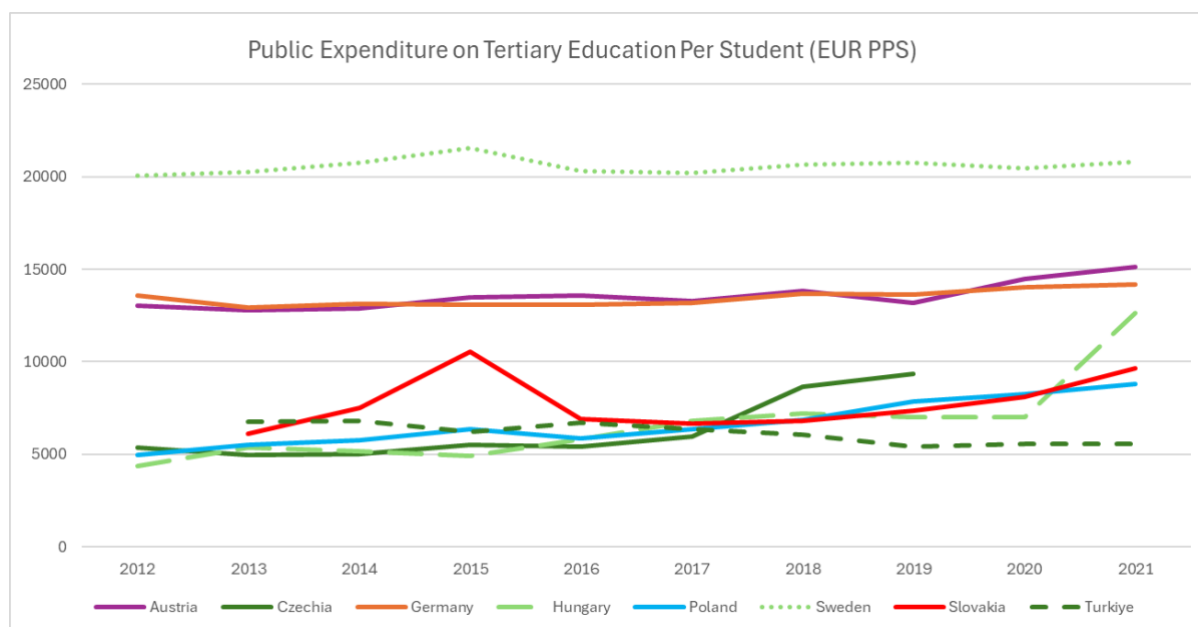
Poland invests an average of **1.13% of GDP** in tertiary education, which puts it slightly below the European average of around 1.27% of GDP. In contrast, **the Czech Republic**,

Hungary and **Slovakia** have been below 1% of GDP for a long time. The **Czech Republic** has recorded values below 0.8% in some years, with a short-term increase around 2018, but this has not been sustained. **Hungary** shows an erratic trend, with the lowest values in 2015 (0.66%) and a spike only in 2021 (1.32%). **Slovakia**, in turn, is one of the countries with the lowest and most volatile expenditure shares, often between 0.7% and 0.9% of GDP. If we compare the results as a share of GDP with absolute expenditure, we can see that while **Germany** and **Turkey** have very high absolute and public expenditure, their relative share of GDP is lower than that of Sweden and Austria. This means that economically strong countries can invest more in absolute terms without having a significant impact on the structure of public expenditure. In contrast, countries with lower GDP per capita, such as Turkey, have high shares of GDP even with relatively lower absolute amounts. For the **Czech Republic** and **Slovakia**, the weak public involvement in financing higher education is confirmed, both in relative and absolute terms. The low share in GDP is complemented by low expenditure in PPS EUR, indicating a long-term structural underfunding of the tertiary sector.

2.4 Public Expenditure on Tertiary Education Per Student

The indicator of expenditure per student in purchasing power parity (PPS) allows to look at the efficiency and intensity of tertiary education financing from the perspective of the individual beneficiary - i.e. the student. This metric also removes the impact of differing price levels between countries and makes international comparisons more accurate.

Fig. 4: Public Expenditure on Tertiary Education Per Student (EUR PPS)



Source: authors, data from (EUROSTAT, 2025a)

Sweden has been the highest performer over the long term, investing on average more than €20 500 PPS per student per year. This result confirms the strong public

commitment to equity of access and high quality higher education. **Austria (€13,570)** and **Germany (€13,450)** are in second and third place, with both countries showing stable investment levels throughout the period under review. In these cases, relatively high public expenditure per GDP is matched by well above-average support per student. **Slovakia**, despite having a lower share of public expenditure in GDP and lower absolute expenditure in comparison, achieved a surprisingly solid level of average aid per student - almost **€7 750 PPS**. However, this figure shows high volatility over time, which may be due to fluctuating student numbers or funding shortfalls. **Poland** invested an average of **€6 660 PPS** per student, placing it among the countries with moderate support for tertiary education.

Based on the previous data, the **Czech Republic**, **Hungary** and **Turkey** lag behind most of the countries surveyed in this indicator, despite some upward fluctuations between 2018 and 2021. In particular, for **Turkey**, it can be seen that despite the high share of public expenditure in GDP and relatively large total amounts, expenditure per student in the PPS is lower, which may be related to demographic pressure and the high number of students in the system. **The Czech Republic** has shown an increase in spending per student in recent years (e.g. more than €9,300 in 2019). An interesting perspective complementing this analysis may be the wage perspective broken down into men and women and the trend of their development in relation to total expenditure (Nedomova, 2017).

2.5 Ratio of Students to Teachers on Tertiary Education

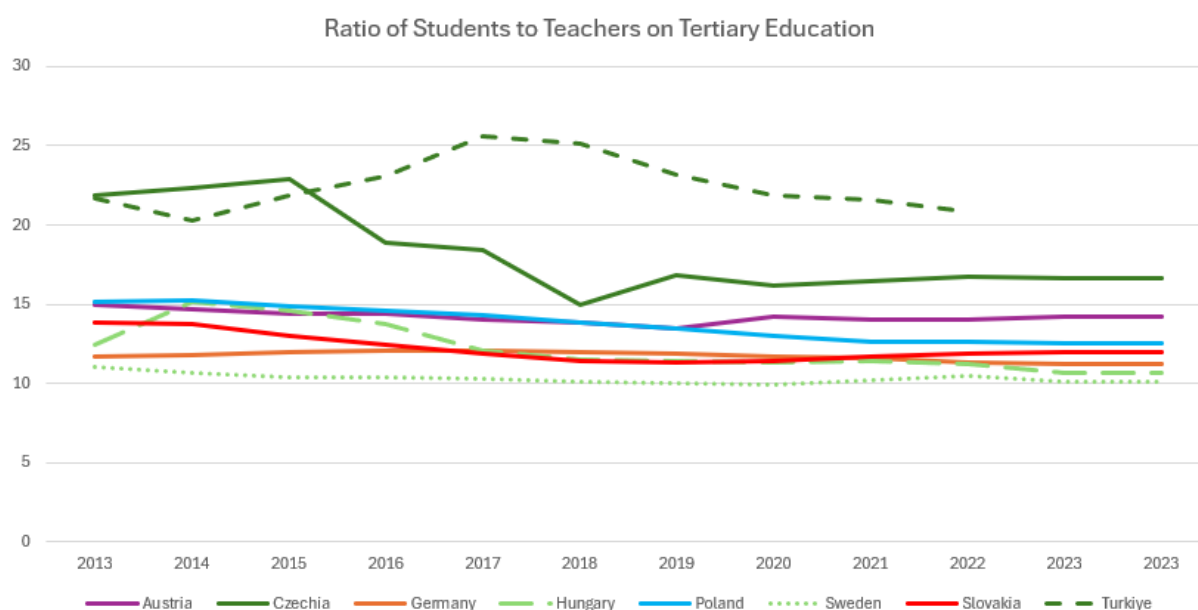
The last analysis is Ratio of Students to Teachers on Tertiary Education. The ratio of students to teachers is a key indicator of the quality of higher education. Lower values usually indicate better conditions for individual access, higher teaching capacity and potentially higher teaching quality.

The data analysed shows that **Sweden** has maintained **the lowest student-teacher ratio** over the long term, averaging **10.3 to 1**. This result confirms a consistent investment policy in human resources and supports previous conclusions about high expenditure per student. The structure of higher education and investment in tertiary education in Sweden, which, as mentioned above, is primarily publicly funded, can also be discussed.

In second place is **Germany** with an average ratio of **11.76 to 1**, also very favourable. This figure is consistent with high public and total expenditure and underlines the comprehensive quality of the German tertiary system. Other countries with relatively low academic workload include **Slovakia (12.23 : 1)** and **Hungary (12.31 : 1)**.

Poland is on the higher end with an average of **13.83:1**, but still remains below internationally accepted limits. In contrast, **Austria** shows higher values (above 14 : 1), with a slight increase in recent years. This trend contrasts with its otherwise above-average spending levels, and may signal a tension between investment and student growth.

Fig. 5: Ratio of Students to Teachers on Tertiary Education



Source: authors, data from (EUROSTAT, 2025b)

The Czech Republic shows a specific development. In 2013-2015, the ratio was above 22:1, which meant one of the highest teacher workloads in the countries analysed. Since 2016, there has been a significant decline, stabilising in the range of 15-17 students per teacher. However, the average over the whole period is still relatively high, at around **17 : 1**, indicating a long-term shortage of academic staff in relation to the number of students. An alternative explanation may be the large number of domestic and foreign students studying in Czech taking advantage of the funding system where public tertiary education is free.

Turkey scores the highest of all countries surveyed. In some years, the ratio exceeds 25:1 (e.g. 2017-2018), which represents a significant overstaffing. Despite partial improvements in recent years (e.g. 20.8 : 1 in 2022), the average remains the highest of the whole sample, which is related to the high demand for tertiary education and the rapid increase in the number of students. This conclusion is a good stimulus for further detailed analysis.

Conclusion

The results of the analysis show major differences in the approach to financing and staffing of tertiary education between European countries and Turkey. Although some countries show high spending in absolute terms, their relative share of GDP may be lower than in countries with less economic strength. This is borne out, for example, by Germany, which, despite having the highest absolute expenditure per student and high public investment, allocates a relatively smaller share of GDP to tertiary education than Sweden

or Turkey. This implies that the assessment of spending must always be interpreted both in absolute terms and in the context of a country's economic performance.

Sweden has not only invested heavily in tertiary education for a long time, but has also achieved a low student-teacher ratio. The result is a stable system that provides a quality learning environment supported by robust public financial support. In stark contrast, Turkey's rapid expansion of the tertiary sector has led to an exceptionally high teacher workload. Despite a high share of public spending in GDP and considerable investment at the system level, there is a lack of balance between quantitative growth and quality of education. The Czech Republic deserves special attention. Although there has been some increase in spending per student and an improvement in the student-teacher ratio in recent years, the level of public spending remains below the European average both in absolute terms and relative to GDP. The student-teacher ratio, although down from its former extremely high levels, is still higher than in Germany, Austria or Sweden. This suggests that the Czech tertiary education system is still underinvested and staff stretched, and that improving it would require a coordinated increase in funding and capacity.

A rather surprising result came from the analysis of Slovakia, where lower systemic expenditure was identified, but at the same time relatively high expenditure per student and a favourable student-teacher ratio. This discrepancy may be due to specific demographics, curriculum structure or reporting methodology, which presents scope for deeper qualitative investigation. Overall, countries with long-term stable and high public investment - such as Sweden or Germany - are able to ensure favourable conditions for teaching and staff stability. Conversely, countries with low investment, or those that focus primarily on expanding access to education without adequate increases in staff capacity, face higher levels of academic overload and less individualisation of teaching.

Future policy decisions in tertiary education should therefore be based on three main principles: sufficient and stable funding, a balance between quantity (**number of students**) and quality (**of curricula and teachers**), and long-term support for human resources. Without these, it will not be possible to ensure the sustainable development of the higher education sector, which is essential for the competitiveness of European economies and their ability to respond to global challenges.

If the Czech Republic really wants to move closer to the European leaders, it must stop seeing investment in tertiary education as a cost and start seeing it as a strategic investment in future prosperity. Increasing public spending, stabilising staff capacity and reducing academic overload are necessary steps if Czech universities are to compete in the 21st century.

Acknowledgment

This part is optional. It may contain references to your projects and sources financial support.

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The Role of the Labor Market in Ensuring the Sustainability of the Pension System

Abstract

The sustainability of the pension system is a key fiscal and social challenge that is exacerbated in the Czech Republic and other developed countries by demographic trends such as population aging, declining birth rates, and increasing life expectancy. These factors are putting increasing pressure on public finances and calling into question the stability of pay-as-you-go financing. The aim of this article is to comprehensively analyze the role of the labor market in ensuring the sustainability of the pension system and to identify key variables and their interrelationships. The analysis uses system dynamics methodology and a causal loop diagram (CLD) created in Stella Professional software. This diagram visualizes the complex system dynamics and feedback loops between key variables such as the number of workers, retirement age, system revenues and expenditures, and the influence of external factors. The results show that the sustainability of the system depends on a fragile balance that can be influenced by political interventions aimed at adapting the labor market. These include measures to support the employment of older workers and incentives to stay in employment longer. It is also crucial for long-term stability to take into account new trends such as flexible forms of employment, migration, and the impact of automation. Furthermore, it is necessary to emphasize the social acceptability of reforms and their accompanying measures in order to ensure not only financial stability but also intergenerational fairness and political acceptance.

Key Words: Causal Loop Diagram, Stella, Expenditures, Labor Market, Pension System

JEL Classification: H55, J26, J14, C63

Introduction

The sustainability of the pension system is one of the key challenges facing fiscal policy in the Czech Republic and other developed countries. An aging population, declining birth rates, longer life expectancy, and a declining ratio of economically active people to pensioners are putting increasing pressure on public finances and calling into question the long-term stability of the pension system. (Bloom et al., 2010; Chybalski & Marcinkiewicz, 2016; OECD, 2023; Valls Martínez et al., 2021). The International

Monetary Fund (IMF, 2025) defines a sustainable pension system as one that is capable of meeting its obligations to pensioners in the future, even in the face of demographic and economic challenges. According to the IMF, the key factors for sustainability are financial stability, social justice, and economic efficiency. While in the past it was possible to maintain the pension system through partial parametric adjustments, today's demographic and economic trends require deeper structural reforms to ensure its long-term stability and fairness across generations. Further studies (Bloom et al., 2014) show that longer life expectancy in good health usually leads to later retirement, but with elasticity less than one. Moreover, over the last century, it appears that rising incomes have encouraged early retirement, outweighing the impact of longer life expectancy. Other authors (Mao et al., 2014) point out that initial salary levels and salary growth rates also play an important role in determining the optimal retirement age. Initial consumption levels and interest rates are also important, but to a lesser extent. Furthermore, the combination of support sources varies depending on the institutional environment and how the population is aging. New ways to make pension financing more efficient are constantly being sought (Eggleston & Mukherjee, 2019).

The sustainability of pension systems has been addressed in a number of studies, which can be divided into analyses based on the Overlapping Generations (OLG) model and other prognostic models focused on individual countries, and comparative studies classifying countries using indicators or synthetic indices. Research based on the Overlapping Generations model has been ongoing for a number of years (Boldrin & Montes, 2009; Börsch-Supan et al., 2006; Fanti & Gori, 2010; Fougère & Mérette, 1999; İmrohoroglu et al., 1995; Krpan et al., 2022; Razin & Sadka, 1999). Other studies (De La Fuente & Doménech, 2013) have taken a different approach based on estimating the impact of the reform by breaking down pension expenditure relative to GDP and monitoring the "generosity" ratio. A similar methodology was used by the European Commission and other authors (Chybalski, 2016; Chybalski & Marcinkiewicz, 2016; Krpan et al., 2022; Skuflic et al., 2020), and other authors who consider pension expenditure as a percentage of GDP, as monitored by Eurostat, to be the main indicator of sustainability. Next studies (Peksevim & Ercan, 2024), emphasize the importance of cash funds, pointing out that pension funds significantly reduce financial stress in both crisis and non-crisis times.

In the Czech Republic, total pension expenditure accounts for approximately 9% of GDP. (Ministry of Finance of the Czech Republic, 2025). The pension system reform, which will take effect in 2025, represents an effort to balance the system's income and expenditure sides. However, its long-term impact will also depend on the labor market's ability to adapt to demographic changes.

1. Methods of Research

The aim of this article is to comprehensively analyze the key factors and their interrelationships that influence the long-term sustainability of the pension system in the context of an aging population, with a particular emphasis on the adaptability of the labor market. Using a Causal Loop Diagram (CLD) created in Stella software, the system

dynamics are visualized and positive and negative feedback mechanisms are identified that can strengthen or weaken the fiscal stability and intergenerational fairness of the pension system. The chosen methodology is based on the principles of system dynamics, which allows for the examination of complex socioeconomic systems through modeling, simulation, and analysis of behavior over time (Sterman, 2000). This approach is particularly suitable for examining long-term macroeconomic processes such as population ageing, labour market participation trends or the sustainability of the pay-as-you-go pension system, where there are delays, feedback loops and non-linear interactions between individual variables.

Simulations and visualizations were performed using Stella Professional, a specialized software designed for modeling levels and flows, which allows for intuitive visualization of the dynamic behavior of systems (ISEE systems, 2025). A Causal Loop Diagram (CLD) was used to identify key variables, their interrelationships, and types of feedback loops. The main variables included in the model are the number of economically active persons, the participation rate of older workers, the number of pensioners, the average retirement age, the average wage, the unemployment rate, the average pension amount, and the system's income and expenditure. The resulting CLD provides an overview of the mechanisms that affect the stability of the pension system and allows for the identification of potential intervention points that fiscal and labor market policies can target in the search for ways to ensure its long-term sustainability.

2. Results of the Research

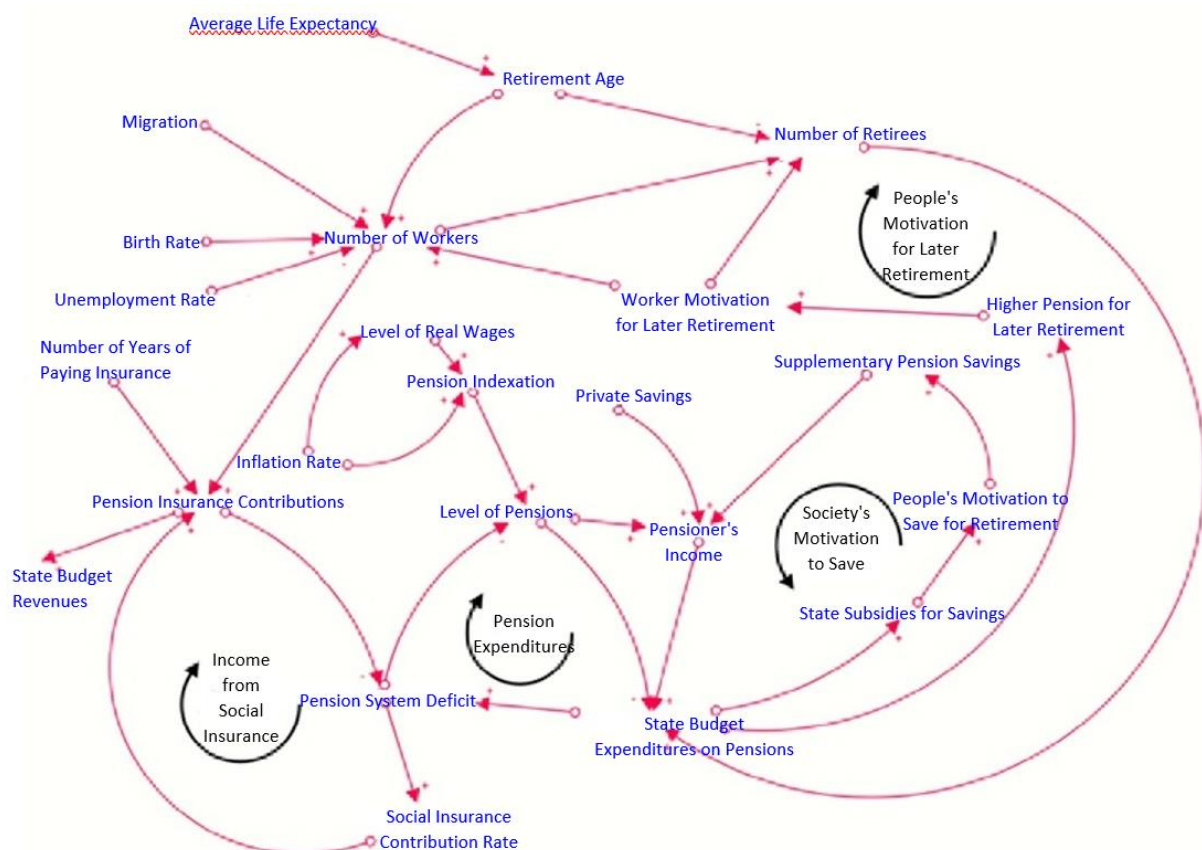
The analysis of the pension system is based on the creation of a causal loop diagram (CLD) that maps the interrelationships between key variables affecting the stability and sustainability of the system. This diagram serves as a basic structure for understanding the dynamics of the pension system, which in the Czech Republic operates on the principle of pay-as-you-go financing – that is, the currently working generation finances the pensions of the retiring generation. The basic and central variable of the entire system is the number of workers. It is this number that has a direct impact on pension insurance revenues and thus on the overall state of the national budget. The number of workers is influenced by several factors, the main ones being the birth rate, migration, the unemployment rate, the retirement age, and people's motivation to postpone retirement. A high birth rate contributes to the growth of the workforce in the long term, while an increased unemployment rate has the opposite effect. In addition, migration also has a significant impact on the number of workers, as it can supplement the workforce in the short term, especially in a situation of an aging population (Karlová, 2025).

Motivating people to remain economically active for longer and retire later is another key factor. This motivation is often stimulated by higher pensions for those who retire later, which creates a positive feedback loop: more people in work means higher revenues for the pension system and lower demands on its expenditure. The retirement age is often adjusted to demographic developments, specifically the increasing average life expectancy. On the revenue side, the amount of social insurance paid by workers and the length of time for which this insurance is valid play an important role. These revenues

constitute a significant part of the state budget revenues allocated to pensions. Increasing revenue from pension insurance helps reduce the pension system deficit, which is desirable. However, if the deficit is high, the state can respond in several ways – for example, by increasing the insurance rate or reducing expenditure, i.e., pensions themselves. State budget expenditure on pensions is influenced by a valorization mechanism that responds to growth in real wages and inflation. This system ensures that pensions do not lose their purchasing power. However, high valorization can increase the burden on public finances over time, especially in periods of high inflation. Pensions are the main source of income for most seniors, but increasing emphasis is also being placed on individual provision, for example in the form of supplementary pension savings and private savings. These components are supported by state subsidies, which aim to increase people's motivation to provide for their own financial security in old age.

The causal diagram (see Fig. 1) clearly shows that the sustainability of the pension system depends on the balance between the number of workers, the amount of their contributions, and the amount of pensions paid out. Political decisions, demographic developments, and economic conditions form an interconnected and dynamic whole that needs to be analyzed as a system, not as a set of isolated measures.

Fig. 1: Causal Loop Diagram of Labor Market Dynamics and Pension System Sustainability



Source: authors' own calculations, based on (Karlová, 2025)

3. Discussion

The results of the analysis confirm that the sustainability of a pay-as-you-go pension system is fundamentally influenced by labor market dynamics, demographic developments, and the parameters of the system. The presented results of the analysis, based on system dynamics methodology and visualized using a causal loop diagram (CLD), confirm and further expand on the findings presented in the introductory section of this article. While a number of previous studies focus on individual parametric adjustments or prognostic models (e.g., within the *Overlapping Generations model*), our analysis emphasizes the complexity and dynamics of the entire system. The causal loop diagram (CLD, Figure 1) illustrates the central dynamics between the number of workers, contributions, pension expenditures, and the resulting reinforcing (R) and balancing (B) loops. It highlights the key feedback mechanisms that determine the long-term stability of the system. Positive feedback, such as the motivation to stay in the labor market longer due to higher pensions, can strengthen fiscal sustainability. This conclusion is consistent with Bloom et al. (Bloom et al., 2010, 2014) who show that longer healthy life expectancy leads to later retirement. At the same time, the analysis highlights the key role of policy decisions and economic conditions, which can strengthen or weaken these feedback loops.

Reinforcing loops underscore the multiplier effects of measures that promote employment, migration inflows, and wage growth—these not only increase contributions but also strengthen confidence in the pension system and extend working life. Balancing loops, on the other hand, capture mechanisms such as pension indexation or spending cuts that stabilize budgets in the short term but can reduce incentives and deepen intergenerational inequality. For example, indexation during periods of high inflation, although necessary for social justice (IMF, 2025) can undermine fiscal stability. Together, these mechanisms illustrate the fundamental trade-off between sustainability and fairness and confirm that neither of these dimensions can be secured in isolation and that a political compromise is necessary.

Furthermore, integrating migration, automation, and flexible forms of work into future models could significantly reshape the existing loops. Migration inflows can reinforce contributions (R) and mitigate demographic pressures (B). Automation can increase productivity and contributions, but may simultaneously reduce labor demand, weakening the reinforcing employment loop. Flexible work can extend labor force participation, reinforcing system stability, but if under-regulated, may also reduce contribution levels, creating balancing effects. These interactions highlight the need to treat labor market transformation as an integral part of pension system modeling. An interesting finding is the role of supplementary savings and private savings as a complementary balancing mechanism. Supporting these instruments with state subsidies creates a loop that reduces dependence on the pay-as-you-go system and strengthens the financial independence of seniors. This finding corresponds to the work of Peksevim et al. (Peksevim & Ercan, 2024) which emphasizes the importance of pension funds in alleviating financial stress.

In the context of the Czech Republic, pension expenditure accounts for less than 9% of GDP (of which old-age pensions account for 6.9%). However, despite being below the EU average, the recently adopted reform will only be successful if it manages to combine parametric changes, such as raising the retirement age, with measures to support the employment and productivity of older workers. Adjustments to the retirement age alone are not sufficient without

parallel steps in the labor market. Another finding is the lack of consideration of the impact of work under DPP ([agreements on work performance](#)) and other forms of flexible employment. Their growing importance requires their inclusion in the system's income prediction models. The social acceptability of reforms is also crucial – raising the retirement age may place a disproportionate burden on low-income groups and physically demanding professions ([Blundell et al., 2016](#)). [Blundell et al. \(2016\)](#) also analyzed evidence on modeling incentives for couples and joint decision-making. Political acceptance, transparent communication, and accompanying measures ([retraining, flexible transition to retirement](#)) are essential for successful implementation.

From a methodological perspective, it is necessary to acknowledge the limitation of the CLD approach: while it helps visualize and identify feedback structures, it does not provide quantitative simulation. This means that the strength of relationships and the magnitude of their impacts cannot be directly measured in this study. Future work should therefore combine CLD with quantitative system dynamics models to enable scenario testing.

Overall, the reform represents a step in the right direction, but it requires a broader strategy combining demographic, economic, and social tools ([Barr, 2012; Börsch-Supan et al., 2020; Börsch-Supan et al., 2006](#)). The latter study ([Börsch-Supan et al., 2020](#)) found that for both men and women, an increase in employment rates coincides with a reduction in incentives for early retirement.

Conclusion

The sustainability of the pension system in the Czech Republic and other developed countries is a complex problem that cannot be solved by isolated measures. This study used system dynamics methodology and visualization through a causal loop diagram (CLD) to demonstrate that the stability and long-term sustainability of the system depend on an interconnected network of factors, with the labor market playing a key role. The fundamental and most important link in the system is the dynamic between the number of workers, the amount of their contributions, and the number and amount of pensions paid. Feedback loops, such as incentives to remain in the labor market longer, can have a stabilizing effect. On the other hand, demographic trends such as population aging and declining birth rates represent external pressures that can lead to destabilization if not offset by the labor market's ability to adapt.

To ensure long-term sustainability, it is necessary to implement policies that not only regulate the parameters of the pension system itself, but also promote flexibility and adaptability in the labor market. This includes measures to promote the employment of older workers, improve their qualifications, and support intergenerational solidarity. To reduce the vulnerability of the system, it is essential to strengthen individual savings and other pillars that relieve the pay-as-you-go system. Future research should focus on how migration, automation, and flexible work interact with the identified feedback loops. Migration may strengthen reinforcing mechanisms by boosting contributions; automation may alter both reinforcing and balancing dynamics by raising productivity but potentially reducing employment; flexible work may extend careers but also create balancing pressures if contributions are lower. Explicit modeling of these interactions will be essential for accurate forecasts. In the context of the ongoing pension reform in the Czech Republic, it is therefore essential to monitor not only its direct fiscal impact, but above all its impact on labor market dynamics. Future research could focus on quantifying these

links and simulating the impacts of different policy scenarios. A combined use of CLD with quantitative simulations would allow testing the strength of different feedback mechanisms and their long-term impact on system sustainability.

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Not Just About the Money: How Investors Evaluate Startup Risks

Abstract

Startups are exciting but risky business. Today's investors look at more than just financial numbers when deciding where to put their money. This paper explores how both financial and non-financial risks affect and how startups are valued. The goal is to understand what kinds of risks matter most to investors and how these risks each other interact. To answer this, we reviewed ten peer-reviewed articles published between 2018 and 2024. These studies focus on topics such as cash flow, capital structure, ESG performance, team dynamics, and innovation. The findings show that investors are used to take a broad view. Weak cash flow can limit innovation, while issues with ESG or team quality can reduce a startup's chances of getting more funding and gaining real business progress. The paper also highlights how risk is seen differently in various parts of Europe, depending on local funding patterns. Startups that manage both types of risk effectively tend to grow faster and attract more stable investments. Financial indicators still matter, but soft factors like adaptability and leadership play a growing role in investor decisions as well. This paper suggests that founders should treat risk management as a strategic tool, not just a financial safeguard. By combining both perspectives, investors and entrepreneurs can mutually make more informed, long-term decisions about the future of a startup.

Key Words: Startup Valuation, Financial and Non-Financial Risk, ESG, R&D

JEL Classification: G32, M21

Introduction

Startups are young companies with big ideas and strong ambitions but also they face many risks. Because usually they're new and often depend on outside funding, investors need to carefully assess what could go wrong. In the past, financial numbers like cash flow or revenue were the main focus. But recent studies show that things like how adaptable

the company is, how strong the team works together, and whether the startup follows ESG (environmental, social, and governance) standards are becoming just as important (Gompers et al., 2016; Bernstein et al., 2016).

This change reflects what's happening in the real world. Startups that ignore or overlook new tech trends or fail to act responsibly often lose investor interest, no matter how strong their financials appear. On the other hand, strong teams and active support from investors can help startups grow faster and survive longer period (Bernstein et al., 2016; Eesley & Roberts, 2012). Many of these risks are connected. If a startup runs out of cash, it can't invest in new ideas, and if it has a weak team, it may not be able to properly react to changes in the market.

This paper looks at how both financial and non-financial risks affect how investors see startups. It also shows how these risks are perceived differently across Europe, where funding often comes from a mix of private investment, public grants, and newer tools like crowdfunding. By bringing together research and real-life insights, the goal is to better understand what really matters when investors decide whether or not to step in a startup.

1. Methods of Research

To select the reviewed articles, we searched databases such as Web of Science, Scopus, Google Scholar and open-access repositories using combinations of terms like "startup valuation," "financial and non-financial risk," "ESG performance" and "R&D." This search initially produced around 120 articles, then it was narrowed the selection by reading abstracts and applying the inclusion criteria described above, which resulted in ten articles chosen for detailed analysis between publishing years 2018 and 2024.. Preference was given to articles that are indexed in well-known academic databases such as Web of Science or Scopus, but inclusion was not limited to these only.

The goal was to include research that focuses on different types of startup risks, both financial and non-financial, as well as studies that explore related areas such as innovation, ESG performance, and investor decision-making. The reviewed articles cover different world regions with some offering of a global perspective. This allowed to make comparison between markets and investment environments.

Inclusion criteria:

- articles published between 2018 and 2024
- peer-reviewed academic publications
- focus on startup risk, valuation, or early-stage investment
- availability of full text
- relevance to financial or non-financial factors in investment decisions

Exclusion criteria:

- non-peer-reviewed articles
- publications older than 2018
- studies not related to startups or investment decision-making

- articles not available in English

2. Results of the Research

The paper found that investors pay attention to two main types of risk when they look at startups. The first one is traditionally financial risk. This includes problems like poor cash flow, spending money too quickly, or relying too much on debt instruments. These risks are easier to measure and are still a big part of how investors decide whether a startup is worth supporting. Investors often check numbers like operating cash flow, the ratio between short-term assets and debts, and how many months the startup can survive without getting more funding. If these numbers are weak, the business may struggle to grow or survive, regardless of the strength of the idea.

Tab. 1: Summary of reviewed articles

Author	Country	Type of risk	Main findings	Limitation
Gompers et al. (2016)	USA / Global	financial & non-financial	investors consider team, adaptability, and potential, not just financials	study based on US-focused VC market
Bernstein et al. (2016)	USA	non-financial	investor involvement leads to faster revenue growth	limited to firms with investor oversight data
Maula et al. (2016)	Global	technological / Strategic	ignoring tech shifts reduces startup survival	applies mostly to high-tech sectors
Eesley & Roberts (2012)	USA	team-related	complementary skills and long-term collaboration matter	focused on team-level dynamics only
Lin (2021)	Europe / Global	ESG / Non-financial	ESG is increasingly central to investment criteria	european ESG focus may not generalize globally
Bertoni et al. (2014)	Europe	financial	financial decisions affect valuation and growth	concentrated on high-tech startups in EU
Chemmanur & Fulghieri (2014)	Global	mixed	innovation funding is shaped by risk profile	broad theoretical focus, lacks specific case data
Cassar (2004)	USA	financial	financial planning is key to early-stage survival	older data may not reflect current funding models
Harrison & Mason (2000)	Global	funding / access	geographic and cultural factors affect capital supply	exploratory, without quantitative analysis

Source: Authors

The second type is non-financial risk. These are harder to measure but just as important to be considered. This includes things like how strong the team is, how well the company handles new technology, and how seriously it takes environmental and social responsibilities. Startups with an unstable or inexperienced team, or those that are not familiar with trends, are often seen as too risky to step in. One study by Gompers and his team in 2016 showed that investors care about trust and teamwork, not just the numbers.

The paper also showed that these risks are often connected. If a startup has money problems, it might not be able to invest in appropriate technology or build a strong experienced team. And if the team does not work well, the company might waste resources or miss big changes in the market. Because of this, investors prefer startups that are strong in both fields. A good financial base means stability, while strong leadership and positive approach to innovation mean future progress. Another finding is that risk is viewed differently depending on the concrete region. In Central and Eastern Europe, for example, startups often rely more on public money, personal savings, or loans. This makes them more vulnerable to changes in public policy or economic conditions. In Western Europe, on the other hand, there is usually more access to venture capital and more varied funding options. In short, the research shows that investors are no longer just looking at money. They want to see the whole picture, including how well a startup is prepared for future challenges and how responsibly it operates.

3. Discussion

The paper shows that financial and non-financial risks play a big role in how investors see and value startups. Financial risks like poor cash flow or high debt are still very important. If a startup runs out of money, it can't survive or grow. But the paper also shows that investors are looking at much more than just numbers. Factors like team quality, ESG performance, and the ability to adapt to new technologies are becoming just as important. Several studies support this view. For example, Bernstein et al. (2016) found that startups with stronger investor involvement tend to grow faster. Lin (2021) explained how ESG is now a key part of investment decisions, especially in Europe. These non-financial risks are often harder to measure, but they can strongly influence whether a startup gets more funding or not.

One important insight is that many of these risks are interconnected. A startup that has weak cash flow may not be able to invest in R&D or attract the people with potential. A poor team may not react well to fast market changes, which can cause the business to fall behind. Ignoring ESG rules can limit access to public funding or discourage investors. In this way, financial and non-financial risks often work together and problems in one area can quickly overflow to trouble in another. This means that both investors and founders should think about risk from more perspectives. Instead of focusing on only one factor, they should look at how different risks interact and affect the long-term value of a startup. A well-assembled risk strategy that includes financial planning, strong leadership, tech readiness, and ESG awareness gives a much clearer view of a startup's real potential.

Conclusion

Startups that handle and manage both financial and non-financial risks are much more probably to grow, survive and attract solid long-term investment. Investors increasingly value qualitative factors like leadership quality, team cohesion, technological adaptability, and ESG responsibility, recognizing their crucial role in a startup's long-term success. The paper showed that challenges in one area often create challenges in others. That is why many investors now take a full-picture approach instead. They want to see financial strength, but also leadership, adaptability, and values that match with their long-term perception of success. The research also showed that broader context matters. In some parts of Europe, especially Central and Eastern regions, startups rely more on public grants or personal funding. This makes them more sensitive to policy changes and market turnovers. Founders in these areas should pay special attention to creating of investor trust and showing that they understand the bigger picture.

Overall, startups that plan ahead, stay flexible, and build strong, responsible, motivated teams are more probable to succeed. Investors invest not only in products or metrics, but in people and vision. The completer and more balanced that picture is, the better the chances for long-term growth exist.

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FinTech Innovations and Their Impact on Financial Inclusion in Central Europe: Evidence from Czechia

Abstract

This study explores the use of digital financial services and digital transformation in the Czech financial sector. It focuses on the adoption of digital payment systems and FinTech services. The aim is to assess how digitalisation improves financial inclusion, operational efficiency, and customer engagement in Czech banking and finance. The research uses a secondary data analysis approach. It draws on market reports, regulatory documents, and transaction data from financial institutions. These sources help map trends in mobile banking, digital payment adoption, and FinTech integration. Key findings show that digital payment systems have expanded financial access and reduced transaction costs. They also support real-time payments, benefiting SMEs and enhancing consumer convenience. However, several challenges persist. These include regulatory misalignment, cybersecurity risks, and digital literacy gaps in the Czech market. The study offers clear implications for policymakers. It highlights the need to support digital finance through supervised regulatory testing environments, strong consumer protection, and financial education. Financial institutions can also use these findings to improve customer experience and build operational resilience. The originality of this research lies in its country-specific focus. It offers a targeted view of digital finance trends in Czechia and supports broader regional strategies for financial modernisation.

Key Words: FinTech, Financial Inclusion, Innovation, Czechia, Central Europe

JEL Classification: E63, G21, O33

Introduction

The rapid evolution of financial technology (**FinTech**) has fundamentally reshaped the global financial landscape. By leveraging tools such as blockchain, artificial intelligence, mobile applications, and digital identity systems, FinTech has enabled new ways of delivering and accessing financial services (**Arner et al., 2016**). These innovations not only enhance efficiency and reduce costs but also challenge the traditional monopoly of brick-and-mortar financial institutions.

One of the most promising dimensions of FinTech lies in its potential to promote financial inclusion. Defined as the availability and accessibility of financial products and services to underserved populations, financial inclusion is considered essential for reducing poverty and enhancing economic participation (Demirgüç-Kunt et al., 2022). FinTech contributes to this objective by offering scalable, user-centric solutions that expand access to credit, insurance, savings, and payment systems for individuals who were previously excluded from formal finance (Ozili, 2018; Sahay et al., 2020). Central Europe has emerged as a region of increasing importance in the digital finance ecosystem. Countries in this region benefit from strong digital infrastructure, growing public trust in technology, and active financial regulatory support. Among these, the Czech Republic stands out for its robust internet penetration, widespread adoption of contactless payments, and a growing number of FinTech firms (EY, 2023). The Czech National Bank (ČNB) and Ministry of Finance have advanced policies that encourage digital transformation, while Czech FinTech startups have introduced services in areas such as online lending, peer-to-peer investment, and digital wallets (Hodula, 2023).

Despite these developments, financial exclusion persists, particularly among older adults, rural populations, and economically disadvantaged households. While digital solutions have lowered entry barriers, factors such as low digital literacy, lack of trust in new technologies, and limited awareness of FinTech offerings continue to prevent many from participating in the evolving financial system (Polák, 2022). This paradox highlights the importance of understanding not only the technological capabilities of FinTech but also the socio-economic and regulatory ecosystems in which these tools operate. While global research confirms the broad benefits of FinTech for financial inclusion (Sahay et al., 2020), there remains limited scholarly attention on how these dynamics manifest within the Czech context. Most existing studies focus on European Union-wide trends or adoption rates, often overlooking the localised challenges that affect inclusion—such as regional disparities in digital access or fragmented regulatory frameworks (Hodula & Havránek, 2023).

Additionally, there is insufficient evaluation of which specific FinTech solutions are most effective in bridging financial gaps. For instance, while tools like peer-to-peer lending and micro-investment platforms are available, little is known about their actual use and impact among marginalised Czech communities (Šolc, 2023). This study addresses these gaps by offering empirical insights that can inform policymakers, FinTech developers, and financial educators.

This paper investigates the following questions:

1. How do FinTech innovations influence financial inclusion in Czechia?
2. Which types of innovations are most effective in increasing access to financial services?
3. What are the key barriers that hinder inclusion for particular demographic or geographic groups?

The main objective is to analyse how FinTech contributes to reducing financial exclusion in the Czech Republic. The study highlights practical innovations, assesses regional and demographic disparities, and examines policy and infrastructure-related obstacles.

The remainder of the paper is structured as follows: Section 2 presents the literature review, synthesizing global and local research on FinTech's inclusionary potential. Section 3 explains the methodology, outlining the qualitative approach used to analyse case data and expert insights. Section 4 presents the findings and discussion, highlighting adoption patterns and barriers to financial inclusion. Section 5 summarizes the challenges and policy implications, identifying key obstacles and offering evidence-based recommendations. Finally, Section 6 provides the conclusion, summarizing the study's contributions and suggesting directions for future research. Through this structure, the study aims to contribute to academic and policy debates on inclusive finance, particularly in the context of digitally transforming economies like Czechia.

1. Literature Review

FinTech—short for financial technology—refers to the integration of digital innovations into financial services, including mobile payments, blockchain applications, and robo-advisors. These technologies aim to reduce operational inefficiencies, enhance service accessibility, and improve user experience (Nicoletti, 2017). The World Bank defines financial inclusion as the ability of individuals and businesses to access affordable and appropriate financial products such as payments, credit, savings, and insurance (Demirgüç-Kunt et al., 2022).

A growing body of literature affirms that FinTech has the potential to lower the costs of financial intermediation, bridge access gaps, and increase usage, particularly among underserved groups (Arner et al., 2016). These advancements support broader socio-economic objectives such as poverty reduction, gender equity, and inclusive growth. The synergy between FinTech and financial inclusion thus aligns with the United Nations Sustainable Development Goals (SDGs), especially those targeting economic empowerment and reduced inequalities.

Empirical studies in low- and middle-income countries underscore the transformative effect of FinTech on financial access. In Kenya, for example, M-Pesa's mobile money services have enabled millions to perform transactions, save money, and access informal credit, all without relying on traditional banking infrastructure (Jack & Suri, 2014). Likewise, online lending platforms in Asia have offered microloans to households and small businesses, facilitating resilience against financial shocks (Balyuk & Davydenko, 2019). Nevertheless, FinTech adoption is not without challenges. Barriers such as limited digital literacy, cybersecurity vulnerabilities, and insufficient consumer protections can hinder widespread uptake, especially in vulnerable communities (Gabor & Brooks, 2017). These constraints suggest that digital inclusion

efforts must be accompanied by capacity building, data protection measures, and responsible innovation to ensure that technological solutions do not exacerbate existing inequalities.

Within the European Union, FinTech development has been supported by robust digital infrastructure, a well-regulated banking sector, and coordinated policy frameworks. The European Central Bank's exploration of a digital euro and the EU's Digital Finance Strategy signal a clear commitment to financial innovation as a tool for inclusion (ECB, 2022). Consumers across Europe have shown a growing readiness to adopt digital tools such as open banking, instant payments, and e-identification systems (EY, 2023).

Tab. 1: Systematic Literature Review

Topic	Key Points	Notable Sources
Conceptualising FinTech and Financial Inclusion	FinTech leverages digital innovations to reduce costs and expand financial access. It is aligned with inclusion and development goals, including poverty reduction.	Arner et al. (2016); Nicoletti (2017); Demirgüç-Kunt et al. (2022)
Global Evidence on FinTech's Impact	In developing regions, mobile money and digital lending promote savings and resilience. However, barriers like digital literacy and cybersecurity risks persist.	Jack & Suri (2014); Balyuk & Davydenko (2019); Gabor & Brooks (2017)
European Context of FinTech and Inclusion	EU policy and infrastructure support FinTech growth. Digital ID systems and open banking foster inclusion, but national disparities require localised strategies.	ECB (2022); EY (2023); Frost (2020)
FinTech and Financial Inclusion in Czechia	Czechia has strong digital readiness and startup activity. COVID-19 spurred adoption, but trust issues, digital gaps, and regulatory fragmentation remain barriers.	Hodula (2023); Polák (2022); Jandová & Slavičková (2023)

Source: Authors' analysis

However, the region's heterogeneity presents unique challenges. Although some member states have made significant progress in digital finance adoption, others lag behind due to institutional or cultural factors. Frost (2020) argues that harmonised regulatory approaches must be accompanied by country-specific adaptations to address local needs, ensuring that inclusion objectives are met equitably across the continent. Czechia is well-positioned for FinTech expansion. The country boasts high internet penetration, a digitally skilled population, and a stable, well-developed financial sector (Hodula, 2023). FinTech startups are active in areas such as digital payments, investment platforms, and peer-to-peer lending. These developments have been further accelerated by the COVID-19 pandemic, which prompted a shift toward contactless payments and remote banking services. Despite these advances, structural and behavioural challenges persist. A survey conducted by Polák (2022) highlights

regional disparities in digital literacy, particularly affecting older adults and rural populations. These disparities not only limit awareness of FinTech tools but also inhibit users' ability to leverage them effectively. Furthermore, Jandová and Slavíčková (2023) show that trust in digital technologies remains low among certain demographic groups, further constraining adoption.

In summary, while Czechia has a strong foundation for inclusive FinTech growth, barriers related to education, trust, and policy coordination remain critical. Addressing these issues is essential for ensuring that FinTech serves as a truly inclusive force within the financial system. The literature review provides a comprehensive foundation for understanding the interplay between FinTech and financial inclusion at global, European, and Czech levels. These insights inform the research focus and help identify key variables relevant to the Czech context. Building on this foundation, the following methodology outlines the approach used to investigate these dynamics through document analysis and comparative evaluation.

2. Methodology

This study adopts a qualitative research design to explore how financial technology (FinTech) innovations influence financial inclusion in the Czech Republic. The analysis is situated within the broader context of Central Europe and reflects the interplay between national and European Union regulatory frameworks. A qualitative approach is particularly appropriate for examining contextual variables—such as institutional dynamics, social trust, and regulatory environments—that are not easily captured through quantitative metrics (Gabor & Brooks, 2017; Yin, 2017). The primary aim is to generate a grounded and interpretive understanding of how FinTech tools expand access to financial services for households and small and medium-sized enterprises (SMEs), and what barriers continue to hinder inclusion. The study also seeks to uncover structural and behavioural constraints—such as digital literacy deficits or geographic disparities—that affect adoption patterns in Czechia.

The study integrates three complementary qualitative methods to capture a multidimensional perspective. The research methodology consists of three complementary components. First, a **systematic literature review** was conducted, encompassing peer-reviewed academic articles, industry reports, and non-academic sources to identify key theoretical frameworks and empirical findings related to FinTech and financial inclusion. This includes sources focused on the Czech Republic as well as comparative studies from Central Europe, highlighting patterns in digital adoption, inclusion outcomes, and the impacts of specific technologies such as mobile banking and peer-to-peer lending. Second, a **policy document analysis** was undertaken, examining national regulatory strategies—such as the Czech National Bank's guidelines on digital finance and consumer protection—alongside EU-wide frameworks, including the Digital Finance Strategy (European Commission, 2020) and policy briefings from the European Central Bank. This analysis helps evaluate the regulatory landscape and its influence on innovation and inclusion. Third, a

comparative analysis was carried out to assess the development of FinTech ecosystems in Czechia relative to Slovakia, Hungary, and Poland. This approach enables the identification of best practices and shared challenges in areas such as regulation, innovation support, and user engagement, while also highlighting country-specific factors that shape financial inclusion dynamics (Frost, 2020). Together, these methods offer a comprehensive framework to explore how digital financial tools interact with institutional and demographic variables across the Czech context.

Analytical Focus

The analysis is structured around three interrelated thematic areas. First, it examines **key FinTech innovations** by identifying the most impactful tools for financial inclusion, such as digital wallets, mobile banking, crowdfunding, and peer-to-peer lending platforms. Second, it explores **adoption barriers**, focusing on structural and behavioural obstacles to FinTech access, including low digital skills, regulatory complexity, and inadequate infrastructure. Third, it investigates **socio-economic determinants**, analysing how factors like income inequality, urban-rural divides, and demographic variables influence FinTech adoption rates and usage patterns. These dimensions are collectively assessed to evaluate how effectively FinTech can mitigate exclusion and enhance financial participation across diverse social groups.

Data Sources

The research draws on a diverse range of secondary data sources. These include **statistical data** from Eurostat and the Czech Statistical Office, which provide demographic and macroeconomic indicators relevant to digital finance usage. It also incorporates **regulatory and institutional data** from the Czech National Bank (CNB), the European Central Bank (ECB), and the European Commission. Additionally, **industry reports** from EY (2023), Deloitte, and the European FinTech Association offer sectoral insights into innovation, adoption, and inclusion. Finally, the research engages with **academic literature**, particularly studies that apply frameworks such as Innovation Diffusion Theory (Rogers, 2003) and Financial Deepening (Beck et al., 2007), to analyse the drivers of digital financial inclusion.

Purpose and Contribution

This methodology enables an in-depth understanding of the opportunities and constraints that FinTech presents for financial inclusion in Czechia. The approach supports a policy-relevant investigation by integrating regulatory context, comparative insights, and socio-economic factors. The findings will contribute to both academic debates and policy dialogues on inclusive digital transformation in finance, aligned with the goals of the **Liberec Economic Forum**, which seeks to link research with practical innovations across Central Europe.

3. Results

This section presents the findings on how **FinTech innovations contribute to financial inclusion in Czechia**, using **secondary qualitative analysis** of data from the

Czech National Bank, Eurostat, European Commission documents, and industry and academic sources.

3. 1 Overview of Key FinTech Innovations in Czechia

The landscape of FinTech in Czechia is shaped by innovations in **digital wallets, mobile banking, peer-to-peer (P2P) lending, digital savings, and investment platforms, and RegTech solutions**. These technologies address gaps in financial services, providing alternatives to cash transactions and expanding access to financial products for underserved populations (Bunea et al., 2016; Philippon, 2016). Table 2 summarises these innovations, their descriptions, adoption trends in Czechia, and relevant data sources.

Tab. 2 Key FinTech Innovations in Czechia

FinTech Innovation	Descriptions	Current Adoption Trends in Czechia	Data Source
Digital Wallets	Mobile and online payment apps enabling cashless transactions	Rapid uptake, particularly among younger users and in urban areas	CNB (2024) McKinsey (2023)
Mobile Banking	Banking services accessed via smartphone apps	High penetration among retail banking customers	Eurostat (2024) European Commission (2023)
P2P Lending Platforms	Online platforms facilitating direct lending between individuals and SMEs	Emerging, with a focus on SME financing alternatives	Arner et al. (2016) McKinsey (2023)
Digital Savings & Investments Platforms	Apps providing micro-investment and digital savings management	Growing interest, especially post-COVID	Philippon (2016) Zalan & Toufaily (2017)
Reg tech solutions	Technologies supporting regulatory compliance and KYC processes	Used by Fin Tech start-ups and banks to reduce compliance costs	BIS (2019), European Commission (2023)

Source: Authors' analysis

Key insights of digital innovations include **Digital wallets and mobile banking**, which have achieved high adoption rates in Czechia, largely driven by their convenience and the availability of robust digital infrastructure in urban areas. **Peer-to-peer (P2P) lending platforms** are emerging as viable alternative financing channels, particularly for small and medium-sized enterprises (SMEs) and individuals who face barriers to accessing traditional credit. Meanwhile, **RegTech solutions** are increasingly being adopted to streamline regulatory compliance and facilitate safer, more efficient customer onboarding, thereby enhancing consumer trust in digital financial platforms.

FinTech innovations have significantly enhanced financial inclusion by increasing transaction accessibility through mobile and online payment systems, expanding credit access via peer-to-peer (P2P) lending for SMEs and individuals, and enabling participation in savings and investment for lower-income groups through micro-investment platforms. However, several challenges remain, including gaps in digital literacy, infrastructural limitations in rural areas, and the need for clearer and more consistent regulatory frameworks, all of which continue to affect the scalability and effectiveness of FinTech-driven financial inclusion (Vial, 2019; Zalan & Toufaily, 2017).

3.2 Impact on financial inclusion

Table 3 presents a structured overview of how key FinTech innovations impact financial inclusion, along with the main challenges they face. Each innovation area is evaluated in terms of its contribution to improving financial access, affordability, and user participation. The table also highlights barriers that hinder broader adoption, such as regulatory gaps, digital literacy, and infrastructure constraints. By mapping both opportunities and limitations, this overview provides a balanced understanding of FinTech's role in inclusive finance. The analysis focuses on technologies relevant to the Czech context but reflects broader regional trends.

Table 3: Overview of impacts and challenges of new technology

Innovation Area	Impact on financial inclusion	Challenges / Barriers
Digital Payments (Wallets & Mobile Banking)	Improves access to transactions, reduces reliance on cash, supports inclusion in rural areas	Digital literacy gaps, device affordability, infrastructure
P2P Lending	Expands credit access for SMEs and individuals underserved by traditional banks	Regulatory uncertainties, risk management, trust issues
Digital Savings & Investments	Facilitates micro-savings and investment participation for low-income groups	Limited awareness, investment risk perceptions
RegTech Integration	Enhances KYC processes, reduces onboarding barriers, and improves consumer protection	Implementation costs, evolving regulatory frameworks

Source: authors' analysis

3.3 Country comparison

This section presents a comparative analysis of FinTech developments across selected Eastern European countries, focusing on Slovakia, Poland, Hungary, and Czechia. The aim is to position the Czech experience within a broader regional context and highlight both commonalities and divergences. The comparison addresses adoption levels, regulatory approaches, and the use of digital technologies to support financial inclusion. It covers key areas such as mobile payments, digital banking, peer-to-peer

(P2P) lending, RegTech, and the growing role of artificial intelligence in automating financial services and enhancing decision-making. National strategies and policy support are examined alongside practical challenges in implementation. Shared issues like digital literacy gaps, infrastructural limitations, and evolving regulatory standards are also considered. The analysis identifies successful practices and recurring obstacles across the region. This regional perspective sheds light on how Czechia compares with its neighbours in promoting inclusive and technology-driven financial services.

The table below provides a comparative overview of FinTech developments in **Slovakia, Poland, and Hungary**. It highlights notable national trends in digital finance and contrasts them with the Czech experience. The comparison focuses on adoption rates, innovation ecosystems, and areas of financial inclusion.

Table 4: Country comparison

Country	Notable trends	Comparison with Czechia
Slovakia	Strong mobile payment adoption, bank-led digitalisation	Similar adoption rates, but Czechia has a more active FinTech startup scene
Poland	High mobile banking and digital wallet usage, a dynamic FinTech system	Czechia aligns with digital payment trends, lower P2P lending penetration
Hungary	Increasing digital finance policy support, moderate adoption rates	Czechia shows stronger FinTech adoption across SME finance and digital payments

Source: authors' analysis

The table illustrates how different FinTech innovations contribute to financial inclusion while also facing distinct challenges. These findings underscore the need for targeted policy support and user education to maximise impact. They also serve as a basis for comparing national responses across the Eastern European region.

4. Discussion

The findings of this study confirm and extend existing research on the role of FinTech innovations in enhancing financial inclusion in emerging European economies. In line with studies by Arner et al. (2016) and Zalan & Toufaily (2017), this paper finds that FinTech can act as a powerful enabler of access to financial services—especially where traditional banking channels are limited or underutilized. In Czechia, digital wallets and mobile banking are now widely adopted, particularly in urban areas with reliable internet access and a digitally literate population. These technologies reduce reliance on physical bank branches, facilitating everyday financial transactions for individuals and SMEs alike (Philippon, 2016).

The use of peer-to-peer **(P2P) lending platforms** is emerging as a complementary mechanism to formal credit institutions. As previous research suggests, such platforms can democratize credit access, particularly for underserved populations such as startups, self-employed individuals, or small business owners (Feyen et al., 2021). While Czechia's P2P lending market is still developing, its flexibility and user-centric design reflect global trends that show increased uptake when traditional finance fails to meet demand. However, the regulatory environment remains fragmented, which could pose risks to consumers and platform operators alike.

One of the study's significant contributions is highlighting the increasing adoption of **RegTech** as a backbone for compliant and secure FinTech services. RegTech streamlines onboarding processes, enhances identity verification, and helps reduce fraud risks—critical features for increasing trust in digital platforms. This aligns with the findings of the BIS (2019) and European Commission (2023), which emphasize RegTech as a catalyst for both regulatory efficiency and consumer protection. Its adoption is particularly relevant for Czechia's expanding FinTech ecosystem, where early-stage firms need affordable and scalable compliance tools. Despite these gains, several **challenges remain**. Digital literacy, particularly among older adults and rural populations, continues to hinder inclusive adoption. Without basic skills in mobile or internet use, many citizens are unable to access even the most user-friendly digital services. Infrastructure gaps, such as limited internet access in remote regions, also persist. Regulatory clarity is another concern—especially in P2P lending and digital asset management—where national frameworks are still catching up to the pace of innovation.

The implications for policymakers, FinTech developers, and financial institutions are threefold. First, targeted digital education programs are crucial for expanding usage beyond digitally native populations. Second, policymakers should support regulatory sandboxes and adaptive legislation to balance innovation with consumer protection. Third, FinTech developers and financial institutions must prioritize user experience, affordability, and trust-building mechanisms, especially for lower-income and underserved users. In sum, while FinTech innovations are helping close the financial inclusion gap in Czechia, their full potential will only be realized through coordinated efforts to address educational, infrastructural, and regulatory bottlenecks.

Conclusion

This paper examined how FinTech innovations are contributing to financial inclusion in Czechia, drawing on a qualitative analysis of secondary data and policy documents. The findings indicate that **digital wallets and mobile banking** are widely adopted, particularly in urban areas, significantly improving access to basic financial services (Eurostat, 2024). **Peer-to-peer (P2P) lending platforms** are emerging as alternative financing channels for SMEs and underserved individuals, reflecting global patterns in alternative credit provision (Arner et al., 2016). The adoption of **RegTech solutions**

further supports trust and compliance, enhancing the efficiency and security of digital finance operations (BIS, 2019). These innovations collectively position Czechia as a regional leader in digital finance transformation, although challenges related to **digital literacy, infrastructure, and regulatory adaptation** remain (Vial, 2019). This study contributes to academic and policy literature by integrating Czechia into broader discussions of FinTech adoption in Central Europe and highlighting the interplay between innovation, regulation, and inclusion. For policymakers and financial institutions, the findings stress the importance of supportive regulatory frameworks, consumer protection, and digital education initiatives.

This study relies exclusively on secondary qualitative data sources, such as reports, policy documents, and academic literature. The absence of primary data collection, such as surveys or interviews, limits the ability to capture user-level perspectives and lived experiences. Future research should therefore complement secondary data with primary evidence to enhance validity and contextual depth. Further research should include user-centered qualitative studies to explore behavioral responses to FinTech, and comparative studies across the Visegrád region to assess cross-border regulatory and technological alignment. Investigating the long-term financial well-being of FinTech users will also be crucial as digital finance becomes increasingly integrated into everyday life.

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Servant Leadership: Bibliometric Analysis and Future Agenda

Abstract

Servant leadership is positioned as a new field of research for leadership scholars. We conducted bibliometric review by using 150 peer-reviewed articles from Web of Science database. The data collection period was from 1990 to 2025 as to provide comprehensive reflection on this topic. We used VoSviewers Software for data analysis. This review generated themes such as servant leadership in hospitality sector, leadership and work engagement, servant leadership as a key driver for innovation, gender, leadership and job outcomes, a review of diversified leadership styles. This review advance our understanding by looking Servant leadership in European perspective as it is an under-explored context. Theoretically, this research contributes to body of knowledge on moral leadership literature. This research provides fresh guidelines on servant leadership for organizations to adopt moral leadership as it is most needed nowadays due to financial scandals and unethical practices.

Key Words: Servant Leadership, Bibliometric Review, Moral Leadership, Future Research Agenda, European Perspective

JEL Classification: M12, M120

Introduction

In the contemporary business landscape, corporate moral responsibility is regarded as an issue for multiple stakeholders within the context of work ([Hess, 2055](#)). At the same time,

In the 21st century, there has been a notable increase in enthusiasm for moral kinds of leadership, including ethical, authentic, and servant leadership (Lemoine et al., 2019). Basically, exploration of servant leadership has progressively shifted from philosophical debate to practice development and preliminary research during the beginning decades of the 21st century, mainly within North American and European contexts. Previously, more leadership practitioners and researchers have been investigate the value of servant leadership in the European context. As, We inhabit a multicultural, different context in which internationalisation has become a fundamental component of corporate survival and Communities from many countries are merging more than at any previous point in civilization (Irving, 2025). This phenomenon is particularly evident across Europe, in which the European Union has encouraged enhanced mutually beneficial economic and cultural interaction within nations that are members (Starren, 2013). As these needs are enhanced cultural awareness among our leaders and creates challenges about the practicality of our leadership paradigms, mostly developed within an Anglo-Saxon structure, in culturally varied economies like those within the EU. Given their primarily knowledge-driven economic growth.

Most importantly, European economies essentially utilise optimising individuals. Listening to the needs of employees is essential for maintaining competitiveness and achieving organizational long-term success (Leary, et al., 2002). Recent research revealed moral leadership is a crucial for organisations to succeed in the long run, and that it is also important for society as a whole (Faluyi & Mboga, 2025). Our main focus is on *servant leadership* one who guides others while also demonstrating qualities such as compassion, sincerity, willingness to embrace others, and responsibility (Van Dierendonck, 2011a). Previous research investigated the current status by adopting a more nuanced perspective on the dynamic characteristics of servant leadership behaviour (Zhang et al., 2025). These studies shows servant leadership is an important for the businesses and society.

However, Huang et al., (2016) classify servant leadership as a style of leadership that focusses on the needs and desires of the people being led, rather than those of the leaders themselves. Sendjaya, (2016) conveys this perspective, asserting that the primary distinction is in the leadership's values. When leading, servant leaders often keep the following priorities in mind (Sendjaya, 2016). Hence, Stone et al., (2004) discussed to fulfil a company's strategic objectives, it is necessary to consciously prioritise its advancement, happiness, and professional growth of its followers. This reflects followers development is possible by engagement of servant leaders at the workplace as to achieve business excellence.

The majority of empirical studies on servant leadership are small-scale and the topic is under-researched (Fröhlich et al., 2025; Schowalter & Volmer, 2023). This new moral leadership style in the nascent phases of understanding its genuine worth for companies and workers (Pass et al., 2020; Pircher Verdorfer, 2019). In a recent developments in leadership feild, Fischer & Sitkin, (2023) and Limoine et al., (2019) be mindful that servant leadership is still "at the early stage of theoretical development" and anticipate a great deal of untapped potential in the area of study. Considering this emerging tendency,

the purpose of this literature review is to promote research in this field and identify potential new avenues for study. Despite extensive systematic reviews on responsible or servant leadership styles from management perspective (Fischer & Sitkin, 2023; Waldman & Balven, 2014; Sendjaya et al., 2008). At the same time, few meta-analysis discussed servant leadership and moral identity in the service-sector (Gui et al., 2021; Xu et al., 2024). However, some of the reviews highlighted role of servant leadership with organizational level outcomes and wellbeing (Eva et al., 2019; Lu et al., 2024; Jonker & Dube, 2025). Another review explored antecedents and outcomes of servant leadership (Langhof, J. G., & Güldenbergh, 2020). In same manner, few bibliometric reviews explored servant leadership in a general sense (Mustam & Najam, 2020; Kalsoom & Zámečník, 2023). These reviews lacks servant leadership from European perspectives to better understand the Western-oriented servant leadership style.

This review contibrutes to leadership field by several ways. Firstly, our review is providning comprehensive bibliometric review on servant leadership in context of Europe. This advances our understanding on insights from European countries. Secondly, we contributes by exploring themes such as *servant leadership in hospitality sector, leadership and work engagement, servant leadership as key driver for innovation, gender, leadership and job outcomes, a review of diversified leadership styles*.

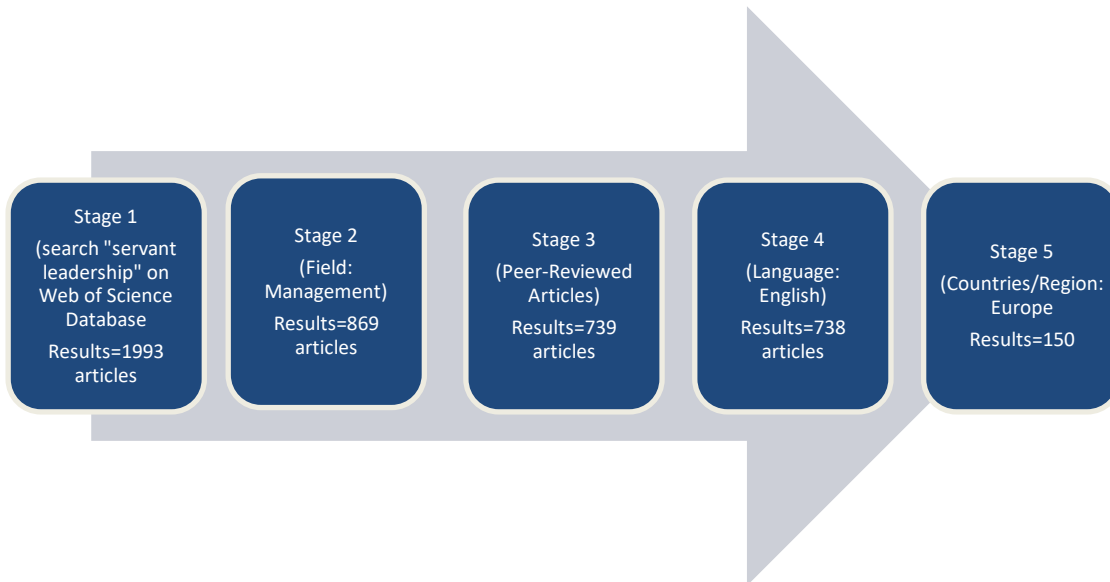
1. Methods of Research

The present research is based on bibliometric review as suggested by Donthu et al., (2021). Notably, this bibliometric analysis serves multiple purposes for academics. It can help them discover patterns in the performance of articles and journals, patterns of collaboration, and research components. Additionally, it can shed light on the intellectual structure of a certain area within the existing literature (Verma & Gustafsson, 2020). Authors run the data for analysis by using VOSviewer software (Wong, 2018). We selected peer-reviewed articles only. Authors mainly focused on articles specifically Management field due to unique charactertics of servant leadership style. We used articles which were only in English language. Finally, authors main focus on specific context such as Europe so they used studies from these European countries: *Netherlands, Spain, Germany, France, Belgium, Poland, Portugal, Finland, Norway, Switzerland, Sweden, Czech Republic, Austria, Greece, Liechtenstein, Romania, Slovenia, Denmark, Estonia, Hungary, Iceland, Slovakia*. Authors searched the keywords such as “Servant leader“, “Servant leadership“. We used on Web of Science database as it is one of the renowned and credible database. The searching period from 1990 to 2025. Authors provided comprehensive picture on this data by using longer period.

In the initial phase, articles were securitised according to their titles and abstracts in order to maintain their relevance. Following the stage's article selection, we carefully read each one while keeping the qualifying requirements in mind. In stage 1, we found 1993 articles by searching on Web of Science database. At second stage, we found 869 articles after applying inclusion criteria of management field. At third stage, we applied articles criteria so we selected only 739 peer-reviewed articles. At fourth stage, we employed

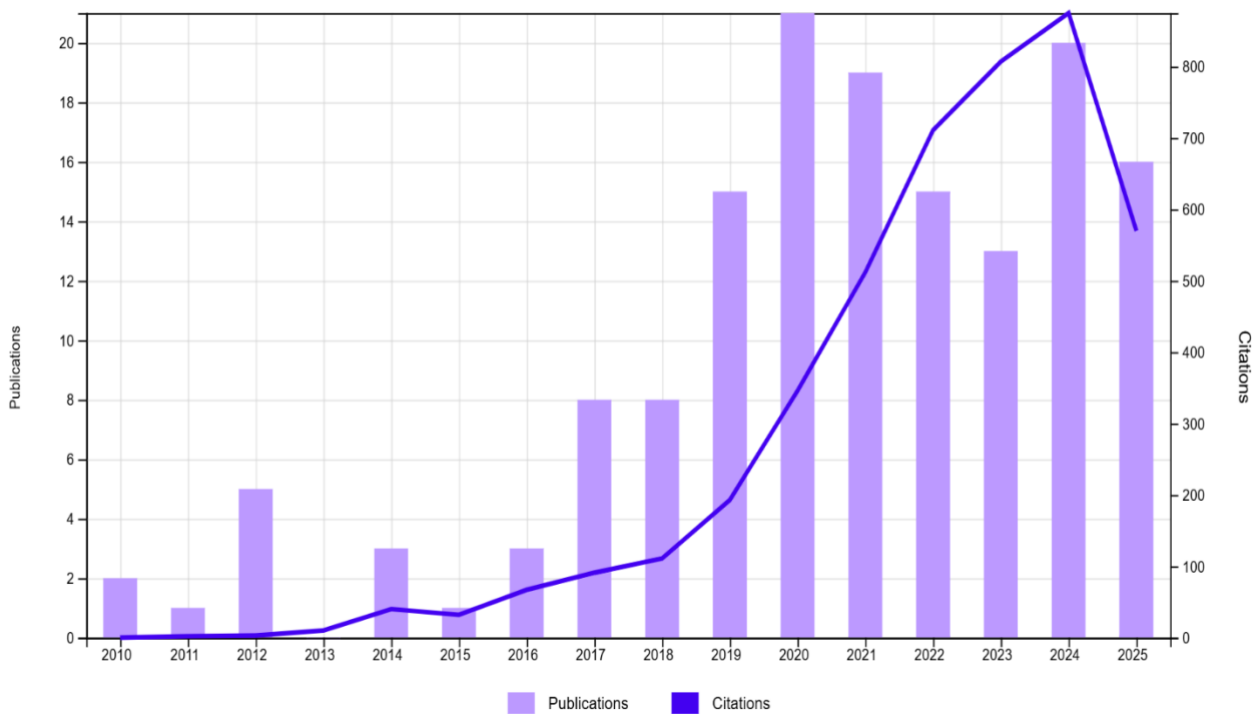
English language as a criterion and we found 738 articles. Final stage, we applied countries/region as Europe so we found 150 articles as our final sample for data analysis.

Fig. 1: Data Collection Process by using Web of Science Database



Source: authors' own, data from (Web of Science Database)

Fig. 2: Time Cited and Publications Over Time



Source: authors' own, data from (Web of Science Database)

Servant Leadership:
Bibliometric Analysis and Future Agenda
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The is gradually rise in research on servant leadership domain from 2019 to 2021. Conversely, it has been reduced in the year 2022 to 2023. Notably, the recent years are important for moral leadership as businesses are facing financial scandals and unethical practices at workplace. In this way, servant leadership studies are crucial to contribute to practice, and theory. The trend analysis shows publications and citation from 2010 to 2025 (See Figure 2).

2. Results of the Research

The Table 1 shows journals and publication on servant leadership topic. The Table 1 shows that 15 studies were published in Leadership & Organization Development. Another relevant 8 studies were also published in Leadership Quarterly. The 5 studies were published in Journal of Leadership & Organizational Studies, Nonprofit Management & Leadership, and Public Management Review respectively. Hence, 4 studies were published in Business Research Quarterly, European Journal of Work and Organizational Psychology and German Journal of Human Resource Management. These results are explicitly visible (See Tab. 1)

Tab. 1: Journals & Publications

Journals	Publications
Leadership & Organization Development	15
Leadership Quarterly	8
International Journal of Contemporary Hospitality Management	5
Journal of Leadership & Organizational Studies	5
Nonprofit Management & Leadership	5
Public Management Review	5
Business Research Quarterly	4
European Journal of Work and Organizational Psychology	4
German Journal of Human Resource Management-zeitschrift fur personalforschung	4
Career Development International	3

Source: authors' own analysis in VoSViewer

Our bibliometric review generated themes in the form of clusters such as themes such as Cluster 1: *servant leadership in hospitality sector*, Cluster 2: *leadership and work engagement*, Cluster 3: *servant leadership as a key driver for innovation*, Cluster 4: *gender, leadership and job outcomes*, Cluster 5: *a review of diversified leadership styles*.

Cluster 1: Servant leadership in hospitality sector

Servant leadership is suitable leadership styles specifically for hospitality sector as this leadership style is serving-oriented where employees' development is crucial (Gui et al., 2021; Bavik, 2020). Organisations in the hotel business rely on fulfilling customer

demands through quick and excellent service (Homburg et al., 2002). Previous research have shown that the mindset of hotel workers is greatly impacted by the servant leadership behaviour of their immediate superiors, who instill a sense of client awareness in them (Carter & Baghurst, 2014). Notably, servant leaders cultivate a distinctive organisational culture by aligning leaders and employees in the pursuit of organisational objectives, eschewing the reliance on positional authority. Servant leaders are driven not by self-interest or the quest for power, but by the desire to inspire and enable personnel to thrive in both personal and professional domains (Van Dierendonck, 2011). This reflects servant leadership is important for service-organizations especially hotels and tourism firms.

Cluster 2: Leadership and work engagement

The leadership improves work engagement at the workplace (Decuyper & Schaufeli, 2020). Leaders deliver an edge in competition to organisations (Ireland & Hitt, 1999). Therefore, businesses put money into leadership programs with the hope that its graduates will inspire their teams to greater heights of efficiency (Gottfredson and Aguinis, 2017). Discussions about employee well-being, and more especially job engagement, are finding more and more space within these advancements, since this is also associated with intriguing business outcomes. In addition to this, Carasco-Saul et al. (2015) developed a model for studying how different types of effective leadership influence employees' dedication to their jobs. On the one hand, they identified potential explanations for transformative leadership; on the other, they distinguished between genuine, charismatic, and ethical leadership.

Cluster 3: Servant leadership as a key driver for innovation

Servant leadership plays a crucial role as the binding force that harnesses the potential of innovation (Van Dierendonck & Rook, 2010b). In a similar fashion, servant leadership enhance employee innovative behaviour (Iqbal et al., 2020). The employee-focused servant leadership paradigm seeks to enhance the intrinsic motivation of people, making it particularly well-suited to comprehending the management of creativity and innovation. We offer a model for servant leadership and creativity in this chapter. It is based on the idea that a servant-leader is someone who mainly encourages their followers to manage their own work. This is also the most important thing for managing creativity in an organisational setting (Van Dierendonck & Rook, 2010b). As a result, scholars have just recently started to look into how servant leadership influences followers' innovative activity (Cai et al., 2018).

Cluster 4: Gender, leadership and job outcomes

Despite the expanding amount of research on the topic of gender in leadership, much of it is still missing key details since the criterion variable of leadership is not well examined (Shen & Joseph, 2021). Additionally, it should come as no surprise that employees value strong ties with their managers. Gender, however, may affect the precise traits that subordinates use to make this assessment, which in turn affects crucial processes and

results that occur later on in the workplace (Collins et al., 2014). Previously, extant study indicates that men and women exhibit divergent responses to certain facets of social connections, which can be classified as either communal or agentic (Koenig et al., 2011). Moreover, gender disparities persist in leadership positions concerning the social dimension (Moskowitz et al., 1994), because female executives are more likely to demonstrate empathy and establish rapport than their male colleagues (Fletcher et al., 2000). These results, taken as a whole, show that leaders of all sexes take on the agentic part of their jobs, but that female leaders also exhibit communal, socially driven behaviours (Eagly & Johannesen-Schmidt, 2001). This shows gender has different nature of job outcomes in leadership.

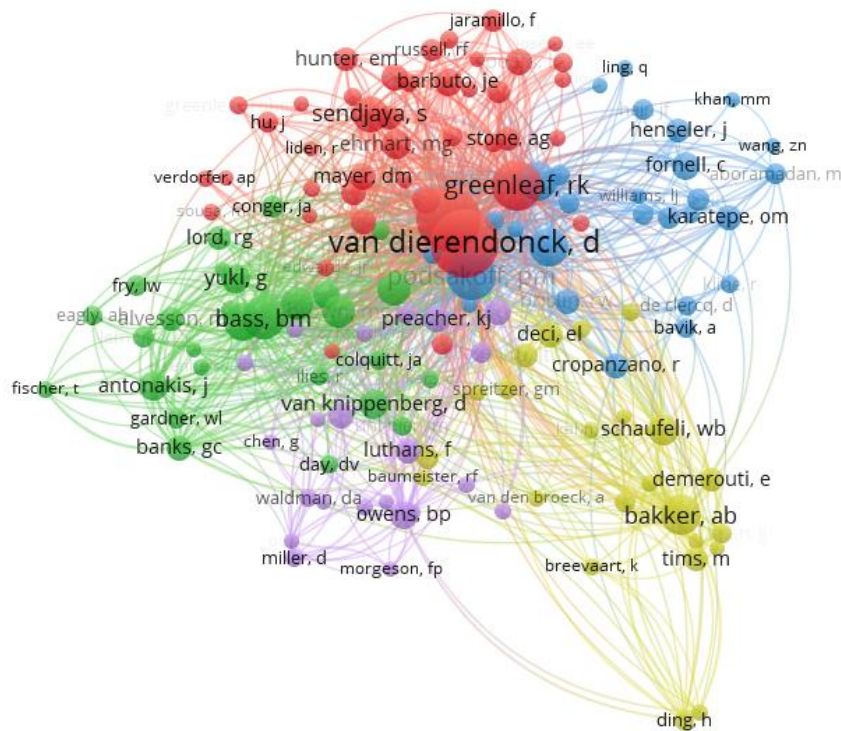
Cluster 5: A review of diversified leadership styles.

Our review found diversified leadership styles considered as important for business and society. Our data revealed authentic, ethical and inclusive leadership increase organizational performance and reputation. Previous study shows pursuit of authentic leadership has skyrocketed in the last decade (Gardner et al., 2011). One way to look at authentic leadership is as a symbol for activities in educational administration that are effective, ethical, and self-reflective. This is leadership that is well-informed, rooted in principles, and expertly carried out (Begley, 2001). In addition to this, an authentic leader is distinguished by: (1) self-awareness, humility, a continuous pursuit of enhancement, consideration for those who are led, and a focus on the well-being of others; (2) the cultivation of trust through the establishment of an ethical and moral framework; and (3) a dedication to organisational success aligned with societal principles (Whitehead, 2009).

From a moral perspective, there is a chance for academics to study how ethical leaders might be more ethical in their work (Brown & Treviño, 2006b). The importance of ethical leadership in organisations has been brought to light by high-profile instances of unethical behaviour on the part of leaders in various fields and contexts (Hartog, 2015). Additionally, prior study indicated a significant and favourable relationship between ethical leadership and workforce performance (Walumbwa et al., 2011). To ensure that their followers are held responsible, ethical leaders lay out the advantages of doing the right thing and the consequences of doing the wrong thing. Then, they employ a balanced punishment system (Brown et al., 2005a).

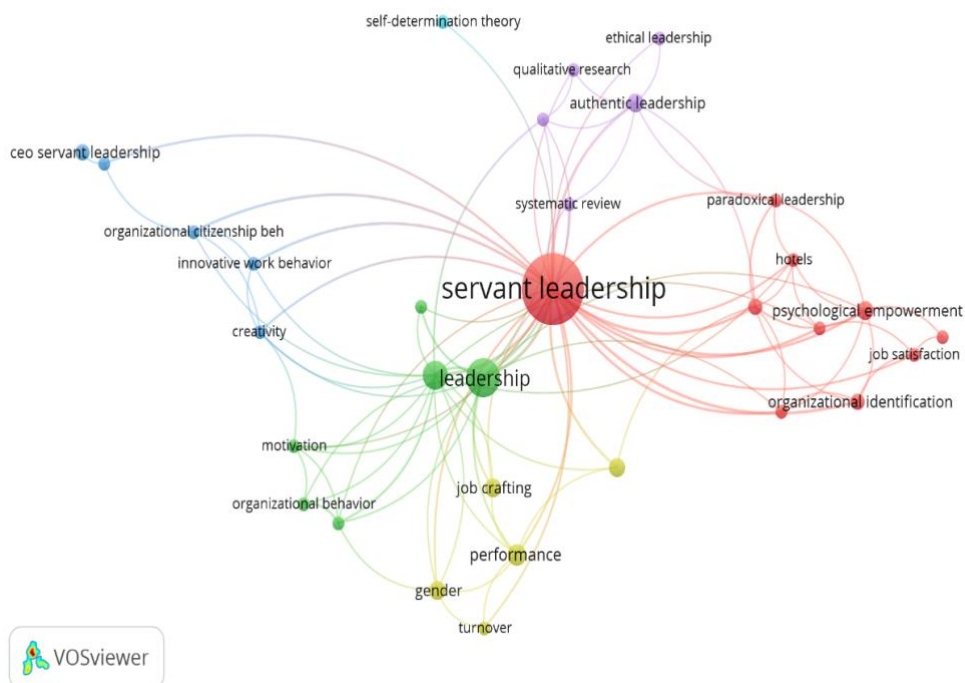
Likewise, inclusive leadership requires that people of diverse identities and backgrounds be able to participate completely and meaningfully in achieving common objectives without compromising their individuality or conforming to societal standards (Ferdman, 2014). The basic premise of inclusive leadership is that everyone has to feel like they belong and that their unique qualities are respected (Shore et al., 2011).

Fig. 3: Co-citations



Source: authors' own, data from (VoSVIEWER)

Fig. 4: Keywords



Source: authors' own, data from (VoSVIEWER)

Servant Leadership:
 Bibliometric Analysis and Future Agenda
 DOI: [10.15240/tul/009/lef-2025-07](https://doi.org/10.15240/tul/009/lef-2025-07)

Tab. 2: Themes on Servant Leadership using VoSViewer

Cluster	Items	Keywords	Co-Occurrence	Topic
Red (Cluster 1)	38	Servant leadership	73	Servant leadership in hotely industry
		Psychological empowerment	5	
		Engagement	4	
		Organizational identification	4	
		Hotels	3	
Green (Cluster 2)	24	Leadership	21	Leadership and work engagement
		Work Engagement	12	
		Motivation	3	
		Organizational Behaviour	3	
		Social Exchange	3	
		Well-being	3	
Blue (Cluster 3)	19	CEO Servant Leadership	4	Servant leader as key driver for innovate work behaviour
		Creativity	3	
		Hospiotality	3	
		Innovative Work Behaviour	3	
		OCB	3	
Yellow (Cluster 4)	37	Performance	7	Role of Leadership, Gender and Job Outcomes
		Gender	5	
		Job Crafting	5	
		Transformational Leadership	5	
		Turnover	3	
Purple (Cluster 5)	32	Authentic Leadership	5	A review of diversified leadership styles
		Ethical Leadership	3	
		Inclusive Leadership	3	
		Qualitative Research	3	
		Systematic Review		

Sample size n=150 peer-reviewed articles

Source: authors' own, data from (VoSVIEWER)

Tab. 3: Top Authors and Citations

Authors	Citations
Van Dierendonck, Dirk	585
Pina e Cunha, Miguel	290
Rego, Armenio	288
Goncalves, Lurdles	285
Owens, Bradley	285
Alkema, Jorrit	283
Boersma, Pieter	283
De Windt, Ninotchka	283
Stam, Daan	283
Ruiz-Palomino, Pablo	247

Source: authors' own

3. Discussion

This review found servant leadership has significant impact on needs of multi-stakeholders. Prior to this. In the European context, the majority of research has been conducted on a variety of leadership styles, including ethical, authentic, responsible, sustainable, and digital leadership. On the other hand, there is a lack of research on servant leadership in the existing literature review. Nonetheless, we discovered that servant leadership is an innovative approach in the research domain, particularly underexplored within the European setting. There is insufficient research on servant leadership in Europe.

Consequently, we identified new opportunities for future researchers regarding this entirely novel leadership style within the European setting. Leadership experts are establishing servant leadership as a new area of research. Our perspectives on appropriate leadership conduct are evolving alongside the times. It is possible that organisations are in need of leadership influenced by the principles of servant leadership theory at this time, given the present desire for more ethical and people-centered management. Notably, it signifies that servant-leaders transcend self-interest.

They are driven by a purpose transcending the need for power, specifically, the imperative to serve (Luthans & Avolio, 2003). Our review provides fresh directions for scholars to explore and advance our understanding on servant leadership domain (See Table 4).

Tab. 4: Future Research Agendas

Clusters	Future Research Agendas
Cluster 1: Servant leadership in hospitality sector	What causes the variability of servant leadership behavior in the European hotels ? How servant leadership improves psychological empowerment in hospitality sector of Europe? What is role of engagement in moral leadership in European Firms? How servant leadership enhance organizational identification in European Manufacturing firms?
Cluster 2: Leadership and work engagement	How leadership theory contributes to work engagement? What is role leadership, work engagement on corporate moral responsibility in European companies?
Cluster 3: Servant leadership as a key driver for innovation	Does servant leader increase innovative work behaviour employees? How servant leadership enhance innovation in European start-ups ?
Cluster 4: Gender, leadership and job outcomes	How gender contributes turnover? What is role of gender in organizational setting? How job crafting enhance employee performance?
Cluster 5: A review of diversified leadership styles.	What is role of authentic leadership on CSR implementation? How ethical leadership improves innovative work behaviour? How authentic leadership improves organizational performance?

Source: authors' own

Limitations

This research has few limitations: First, this study conducted a bibliometric review by using web of science database the period from 1990 to 2025. In this manner, the sample size was 150 peer-reviewed articles, which was focused and limited to the European context. However, Future scholars need to explore in the cross culture context with larger sample size. Secondaly, servant leadership is a novel research area that is connected with ethics, virtues, and morality. As, Critics are currently debating whether this is definitely real, and scholars are actively pursuing publication avenues for quantitive research on within developing countries. Additionally, this freh and a newly developed area in the European context and also It significantly impacts expectations of several Organizational stakeholders such as managers, employees, Customers, Suppliers, Government and Society as well. Finally, future researchesrs can explore Responsible and digital leadership.

Conclusion

We conducted bibliometric review on servant leadership. We conducted bibliometric review by using 150 peer-reviewed articles from Web of Science database. The data collection period was from 1990 to 2025 as to provide comprehensive reflection on this topic. We used VoSviewers Software for data analysis. This review contributes to body of knowledge on moral leadership domain as it is under-explored phenomenon. We focused on European countries.

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Structural Determinants of Crowdfunding Adoption Across Countries

Abstract

This study is focused on the structural determinants influencing crowdfunding volumes ([total digital capital raising](#)) across countries using macroeconomic and institutional variables. A dataset was consisted of 31 countries over a three-year period, the analysis investigates how GDP per capita ([PPP](#)), Ease of Doing Business Score, income inequality ([GINI coefficient](#)), digital infrastructure, and innovation capacity affect the intensity of digital capital raising per capita. Pearson correlation and multiple linear regressions were employed to assess the explanatory power of each factor. Results show that economic development, ease of doing business, and income inequality are significant predictors of crowdfunding activity, while online banking penetration and the Global Innovation Index did not show statistical significance. The findings suggest that crowdfunding adoption is shaped primarily by systemic and structural readiness rather than narrow technological access. The study contributes to the literature by highlighting the compensatory role of crowdfunding in more unequal societies and using credit card penetration as a proxy of credit market.

Key Words: Digital Finance, Alternative Financing, Crowdfunding

JEL Classification: G23, E44, O57

Introduction

A modern crowdfunding is close to celebrate its twenty-fifth anniversary as the platform ArtistShare was founded in 2001. This USA-based platform, unknown to most outside of the USA, was a "fan-funding" platform which became later the blueprint for many of today's well-known crowdfunding websites such as Kickstarter, IndieGoGo and PledgeMusic ([Camelio Group, 2001](#)). Crowdfunding moved far from raising funds for artists and today it exhibits tremendous potential to support entrepreneurial activities ([Cai et al., 2020](#)). The event of global financial crisis in 2008 global financial crisis had significant consequences, particularly in

depleting investment capital for small and medium-sized enterprises. Crowdfunding stepped in as an alternative channel which assisted projects in raising funds (Wille, 2025). Since then crowdfunding manifested strong growth rates over the years (Dushnitsky & Zunino, 2018). Pašalić and Pepur (2022) gave crowdfunding as an example of the digital transformation of financial intermediation, yet emphasized that it transcends the boundaries of mere financial transactions. As a result, crowdfunding has gained considerable traction over the last two decades and it became a phenomenon for which both academicians and policy-makers were trying to identify and create a thriving environment.

This article investigates the phenomenon of crowdfunding, with a particular focus on identifying the structural, economic, and institutional factors that influence its level of use across countries. Crowdfunding, a digital and decentralized way to raise money, grows differently in each region. Adamek et al. (2022) offered a compelling macroeconomic perspective on the determinants of crowdfunding, which directly aligns with efforts to understand how structural factors influence digital capital raising. In their analysis of 27 OECD countries, they demonstrated that the development of crowdfunding, specifically the reward-based model is significantly shaped by the institutional depth of the traditional banking sector and macroeconomic indicators such as GDP growth. Outside of OECD in less developed economies more factors start to interact as structural readiness and technological infrastructure is more pronounced in shaping crowdfunding adoption (Adjakou, 2021).

Which of factors such as the economic output, digital access, and how many people use financial services explain crowdfunding usage? Understanding the wider context in which crowdfunding platforms operate becomes important for explaining national differences. The main objective of this study is to uncover what drives the adoption and intensity of crowdfunding in various national contexts and to describe how these drivers interact.

1. Literature research, methods and data

Pašalić and Pepur (2022) emphasized the role of crowdfunding in creating a closer connection between investor and creator. At the same time, it places greater demands on the creation of a collaborative ecosystem in which the interests of all actors are aligned and effectively managed (Maraglino, 2024).

Adamek et al. (2022) offered a compelling macroeconomic perspective on the determinants of crowdfunding, which directly aligns with efforts to understand how structural factors influence digital capital raising. In their analysis of 27 OECD countries, they demonstrated that the development of crowdfunding, specifically the reward-based model is significantly shaped by the institutional depth of the traditional banking sector and macroeconomic indicators such as GDP growth. It was indicated by their findings that in environments where conventional financial intermediation is either inefficient or access to credit is constrained, crowdfunding

emerges as a more appealing alternative for entrepreneurial finance. This observation substantiates the broader hypothesis that financial inclusion and systemic access barriers are central to explaining the adoption of non-traditional financing tools. Crucially, their macroeconomic framework emphasizes the role of structural financial infrastructure rather than merely individual or firm-level characteristics as a key explanatory domain for cross-country variance in crowdfunding activity. In parallel, Adjakou (2021) expanded this structural focus by exploring crowdfunding in the context of a lower income economy where structural readiness and technological infrastructure is even more pronounced in shaping adoption. Taken together, these studies show that macroeconomic fundamentals, institutional quality, and digital trust infrastructure all play a key role in shaping both the demand for and the viability of crowdfunding platforms, making them crucial factors. It was pointed out by Cicchiello et al. (2022) that national welfare models had a strong impact on how widely crowdfunding is adopted. According to Halim (2024), crowdfunding is a growing force in digital financial inclusion, transforming access to finance when supported by strong digital infrastructure, policies, and public trust.

Building on the macroeconomic and institutional insights especially of Adámek et al. (2022), Adjakou (2021) and Cicchiello et al. (2022), this study investigates whether key national characteristics, both economic and institutional, act as significant predictors of digital capital raising across countries. In doing so, it formulates a set of hypotheses reflecting the anticipated relationships between selected macroeconomic, financial, and technological indicators and the intensity of crowdfunding use. This served as our dependent variable: total digital capital raised per capita in USD PPP (later abbreviated as LNDIGF) representing the intensity of crowdfunding use.

As for independent variables, or in general a possible factors of crowdfunding usage, we employed first, Gross Domestic Product per capita in PPP (GDPPC). The variables was used in the analysis due to its empirically established influence on crowdfunding volumes. This relationship was demonstrated by Kukk and Laidroo (2020) as well as Cicchiello et al. (2022), that identified a statistically significant and positive association across multiple model specifications. Their findings indicated that higher GDPPC correlates with increased crowdfunding activity per capita, particularly when controlling for cultural-cognitive variables such as digital service adoption. Second, drawing on insights from Baber (2021) and Rau (2017), the analysis also includes online banking penetration (OBP), which has been recognized as both a relevant determinant of digital finance adoption and a suitable proxy for the maturity of financial infrastructure. Third, Ziegler et al. (2020) suggested that countries with higher innovation capabilities which was reflected in strong Global Innovation Index (GII) scores and a tendency to have more developed crowdfunding ecosystems. Thus GII index was selected as a factor possibly influencing the digital capital raising in a country. Fourth, the relationship between the Ease of Doing Business (EASEOFDB) and crowdfunding was selected. Business friendly regulations and strong investor protections often foster crowdfunding growth. Di Pietro and Buttice (2020) found that the market is larger in countries with a

business friendly legal environment. On the other hand, Rau (2017) observed a negative correlation between a country's EASEOFDB rank and crowdfunding volume. Accordingly, EASEOFDB is included in the model to reflect the regulatory and institutional environment. Following Melton et al. (2020), crowdfunding tends to expand where formal finance is hindered by regulatory barriers, suggesting that lower EASEOFDB scores may correspond with greater crowdfunding activity. Finally, we added two novel dimensions: the Gini Coefficient (GINI), representing income inequality that may drive demand for alternative financing, and Credit Card Penetration (CCPEN), capturing the level of financial infrastructure and digital readiness necessary for participation in crowdfunding.

The research question stands as a determination to what extent specific national, above discussed, variables contribute to the intensity of digital capital raising. This research question breaks into subsequent hypotheses, each of which examines and empirically tests one dimension of this broader relationship:

- H_1 : GDP per capita (PPP) is a factor of digital capital raising per capita (USD PPP) in a given country.
- H_2 : The online banking penetration rate is a factor of digital capital raising per capita (USD PPP) in a given country.
- H_3 : The Global Innovation Index is a factor of total digital capital raising per capita (USD PPP) in a given country.
- H_4 : The Ease of Doing Business Score is a factor of total digital capital raising per capita (USD PPP) in a given country.
- H_5 : The credit card penetration rate is a factor of total digital capital raising per capita (USD PPP) in a given country.
- H_6 : The Gini coefficient is a factor of total digital capital raising per capita (USD PPP) in a given country.

The scope of the analysis is cross-national and macro-level, based on data from 31 countries over a three-year period. This measure includes only alternative financing mechanisms intended for small and medium-sized enterprises (SMEs) and self-employed individuals who do not rely on the traditional banking sector. Specifically, the dataset incorporates volumes associated with equity-based crowdfunding (crowdinvesting), reward-based crowdfunding, loan-based crowdfunding, online marketplaces for personal loan requests funded by private investors, and peer-to-peer lending platforms. Traditional bank loans and classic venture capital investments from institutional or private equity sources are explicitly excluded, as their operational logic and market structures differ fundamentally from the emerging, digitally mediated financing methods on which this analysis is centered.

The dataset consists of 31 countries that represent a diverse mix of economic contexts over the past three years, with the aim of quantifying the structural and macroeconomic determinants of crowdfunding adoption. It includes advanced economies such as the United States, the United Kingdom and Germany alongside major emerging markets like Brazil, South Africa, India, and Indonesia, as well as resource-driven and regionally distinctive economies including Saudi Arabia,

Nigeria. The sample contains both OECD and non-OECD members, with the goal of variety across Europe, Asia, Africa, the Middle East, and the Americas. Data was used only from past three years, because period 2019–2021 represents an exceptional structural break in the crowdfunding market and therefore should not be treated as part of the normal trend. During COVID-19, the global alternative finance market (excluding China) expanded by 24% in 2020 to \$113 billion. Donation-based crowdfunding rose by 160%, MSME funding increased by 51%, and equity crowdfunding grew by nearly 47%. This shows growth far exceeding ordinary growth patterns. (Ziegler et al., 2021).

The data for Gross Domestic Product per capita in PPP, the Ease of Doing Business Score, and the GINI coefficient were retrieved from the World Bank. The online banking penetration rate and credit card penetration figures were sourced from the Statista database. The Global Innovation Index (GII) was obtained from the World Intellectual Property Organization.

The quantitative analysis was conducted using IBM SPSS 30.0. To ensure a more normalized distribution and allow for elasticity-based interpretation of the results, total digital funding per capita was transformed into its natural logarithmic (LN) form creating LNDIGF variable as dependent variable. In the first phase, a Pearson correlation matrix was generated to examine the strength and direction of linear relationships between the dependent variable and a set of explanatory variables. The correlation matrix served as an initial diagnostic tool to reveal potential associations and detect correlations among independent variable pairs. In the second step, the Variance Inflation Factor (VIF) was calculated to evaluate the extent of collinearity among the independent variables, ensuring the robustness of subsequent regression modeling. As the final step, a multiple linear regression analysis was conducted to assess how the selected variables together affect the logarithmic value of digital funding per capita in PPP (LNDIGF).

2. Results of the Research

The empirical analysis focused on identifying macroeconomic and institutional factors that influence the volume of digital capital raised per capita across countries. In the first stage, the Pearson correlation matrix was used to explore pairwise relationships between variables, see Tab. 1.

The strongest and statistically significant correlation with LNDIGF was observed for GDP per capita ($r = 0.653^*$), followed by Ease of Doing Business ($r = 0.622^*$), online banking penetration ($r = 0.593^*$), and credit card penetration ($r = 0.575^*$). The Global Innovation Index was weakly correlated with LNDIGF ($r = 0.192^*$), while the GINI coefficient was negatively correlated ($r = -0.118$), though the result was not statistically significant.

Among the independent variables notable correlations were observed, especially between include GDP per capita and OBP ($r = 0.684^*$), OBP was strongly correlated

with EASEOFDB ($r = 0.736^*$) suggesting a possible multicollinearity. The VIF calculation showed 2.73 as the highest value in the case of OBP. The multicollinearity issue was found to be without a notable influence on the result, see Tab. 2.

Tab. 1: The correlation matrix between the independent variables

	LNDIGF	GDPPC	OBP	GII	EASEOFDB	CCPEN	GINI
LNDIGF	1.000						
GDPPC	0.653*	1.000					
OBP	0.593*	0.684*	1.000				
GII	0.192*	0.186*	0.177	1.000			
EASEOFDB	0.622*	0.643*	0.736*	0.250	1.000		
CCPEN	0.575*	0.588*	0.579*	0.226*	0.536*	1.000	
GINI	-0.118	-0.322*	-0.366*	-0.109*	-0.436*	-0.281*	1.000

* $p < 0.05$

Source: authors' calculations in IBM SPSS 30.0

Several models were created based on variables that showed a significant correlation coefficient toward the dependent variable of logarithmic value of digital funding per capita in PPP (LNDIGF). The Gini coefficient was included in the two final models because it manifested statistically significant coefficient in spite of not being significantly correlated directly to explained variable. Model 1 included all the chosen variables, while Model 2 excluded credit card penetration variable. The results of both models are shown in Tab.2 and Tab. 3.

Tab. 2: Regression coefficients and collinearity statistics – Model 1

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-12.647	3.007		-4.206	0.000		
GDPPC	0.000	0.000	0.327	3.092	0.003*	0.450	2.221
OBP	0.009	0.014	0.079	0.675	0.502	0.365	2.736
GII	0.001	0.007	0.009	0.127	0.899	0.923	1.083
EASEOFDB	0.118	0.041	0.329	2.874	0.005*	0.383	2.610
CCPEN	0.024	0.010	0.221	2.367	0.020*	0.579	1.728
GINI	6.942	2.470	0.222	2.811	0.006*	0.804	1.244

* $p < 0.05$

Source: authors' calculations in IBM SPSS 30.0

The results show that the variable GDPPC has a positive and significant effect (Beta = 0.327), indicating its moderate positive relationship with crowdfunding activity. Weaker, yet significant, positive relationship was found for Ease of Doing Business

EASEOFDB (Beta = 0.329), CCPEN (Beta = 0.221), and GINI (Beta = 0.222). On the other hand, the model 1 did not produce significant result for parameters of online banking penetration (OBP) and the Global Innovation Index (GII). Therefore, the results of our hypotheses are as follows:

- H_1 : GDP per capita (PPP) is a factor of digital capital raising per capita (USD PPP) in a given country. RETAINED
- H_2 : The online banking penetration rate is a factor of digital capital raising per capita (USD PPP) in a given country. REJECTED
- H_3 : The Global Innovation Index (GII) is a factor of total digital capital raising per capita (USD PPP) in a given country. REJECTED
- H_4 : The Ease of Doing Business Score is a factor of total digital capital raising per capita (USD PPP) in a given country. RETAINED
- H_5 : The credit card penetration rate is a factor of total digital capital raising per capita (USD PPP) in a given country. RETAINED
- H_6 : The GINI coefficient is a factor of total digital capital raising per capita (USD PPP) in a given country. RETAINED

Tab. 3: Regression coefficients and collinearity statistics – Model 2

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-13.010	3.082		-4.222	0.000		
GDPPC	0.000	0.000	0.397	3.811	0.000	0.488	2.047
OBPEN	0.016	0.014	0.135	1.149	0.254	0.381	2.624
GII	0.003	0.007	0.030	0.392	0.696	0.936	1.069
EASEOFDB	0.126	0.042	0.353	3.018	0.003	0.386	2.590
GINI	6.752	2.533	0.216	2.666	0.009	0.805	1.243

* $p < 0.05$

Source: authors' calculations in IBM SPSS 30.0

The Model 2 excluded the credit card penetration variable from the set of predictors. In this setting, GDP per capita (GDPPC) remained a statistically significant and positive predictor (Beta = 0.397) with a slightly higher standardized coefficient than in Model 1 (Beta = 0.327). The Ease of Doing Business Score (EASEOFDB) and Gini coefficient remained significant with very limited change in the relationship strength.

Both variables, online banking penetration (OBP) and the Global Innovation Index (GII), remained without a significant beta parameter. However, in comparison to Model 1, the p-value for OBP decreased, indicating a small shift in explanatory power. This suggests a partial reduction in overlapping explanatory variance between the two financial access indicators.

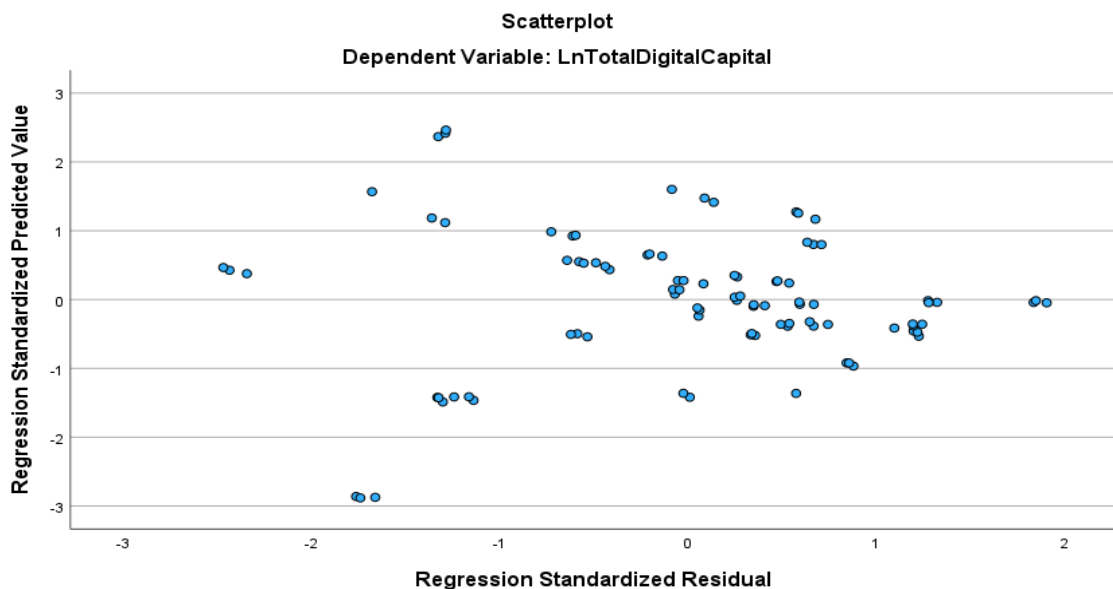
The model quality was assessed by index of determination of 0.567, indicating that approximately 56.7% of the variance was explained by the included predictors. See tab. 4 for more details. Final quality assessment included the residual analysis, see Fig. 1. A fairly random distribution around zero and without a clear linear pattern or several compact and separated clusters confirmed that the assumptions of linearity and homoscedasticity were not violated.

Tab. 4: Model 2 summary

Model Summary					
Model	R	R Square	Adjusted Square	R	Std. Error of the Estimate
2	,753	0.567	0.537		1.62788

Source: authors' calculations in IBM SPSS 30.0

Fig. 1: Residual Plot for Model 2



* $\alpha = 0,05$

Source: authors' calculations in IBM SPSS 30.0

3. Discussion

Based on the results of model 1, we retained H1, H4, H5 and H6 hypotheses. Therefore, we claim that GDP per capita in PPP (GDPPC), Ease of Doing Business Score (EASEOFDP), Credit Card Penetration (CCPEN), and the Gini coefficient (GINI) are predictors of total digital capital raising per capita in PPP (LNDIGF). These results are consistent with Adámek et al. (2022), who emphasized the role of economic development and institutional strength, and Cicchiello et al. (2022), who described the importance of a supportive regulatory environment. The positive

effect of GDPPC is in accord with findings by Kukk and Laidroo (2020) and Baber (2021), while the significance of EASEOFDP supports the conclusions of Di Pietro and Buttice (2020). The result of H6 related to Gini coefficient suggests that income inequality may contribute to greater crowdfunding uptake, as crowdfunding often serves populations excluded from traditional finance. The exact mechanism likely varies with the structure of the economy, levels of social trust, and the dominant type of crowdfunding. The findings suggest that inequality does not necessarily suppress crowdfunding. This is in line with Adjakou (2021). It suggests that alternative finance may serve a compensatory role in contexts of high inequality.

We rejected H2 and H3 covering Online Banking Penetration (OBP) and the Global Innovation Index (GII). They did not reach statistical significance, despite being highlighted by Rau (2017) and Ziegler et al. (2020) as potentially supportive of digital finance ecosystems. Their insignificance in this model may reflect varying levels of user engagement or lag effects between infrastructure availability and platform usage. Given these findings, further research is recommended to better understand the role of income inequality measured by the Gini coefficient in shaping crowdfunding behavior, as well as to re-evaluate the influence of Credit Card Penetration (CCPEN) through more granular or behavioral-level data.

Although credit card penetration initially appeared statistically significant in the full regression model, due to its theoretical overlap with online banking penetration, we created a separate model 2. An overlap in a form of multicollinearity was not confirmed by VIF, however, the Occam's blade approach prevailed as model quality changed almost unnoticeably. Moreover, the conceptual distinction between credit card usage and broader digital banking infrastructure may be less relevant in countries where mobile or online payments dominate without relying on credit-based instruments. Credit card penetration may also act more as a proxy for the general economic advancement of a country, rather than capturing a unique, independent dimension of crowdfunding behavior. More in depth research on the matter is needed because it cannot be ruled-out that a specific pro-crowdfunding behavior might be captured by the credit card usage as a proxy.

Overall, the results support the idea that crowdfunding is shaped by broad macroeconomic and institutional frameworks rather than narrow technological measures. The findings provide confirmation of the expectations derived from prior literature except from online banking penetration and the Global Innovation Index which for more in depth research that for example performs segmentation prior to model construction or an analysis of a possible moderation effect instead of a direct linear influence. There are also other variables that may increase the model quality or serve as more precise predictors such as (central) bank interest rates, economic uncertainty, microcredit volume, default rate, HDI or IHDI, financial system type, corruption index, and others. Shneor et al. (2020) also suggests that crowdfunding may not be best to evaluated only by traditional financial indicators to evaluate its performance and development. As an alternative dependent variable a socio-economic benefits are suggested.

Conclusion

Crowdfunding provides an opportunity for projects and businesses that may otherwise struggle in fundraising. We investigated which variables contribute to the intensity of digital capital raising and to what extent. We modelled the total digital capital raising per capita in PPP being explained by a set of GDP per capita in PPP, online banking penetration rate, Global Innovation Index, and Ease of Doing Business Score all employed in a previous literature. We contribute by testing credit card penetration rate and the Gini coefficient.

The findings provided confirmation of the expectations derived from prior literature with the exception of Global Innovation Index and online banking penetration rate. GDP per capita in PPP, Ease of Doing Business Score and both card penetration rate and the Gini coefficient showed positive weak-to-moderate effects on total digital capital raising per capita in PPP. The results reinforce the conclusions drawn by Adámek et al. (2022) and Cicchiello et al. (2022), who emphasized the role of structural capacity over individual-level digital adoption in explaining cross-country differences in alternative finance uptake. The results suggest that alternative finance may serve a compensatory role in contexts of high inequality as proposed by Adjakou (2021). An inequality plays a role in shaping demand for alternative finance and, in certain contexts, it may even stimulate its use by encouraging excluded individuals to seek alternative financial channels.

The analysis confirms that structural and macroeconomic conditions influence the level of digital capital raised per capita. The findings suggest that crowdfunding adoption is shaped primarily by systemic and structural readiness rather than narrow technological access. Economic development and regulatory quality proved to be consistent predictors of crowdfunding activity, while digital access do online banking and innovation indicators showed no significant effect when considered alongside aforementioned variables. That raises the need of a further research.

The article faces several limitations that should be considered. First, the analysis relies on data from a three-year period, which restricts the ability to capture long-term patterns or structural changes in crowdfunding dynamics. Second, the study includes a relatively small number of countries, which may reduce the generalizability of the findings and weaken the reliability of statistical conclusions. Third, the countries in the sample represent a wide variety of economic contexts, from highly developed to low-income economies, each operating under different institutional, financial, and cultural conditions. This diversity introduces heterogeneity that a single model may not fully accommodate, potentially affecting the consistency of the observed relationships. Moreover, we did not employ a control variables for a geographical or institutional influence.

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Traffic source investigation of waste management websites: implications for institutional communication

Abstract

Effective communication is a crucial but often underestimated component of successful waste management systems. This study investigates the digital behaviour of users on waste management-related websites, with the goal of identifying the most significant online traffic sources. The research was conducted as part of a broader innovation project aimed at optimizing technological, algorithmic, and procedural elements of municipal waste management, with a dedicated focus on the communication strategies required to support these innovations. A total of 55 websites relevant to waste management — including institutional platforms, company websites, and online magazines — were identified through curated sources and AI-supported search processes.

After eliminating duplicates and incomplete entries, 42 websites were analysed using the enterprise version of Similarweb. Key metrics collected included visit volume, user behaviour, device usage, and the distribution of traffic across seven standard internet sources (e.g., direct, organic search, social, referral). The data revealed that organic search and direct access are by far the most dominant traffic sources, while email, display advertising, and paid search play marginal roles. Mobile devices accounted for the majority of access, reinforcing the need for mobile-first design. Based on these findings, a set of practical, source-specific recommendations is proposed, tailored to the needs of a public institution currently undergoing waste management reform. The results provide valuable insights not only for the analysed institution but also for other organizations seeking to improve environmental communication through data-informed digital strategy.

Key Words: waste management, traffic sources, website, internet, marketing communication.

JEL Classification: M31

Introduction

Public communication plays a pivotal role in the successful implementation of waste management infrastructure. As highlighted by Kirkman & Voulvoulis (2017), it is essential to engage the public from the earliest stages of planning. Citizens must not only accept but understand the purpose, complexity, costs, and technological aspects of new infrastructure. Scientific literacy is fundamental in this process, as it fosters meaningful public involvement in shaping decisions that directly impact their communities. Environmental awareness can be significantly influenced by the availability and quality of information. Bassi et al. (2019) demonstrate that targeted communication, particularly around themes such as ecological connectivity, increases environmental awareness. Their study further suggests that demographic variables, such as age and gender, mediate the effectiveness of such communication, emphasizing the need for differentiated outreach strategies. Modern waste management increasingly relies on information and communication technologies (ICTs) as a critical enabler of efficiency and transparency. According to Singh (2022), ICTs are essential for addressing practical issues in waste disposal, including site selection, monitoring, and recycling logistics. Similar emphasis is placed by Mazzi et al. (2020), who underline the importance of external communication within environmental management systems, particularly in the context of waste treatment. Beyond operational benefits, ICTs can contribute to cost reductions. Mousavi et al. (2023) explored the integration of spatial, identification, and data transmission technologies, alongside energy harvesting systems, and concluded that such tools not only lower operational costs but may redefine future standards in waste management systems. Likewise, Handayani et al. (2024) stress that successful implementation of waste policy requires more than technology; it also demands institutional commitment, strong internal and external communication, and optimal resource allocation. In construction sectors, ICTs have proven to support both cost efficiency and the sustainability of waste management processes. Mandičák et al. (2021) found that ICTs positively influence sustainable chain management and cost reduction in construction waste, highlighting the transferability of digital communication principles across sectors. Research indicates that consumer perception is not shaped solely by the inherent attributes of a product, but significantly by the way these attributes are communicated. A study focusing on the perceived quality revealed that while respondents initially did not consider environmental aspects important, their attitudes shifted noticeably once those aspects were explicitly highlighted through targeted marketing communication (Čarnogurský et al., 2019). Effective communication in waste management must also be audience-specific. Kala et al. (2020) developed models for selecting suitable communication traffic sources based on socio-economic categories, showing how targeted strategies improve campaign efficiency. This is consistent with findings by Kozel et al. (2019), who observed that younger age groups (under 18) can significantly influence the environmental attitudes of older generations, indicating a strong intergenerational communication dynamic. It is essential to tailor both the content and selection of communication platforms to the needs and habits of younger generations, as their online behaviour and user journey differ notably from those of older age groups (Drabik et al., 2023). Online platforms — particularly websites — remain key tools for informing the public. Repovienė & Pažėraitė (2023) found that most current web content produced by waste management institutions tends to repeat functional messages, often neglecting emotional or motivational elements

that could enhance engagement. Frempong et al. (2020) add that value co-creation — involving customers in shaping their experience — is positively influenced by firm-managed web platforms and can lead to increased electronic word-of-mouth, a critical factor in community-level environmental behaviour change. Incentivization mechanisms such as gamification are emerging as powerful tools. Daas et al. (2025) describe a mobile application that uses redeemable rewards to encourage recycling behaviour, successfully addressing low participation rates. Understanding digital traffic dynamics is essential for designing effective communication strategies. Filippou et al. (2024) concluded that three key marketing traffic sources can explain over 60% of website traffic variance, providing actionable insights for public and private waste management communicators. Their subsequent research (Filippou et al., 2025) also shows that optimizing a single marketing traffic source — such as lower-funnel campaigns — can have positive spillover effects on other traffic sources, such as branded search. Furthermore, Piccardi et al. (2021) identified Wikipedia and other external knowledge platforms as high-performing sources of website traffic, effectively acting as bridges between search engines and third-party content. Collectively, this body of literature underscores the strategic importance of communication and digital traffic sources in contemporary waste management. From participatory public planning to traffic source-level traffic optimization, successful waste management in the 21st century is increasingly as much about communicating well as it is about managing waste effectively.

1. Methods of Research

This article emerged as a natural response to the needs of a broader research and development project focused on designing technological, algorithmic, and process-level optimizations for municipal waste management systems. Within this context, the current study addresses the challenge of how to disseminate waste management-related information effectively via digital channels. It contributes to the marketing and communication part of the larger project and is considered a partial fulfillment of the broader project's objectives. The main aim of this article is to examine the most significant sources of website traffic in the field of waste management and to propose effective online channels for content distribution, tailored to the needs of a specific institution currently optimizing its waste management processes.

The article thus focuses on analysing actual user behaviour on websites related to waste management, with the goal of identifying which digital traffic sources — such as search engines, social media, or referrals — are the most effective in driving traffic. These insights will serve as a foundation for concrete recommendations aimed at improving public communication strategies in the waste management domain.

This study aims to analyse the structure and significance of online traffic sources for websites operating in the field of waste management, with the objective of informing strategic recommendations for digital communication. The methodological approach followed a structured multi-step process involving sample construction, data collection, data cleaning, and statistical analysis. The initial research phase focused on the identification of relevant websites. A total of 55 unique websites with a clear connection

to the topic of waste management were selected for analysis. The inclusion criteria required that the website either provide information on waste-related topics (e.g. educational or journalistic content), offer waste management products or services, or represent an institution engaged in the governance or coordination of waste management activities. The final sample included websites across three main categories: online magazines, commercial companies, and institutional entities. The sample was compiled from three complementary sources to ensure coverage and diversity. First, a curated list of waste management websites published by Fireart Studio was used as a foundation. Second, two iterative prompt-based queries were conducted using the ChatGPT large language model to identify additional relevant websites. The outputs from all three sources were consolidated, and duplicate entries were eliminated based on URL and content identity, resulting in the removal of one redundant item. The final dataset of 55 websites was then subjected to traffic analysis. Traffic data for each website were collected using the enterprise (paid) version of the Similarweb platform, which provides detailed web analytics and traffic source segmentation. For each domain, the following quantitative indicators were extracted and recorded in a structured spreadsheet: total number of visits, visits segmented by device type (desktop and mobile), average monthly visits, average monthly unique visitors, deduplicated audience size, average visit duration, average number of pages viewed per visit, and bounce rate. In addition to these performance metrics, a key focus of the study was on the origin of web traffic. Therefore, for each website, we recorded the estimated share of traffic attributed to the following standardized traffic sources, as defined by Similarweb: Direct traffic, Organic search, Paid search, Referral traffic, Display advertising, Social media, and Email campaigns. These categories comprehensively cover the range of primary digital traffic sources commonly used in online marketing and communication strategies.

During the data collection process, 13 websites were excluded from the analysis due to insufficient or incomplete data — specifically, 7 websites had no traffic data available across any of the measured metrics, and 6 lacked at least one of the critical variables required for comparison. The final analysed sample thus comprised 42 websites with complete and comparable traffic data. The exclusion of these websites may have influenced the overall representativeness of the dataset in several ways. First, it is likely that websites with insufficient data tend to have lower traffic volumes and limited digital engagement, which means the final analysed sample may slightly overrepresent websites with more established or better-optimized online presence. As a result, the relative strength of dominant traffic sources — such as organic search and direct traffic — could be amplified, while the variability typical of low-traffic websites (e.g., reliance on niche sources or local referrals) may be underrepresented.

Second, the removal of low-traffic websites might have affected the balance across website types (e.g., institutional vs. commercial), although care was taken to ensure diversity in the remaining sample. Nevertheless, the results should be interpreted as reflecting patterns among active and measurable websites, rather than the entire population of waste management websites. While the decision to exclude incomplete entries was made to preserve methodological consistency and comparability across metrics, future research may consider complementary qualitative or case-based

approaches to capture insights from smaller or emerging websites that fall below the detection threshold of traffic analytics tools.

Following data preparation, we conducted descriptive statistical analysis on the cleaned dataset. For each traffic source category, we calculated the mean, minimum, and maximum values of its contribution to total website traffic across the sample. These descriptive statistics allowed us to construct a relative ranking of traffic source importance, indicating which traffic sources are most and least effective in driving traffic to websites in the waste management sector. Based on this ranking and with consideration of the communication goals of public institutions engaged in waste management optimization, we developed a set of practical recommendations on which traffic sources should be prioritized to ensure effective dissemination of information to the general public.

2. Results of the Research

The table below shows the average percentage distribution of website traffic sources across all analysed waste management websites. Data were collected using Similarweb and represent the mean values for particular metrics.

Tab. 1: Average website performance metrics of waste management websites

	Total visits	Monthly visits	Monthly Unique Visitors	Deduplicated audience	Visit Duration	Pages / Visit	Bounce Rate
Average	2 775 776	231 369	140 840	122 062	00:01:42	2,60	47%

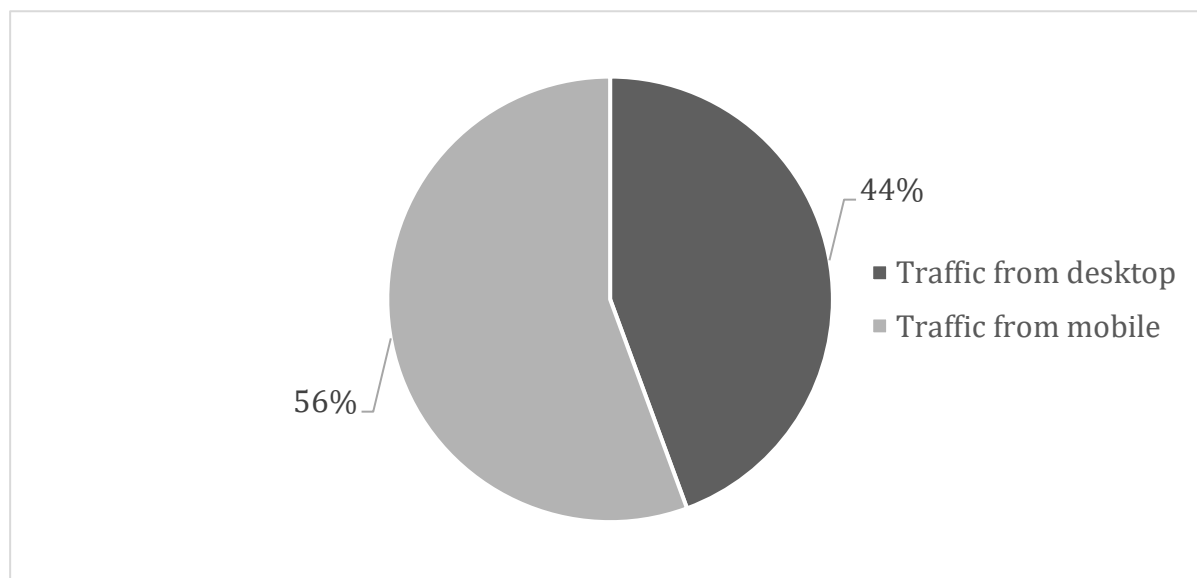
Source: authors' procession

According to the results, the most significant source of traffic is direct access, accounting on average for 38.7% of all visits. This indicates that a substantial portion of users either enter the website URL directly, use bookmarks, or arrive through offline prompts such as printed materials or branded vehicles. Organic search ranks second with 33.9%, highlighting the importance of search engine visibility and the role of non-paid search engine queries in website discovery. Other traffic sources play more marginal roles: referral traffic (10.3%) and social media (9.4%) contribute moderately, while paid search (3.2%), display advertising (2.4%), and email marketing (2.1%) show minimal impact on overall traffic. These results underscore the relevance of cost-effective, inbound-oriented strategies — such as SEO and brand recognition — in the digital outreach of waste management websites. The distribution of traffic sources as shown in the table serves as a data-driven foundation for prioritizing digital communication channels, especially for resource-constrained organizations operating in the environmental services sector.

The following chart illustrates the average distribution of website traffic by device type across all analysed waste management websites. Based on data obtained from the

Similarweb platform, two primary categories were distinguished: mobile devices and desktop computers. For each website, the share of visits originating from each device type was recorded, and the resulting percentages were averaged across the entire sample

Graph 1: Traffic share depending on device of waste management websites



Source: authors' procession

The analysis of user device preferences revealed that, on average, 56% of visitors access waste management-related websites via mobile devices, while the remaining 44% use desktop computers. This finding highlights the increasingly dominant role of mobile browsing in the context of environmental and utility-related online content. The mobile-first behavior observed in this dataset reflects broader digital consumption trends, but it also has specific implications for the waste management sector. Many users may be searching for practical, time-sensitive information — such as collection schedules, sorting instructions, or service updates — while on the move or outside the home. The convenience and immediacy offered by smartphones thus make them a preferred access point for this type of content. From a practical standpoint, this emphasizes the critical importance of mobile optimization for websites dealing with waste management communication. Websites should be fully responsive, fast-loading, and easy to navigate on smaller screens. Key information — such as dates, contact forms, recycling instructions, or search functions — should be prominently placed and easily accessible without excessive scrolling or zooming. For organizations with limited technical capacity, ensuring at least a mobile-friendly layout using established templates or CMS systems (e.g., [WordPress with responsive themes](#)) should be considered a priority. In addition, user behavior data suggests that mobile experiences should be designed with simplicity and utility in mind — prioritizing clarity over visual complexity. This trend toward mobile usage also has implications for the selection of communication channels. For example, QR codes on printed materials or containers can serve as effective bridges between offline environments and mobile digital platforms. Likewise, social media campaigns — often

consumed primarily on mobile devices — may prove more effective than traditional desktop-bound formats in reaching the public.

The following table provides an overview of the relative significance of individual traffic sources for websites dealing with waste management topics. Based on data collected through the Similarweb analytical platform, a total of seven standard traffic sources were examined. For each analysed website, the percentage share of traffic from these sources was identified, and subsequently, the average values across all websites were calculated. These averages were then used to rank the traffic sources from the most to the least significant in terms of their contribution to total website traffic. The resulting ranking offers insight into which digital channels play the most prominent role in driving users to waste management websites.

Tab. 2: List and significance of traffic sources of waste management websites

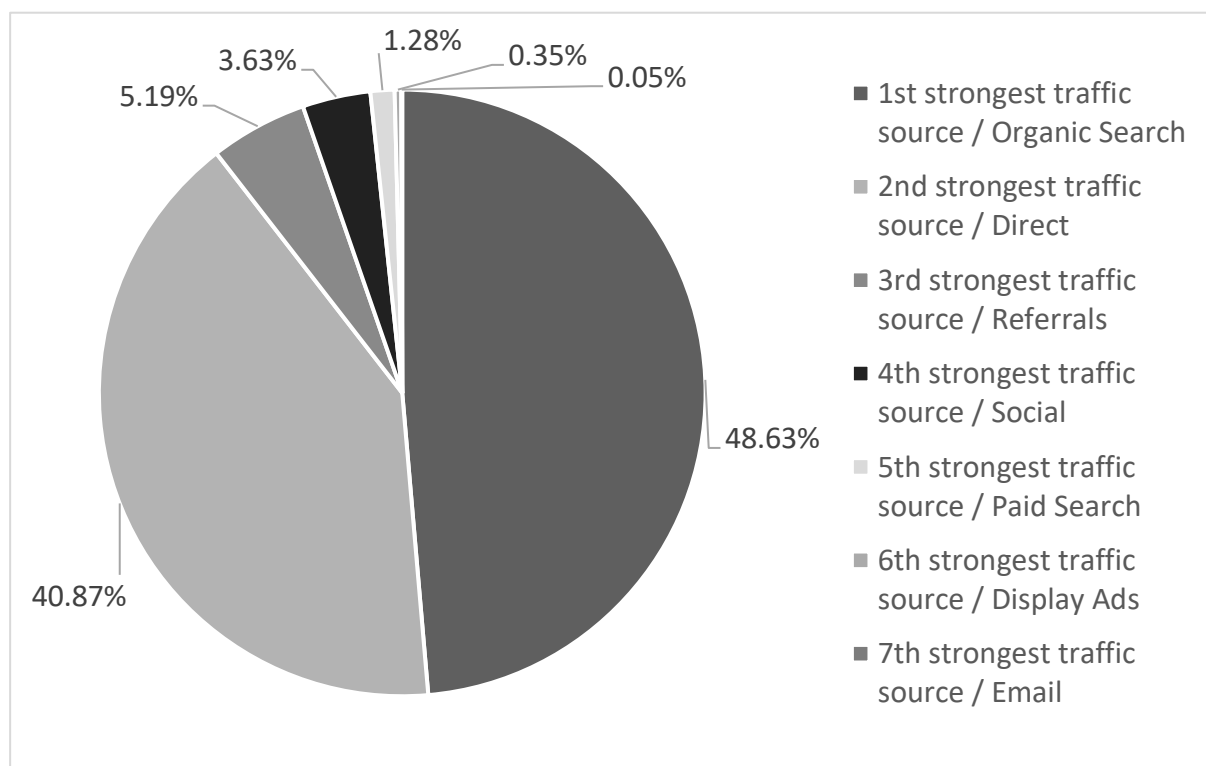
Position	Source	Percentage (average)
1st strongest traffic source	Organic Search	48,63%
2nd strongest traffic source	Direct	40,87%
3rd strongest traffic source	Referrals	5,19%
4th strongest traffic source	Social	3,63%
5th strongest traffic source	Paid Search	1,28%
6th strongest traffic source	Display Ads	0,35%
7th strongest traffic source	Email	0,05%

Source: authors' procession

The table and graph present the aggregated ranking of internet traffic sources based on their average position across all analysed websites related to waste management. Each row represents a specific type of traffic source — such as direct traffic, organic search, social media, and others — and indicates its relative strength in generating website visits within the dataset. The ranking was determined by evaluating the order of importance of each traffic source for every individual website (i.e., whether it was the first, second, third strongest source, etc.). These individual positions were then averaged across all websites that had complete data, allowing for the construction of an overall hierarchy of traffic sources. According to the results, direct traffic and organic search emerged as the two most dominant sources of visits. This suggests that users typically either access waste management websites by entering URLs directly (often as a result of strong brand awareness or offline communication), or discover them through unpaid search engine results. Referral traffic and social media also contribute significantly, whereas display

advertising, paid search, and email campaigns were generally less influential within the analysed sample.

Graph 2: Visualised significance of traffic sources of waste management websites



Source: authors' procession

3. Discussion

Beyond descriptive ranking, each of these traffic sources offers specific opportunities for strategic optimization. For waste management companies, which often operate under limited marketing budgets and in regulated environments, it is essential to focus on cost-effective communication methods and build trust through transparent public engagement. Below are tailored recommendations for each traffic source:

1) Direct Traffic can be improved through local offline campaigns that raise awareness of the company's web presence. This includes using printed materials (e.g., flyers, invoices, recycling schedules), signage on vehicles or containers, and integrating the website address into all public-facing communications. School and Kindergarten Campaigns are another option how to educate children from the early age towards waste collection, separation, and awareness, what is waste's environmental and social impact. Local campaigns, or visits can be arranged in schools. Most of kindergartens and schools are tied to the local government in Slovakia, and those are directly or indirectly owned, or operated by the same municipality, or district as the waste separation and collection entities. Such an engagement can lead not only to better awareness among children, but

also can link these to the waste management's company website, social media, etc. A basic visit by the waste management company truck, and / or associate with a short demonstration and presentation about waste separation is a highly effective option. Participation in open days, press briefings, and community events can also help drive recognition and encourage users to visit the website directly.

2) Organic Search (SEO) represents a highly cost-effective, long-term investment. Waste management companies can enhance organic visibility by creating informative content around local waste regulations, recycling tips, and service updates. Publishing regular news articles or blog posts aligned with common search queries (e.g., "how to dispose of electronics") and maintaining an accessible, mobile-friendly website structure are essential steps. Collaborating with municipalities to be featured on their official websites or digital bulletins can also improve SEO through backlinking.

3) Referral Traffic can be optimized by building relationships with local institutions, news outlets, NGOs, and environmental organizations. For example, press releases distributed to regional media can result in valuable mentions and inbound links. Being listed on municipal portals, regional directories, or public procurement databases can also enhance referral volume at minimal cost.

4) Social Media should focus on community-oriented content that reflects the company's environmental and social impact. Instead of paid promotions, firms can leverage platforms like Facebook and Instagram to share behind-the-scenes updates, respond to community questions, and document activities such as cleanup campaigns or recycling initiatives. Collaborations with local schools, civic groups, or media partnerships can further extend reach organically.

5) Paid Search and Display Ads tend to be cost-intensive and may not yield optimal return on investment for smaller waste management companies. These traffic sources should be used selectively, for example during peak service updates (holiday waste schedules) or in competitive tenders. In general, such companies should prioritize organic and relationship-based reach over paid advertising.

6) Email Campaigns may still provide value when used as part of service communications — such as reminders about pickup days, changes in service, or announcements of public events. Building a small but relevant mailing list through online sign-ups or physical interactions (e.g. during open days) can support direct, low-cost engagement with interested residents.

In summary, while large-scale advertising may be out of reach, strategic use of press relations, institutional collaboration, and community engagement can effectively enhance traffic from key sources. This cost-conscious approach aligns well with the mission-driven nature of waste management services and can yield both operational and reputational benefits.

The findings should be interpreted in light of the fact that the effectiveness and structure of digital communication are strongly influenced by contextual variables. Cultural norms,

technological infrastructure, and levels of digital literacy all shape how users interact with websites and respond to environmental topics such as waste management. In particular, preferences for specific traffic sources — such as search engines, direct access, or social media — may vary depending on local habits, digital ecosystems, and user expectations. Moreover, the perceived relevance of waste management itself, along with the public's willingness to engage with institutional communication, is often shaped by broader societal factors such as environmental awareness, trust in public institutions, and media consumption patterns. These factors can significantly differ across regions and populations, meaning that while the current study offers useful insights for designing digital strategies, its generalizability to radically different sociotechnical contexts (e.g., countries with limited internet access or different platform preferences) may be limited. Therefore, the implications derived from this research are most applicable within digitally mature environments where public institutions already maintain some level of web-based communication infrastructure

Conclusion

This study explored the digital communication landscape of waste management-related websites, with a specific focus on identifying which internet traffic sources most significantly contribute to user visits. By analysing a curated sample of 42 relevant websites through the Similarweb platform, the research revealed that the most dominant traffic sources are organic search and direct traffic, which together account for nearly 90% of total visits. These findings underscore the importance of maintaining strong search engine visibility and brand recognition, particularly for institutions operating under constrained communication budgets. The analysis also emphasized the growing dominance of mobile access, suggesting that any digital strategy in the field of waste management must prioritize mobile responsiveness and clarity of content across devices. Furthermore, less impactful traffic sources such as display ads or email campaigns were shown to play a relatively minor role in overall traffic generation — indicating that their use should be selective and purpose-driven. Based on these insights, the article offered practical, source-specific recommendations for optimizing communication strategies, particularly for public institutions currently undergoing waste management transformations. These recommendations align with broader goals of transparency, efficiency, and public engagement in the environmental services sector. In a broader sense, this research demonstrates that digital behaviour data — when interpreted appropriately — can serve as a powerful input for strategic planning in public services.

Although this study focuses on the waste management sector, the observed dominance of organic search and direct traffic as primary acquisition channels appears to be consistent with digital behaviour trends in other public service domains, such as healthcare or energy. In these sectors as well, users typically seek trustworthy information through search engines or direct access to known institutional sources. This suggests that some patterns identified in this research — particularly the importance of content accessibility, SEO optimisation, and brand trust — may be applicable across various areas of public service communication. However, sector-specific nuances, such as urgency of need or emotional framing, should be considered when translating these findings beyond the waste management context. Future research may expand this approach by including

longitudinal analysis of traffic patterns, content impact assessments, or segmentation by region and language. Moreover, integrating qualitative user feedback with traffic analytics could help develop more holistic, citizen-oriented communication strategies. Ultimately, the findings of this study are not only relevant for a single institution but contribute to a more general understanding of how digital ecosystems support — or constrain — the effectiveness of environmental communication in the 21st century.

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Collection of local accommodation fee in municipalities in the Hradec Kralove Region, the Czech Republic

Abstract

This paper investigates the effectiveness of local accommodation fee collection in the municipalities of the Hradec Králové Region, Czech Republic, during 2024. Employing a comparative methodology, official tourism statistics from Tourdata.cz are evaluated against residual mobile network (GSM) data to estimate the true volume of overnight stays. The further analysis of financial data of the communal budgets reveals a substantial reporting gap, with 68–83% of overnight stays potentially unregistered for fee purposes. These discrepancies are attributed to structural deficiencies in municipal collection systems, including limited administrative capacity, fragmented legislative alignment with the short-term rental sector, and pronounced information asymmetry between service providers and local authorities. Financial modelling indicates unrealized revenues of CZK 30.0–39.5 million under current municipal coverage and CZK 51.25–62.69 million under full regional implementation, representing potential increases of 40–83% relative to 2024 collections for the proposed models.

The findings highlight the urgent need for integrated digital monitoring tools, notably the eTurista platform, which is mandated under EU Regulation 2024/1028 as a single national registration point for short-term accommodation services. The study contributes to the literature on local public finance, tourism taxation, and compliance behaviour by demonstrating the scale of fiscal leakage in decentralized fee systems. Policy implications stress the necessity of harmonized data-sharing mechanisms, targeted enforcement strategies, and capacity building at the municipal level to enhance compliance, ensure equitable cost distribution among accommodation providers, and foster sustainable tourism development.

Key Words: Accommodation Fee, Municipal Finance, Information Asymmetry, Short-Term Rental Market, Tourism Policy

JEL Classification: H71, R53, Z32, D82, C21

Introduction

The efficiency of fee collection is constrained not only by limited municipal control capacity but also by the absence of shared data tools. These institutional weaknesses create an environment in which accommodation providers may underreport the number of overnight stays, thereby reducing their fee liability. Such behaviour reflects a broader structural problem that can be meaningfully interpreted through the lens of information asymmetry theory. This theory highlights the uneven distribution of information between actors with diverging interests—in this case, between accommodation providers, who hold precise knowledge of visitor numbers, and municipalities, which rely on self-reported data for fee administration. Where data sharing is absent and control mechanisms remain weak, this asymmetry is further reinforced, opening space for systematic distortions and deliberate underreporting (STIGLITZ, 2000). In the Czech context, the situation is exacerbated by the disconnection between the legislative framework and the rapidly evolving short-term accommodation market. As Lucie Plzáková and Petr Studnička (PLZÁKOVÁ & STUDNIČKA, 2021) show, institutional ambiguity and gaps in administrative practice enable providers to exploit these asymmetries to evade their obligations. Importantly, such structural conditions not only facilitate non-compliance but also shape the behavioural dynamics of trust and enforcement, providing a direct link to explanatory frameworks from behavioural economics, such as the slippery slope model and theories of blame avoidance.

From the perspective of behavioral economics, this phenomenon can be interpreted using the slippery slope model (KIRCHLER et al., 2008) which points to a close relationship between the level of trust in authorities and the willingness to comply with fiscal obligations (LISI, 2019; MARDHIAH et al., 2019). This model describes the situation where a low level of control and trust in a fair system leads to a weakening of moral motivation to fulfill obligations. Added to this is the theory of blame avoidance (HINTERLEITNER, 2019), which explains why local governments are often not active performers of control functions—they transfer responsibility or avoid it due to concerns about reputational and political costs.

Taken together, these theoretical frameworks demonstrate a high degree of relevance for the Czech context. The combination of information asymmetries, weak enforcement capacities, and limited trust in municipal governance helps explain the persistent underreporting of overnight stays identified in this study. In practice, this means that a significant share of potential fee revenues is not realised, reducing the fiscal capacity of municipal budgets to reinvest in tourism infrastructure and services. The observed revenue gap thus illustrates how structural and behavioural factors jointly undermine the effectiveness of the accommodation fee system.

1. Methods of Research

Fees paid by citizens and businesses to municipal budgets in the Czech Republic are generally regulated by Act No. 565/1990 Coll. on local fees. Until December 31, 2019,

municipalities had the right to collect two types of fees based on a decree issued by the municipality: Accommodation capacity fee pursuant to Section 7 of Act No. 565/1990 Coll. on local fees (as amended by Amendment No. 278/2019 Coll.) and a spa or recreational stay fee pursuant to Section 3 of Act No. 565/1990 Coll. (PARLIAMENT OF CZECH REPUBLIC, 1990). With effect from January 1, 2020, the accommodation fees were unified by Amendment No. 278/2019 Coll. which amended Act No. 565/1990 Coll. on local fees, as of January 1, 2020 (Section 3 of the Act). The accommodation fee replaced both of the above fees (it can be understood as a combination of the accommodation capacity fee and the recreational/spa stay fee).

- **Subject:** Any stay for consideration in any facility intended for temporary accommodation in the municipality.
- **Payer:** Accommodated persons; the fee is collected by the accommodation provider and paid to the municipality.

The law defines the maximum amount of the fee that the municipality may set by decree, as well as the persons and conditions for exemption from the fee. The municipality may establish further exemptions and relief. Maximum rates of the fee as applicable in the period 2020-2024:

- **2020:** max. CZK 21 per person per day
- **from 2021:** max. CZK 50 per person per day
- Summary of fee developments 2017–2024

Tab. 1 development of statutory limits on accommodation fees

Period	Type of fee	Rate (maximum amount)	Legal regulation
2017	Accommodation capacity fee	CZK 6/bed/day	Section 7 of Act No. 565/1990 Coll. (until 31 December 2019)
2017	Spa/recreational stay fee	15 CZK/person/day	§ 3 of Act No. 565/1990 Coll. (until 31 December 2019)
2020	Accommodation fee	CZK 21/person/day	§ 3 of Act No. 565/1990 Coll. (amended by No. 278/2019 Coll.)
2021	Accommodation fee	50 CZK/person/day	Section 3 of Act No. 565/1990 Coll.

Source (PARLIAMENT OF CZECH REPUBLIC, 1990)

Note: Municipalities may set fees lower than the maximum amount, and some municipalities also offer discounts and exemptions. The wording of specific decrees varies.

The individual municipal decrees covered by this study are published in the Collection of Legal Regulations of Local Government Units and Certain Administrative Authorities, available online without registration at the link provided in the list of sources. Another source is the websites of individual municipalities, where municipal decrees are published. The rates from these sources were used for the purposes of this analysis.

(MINISTRY OF INTERIOR OF THE CZECH REPUBLIC, b.r.) A publicly available source for the amount of revenue from fees for the period 2017–2024 for individual municipalities is the specialized information portal of the Ministry of Finance, which provides the public with free access to budget and accounting information from all levels of state administration and local government. The information presented comes from the State Treasury system (MINISTRY OF FINANCE OF THE CZECH REPUBLIC, b.r.) and is updated quarterly. In the IISSP monitor, data on revenues from individual fees, accommodation capacity fees, spa or recreational stay fees, and stay fees have been obtained.

Explanation of Item code:

- 1342 - until 31 December 2019 – Spa and recreation fee, from 1 January 2020 - Accommodation fee (to date)
- 1345 – until 31 December 2019 – accommodation capacity tax

Tab. 2 The data export settings from IISSP for individual districts - EXAMPLE – Sokolov district

Revenues and expenditures of territorial budgets (export from monitor.statnipokladna.cz, date 07/23/2025)
Units: CZK
Year: 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024
Consolidation of accounting units (name): Yes
Item code: 1342, 1345
District (name): Sokolov (total number of municipalities: 38 (12 towns and 26 municipalities))

Source: The authors

The data processed for each town or municipality with a valid decree on local accommodation tax in the districts of Hradec Králové, Trutnov, Jičín, Náchod, and Rychnov n. Kněžnou were aggregated and processed for the Hradec Králové Region in the outputs listed below. Data on accommodation capacities and the number of beds were obtained from the statistics of the Czech Statistical Office (CZSO). CZSO provides data on the capacities of collective accommodation establishments (HUZ) by municipality. This information is available in the office's statistical surveys and publications. (CZECH STATISTICAL OFFICE, 2024)

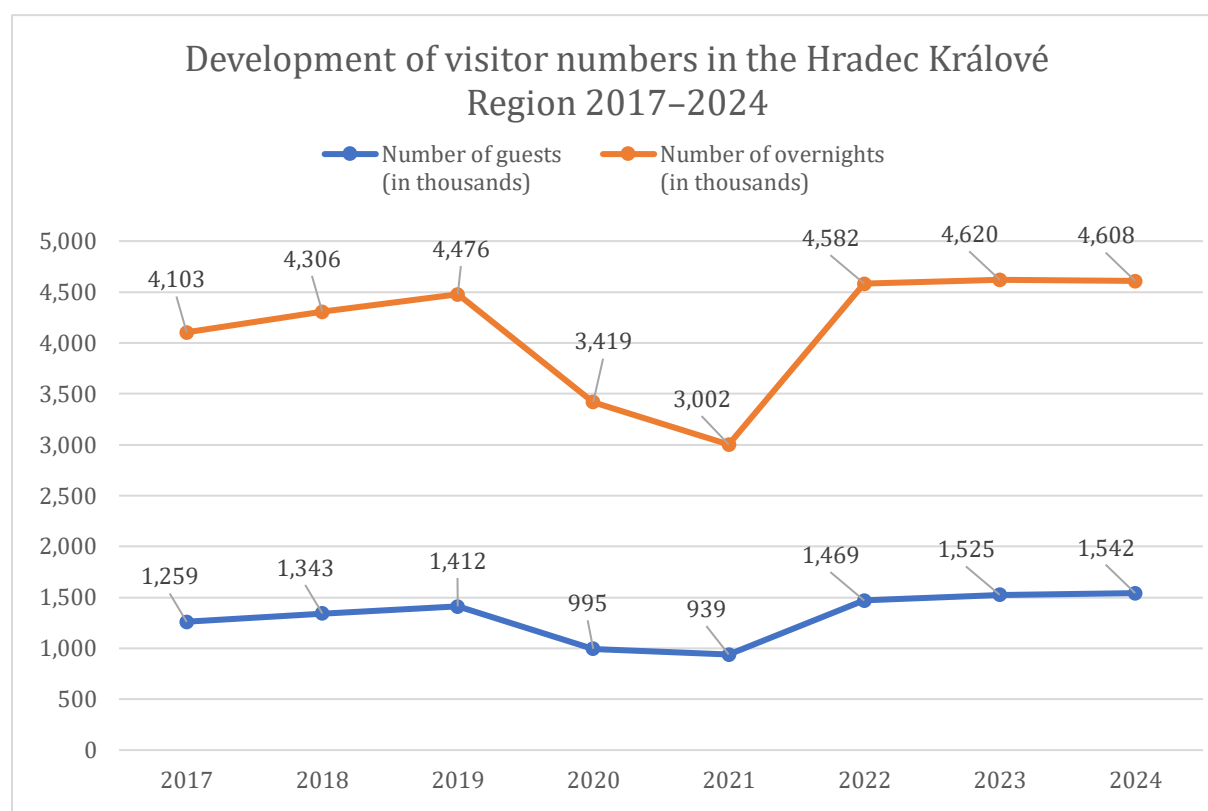
2. Results of the Research

Since 2017, the number of municipalities involved in the collection of fees in the Hradec Králové Region has been steadily increasing, as has the total amount of funds collected. Several factors influenced the changes in the amount of funds collected during this period.

Collection of local accommodation fee in municipalities
 in the Hradec Kralove Region, the Czech Republic
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One is the legislative framework described in the methodological section, which gradually simplified and unified the fees collected into a single fee, namely the local accommodation fee (hereinafter referred to as “the fee”), which simplified the work of municipalities with fees. Another factor was the relaxation of the maximum amount of fees, which rose from the original CZK 6 from the accommodation capacity fee (until December 31, 2019) and CZK 15 from the spa or recreational stay fee (until December 31, 2019) to a maximum accommodation fee rate in 2020 of CZK 21 to a maximum of CZK 50, which is the upper limit that has been in effect since 2021.

Fig. 1 Development of visitor number in KHK



Source: Author's own Graph, data source (CZECHTOURISM, b.r.)

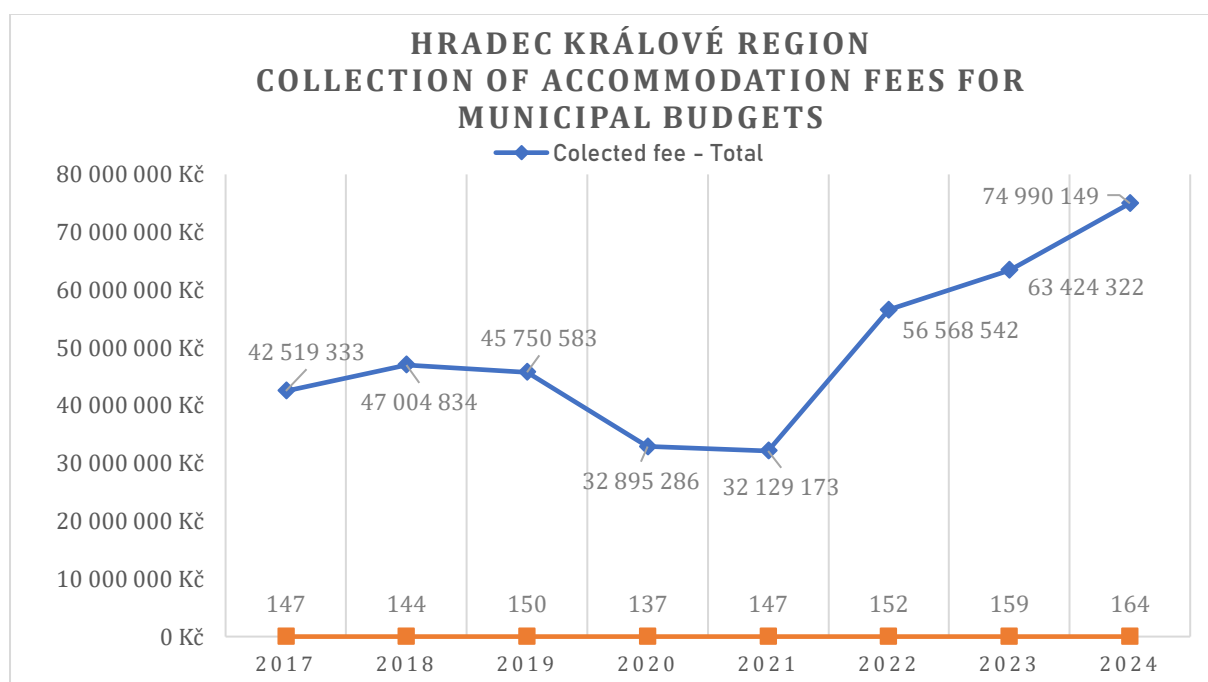
Naturally, the key factor is the number of visitors to the region, which is gradually increasing, with the exception of a decline in 2020 and 2021 caused by the impact of restrictive measures during the global COVID-19 pandemic. The following graph shows the growth dynamics of accommodation fee collection in 2017–2024 influenced by the above factors (MINISTRY OF FINANCE OF THE CZECH REPUBLIC, b.r.). The Hradec Králové Region is interesting for its range of tourist destinations. It offers mountainous terrain for outdoor activities throughout the year, as well as the Elbe River lowlands, which are ideal for cycling, UNESCO monuments and historic towns, and natural, cultural and historical destinations for a wide range of visitors.

Tab 3. Development of the number of guests and overnight stays and length of stay in the Hradec Králové Region

Year	Number of guests (in thousands)	Number of overnight stays (in thousands)	Average length of stay (days)
2017	1,259	4,103	4.0
2018	1,343	4,306	4.0
2019	1,412	4,476	4.2
2020	995	3,419	4.0
2021	939	3,002	4.2
2022	1,469	4,582	4.1
2023	1,525	4,620	4.0
2024	1,542	4,608	4.0

Source: (CZECHTOURISM, b.r.)

Fig. 2 Development of fee collection and number of municipalities with accommodation fee regulations

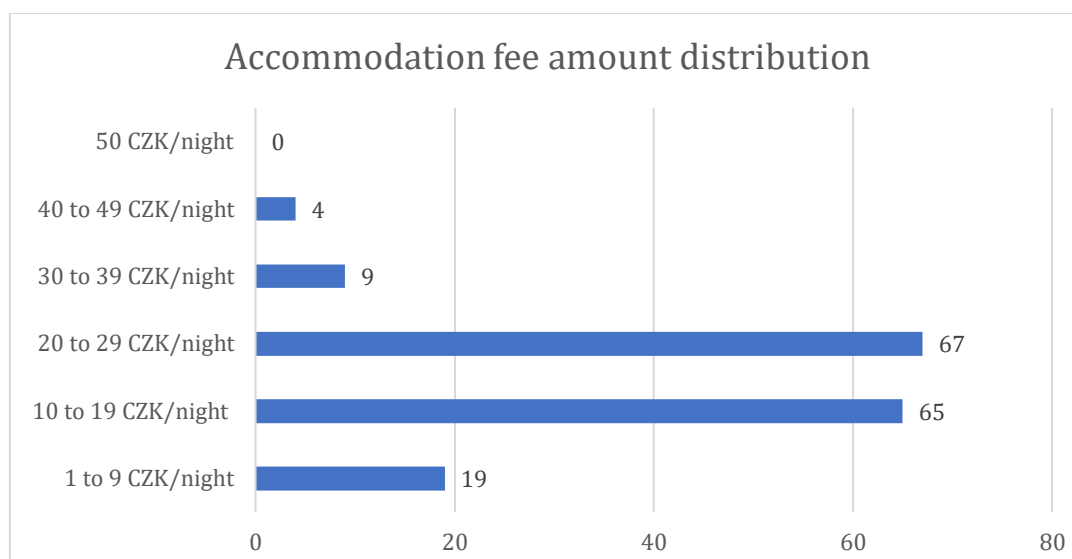


Source: The authors

In 2024, 164 towns and municipalities (out of a total of 448 municipalities) in the Hradec Králové Region took advantage of the option to collect accommodation fee and therefore have a valid municipal decree. This is a share of 36.24% and is close to the Czech average (32.24%; 2016 out of a total of 6,254 municipalities in 2024). In 2025, an analysis was co-authored with Associated Professor Ing. Petr Janeček, Ph.D., from the CzechTourism agency entitled eTurista: Economic Impact of Local Tourist Taxes on Municipal Budgets (KÜHR & JANEČEK, 2025). The study examines the implications of short-term rentals

operated through platform economy business models, which have increasingly supplanted the traditional sharing economy within the accommodation services sector.

Fig. 3 Distribution of the fees



Source: The authors

As part of this analysis, potential revenues from improved registration and collection of the accommodation fee were quantified. The methodological approach involved comparing official statistical data on the number of overnight stays with estimates derived from residual mobile operator data (hereinafter “GSM data”) for the year 2024. The GSM dataset was processed by INTENS for the CzechTourism agency. These findings constitute one of the calculation bases used to demonstrate the significant discrepancies that arise between different statistical sources and data collection methods when assessing the scale of overnight stays.

While GSM-derived mobility data offer a valuable proxy for measuring visitor presence, their accuracy varies by context. In urban municipalities, dense cell coverage enables high spatial precision (hundreds of meters), whereas rural municipalities may be affected by larger coverage areas, reducing locational accuracy. In addition, children and some demographic groups are underrepresented in GSM data, requiring demographic corrections. To address these limitations, the estimates in this study were adjusted for seasonality, family composition, and accommodation capacity, following international methodological guidance (EUROSTAT, 2014). Comparable studies also point to broader governance and sustainability challenges when integrating mobile positioning data into official tourism statistics (RAHMADIAN et al., 2023).

The study shows that the number of overnight stays calculated for the Hradec Králové Region based on residual GSM data, to which the accommodation fee levy applies, is 5,025,542 person-nights in 2024 (KÜHR & JANEČEK, 2025). According to Tourdata.cz, there were 4,608,488 statistically recorded nights in the Hradec Králové Region in 2024 (CZECHTOURISM, b.r.).

These discrepancies not only highlight methodological challenges in tourism statistics but also point toward systemic governance issues in fee collection, which are further illuminated by compliance theory

Using data from the State Treasury information system - IISSP Monitor, it is possible to determine the reported income of individual municipalities in 2024 from local accommodation fee. The accommodation fee amount valid in 2024 was also determined for each municipality. Combining this data for each municipality and then for the districts of Hradec Králové, Trutnov, Jičín, Náchod, Rychnov nad Kněžnou, and for the entire Hradec Králové Region, the number of overnight stays (person-nights) from which local accommodation fees were paid was calculated. To calculate the number of nights based on the amount of fees collected for individual municipalities and districts, the ratio of the fee revenue to the fee was used. At the same time, the weighted average of the fee in the Hradec Králové Region for individual municipalities and for the region as a whole was calculated and related to the number of person-nights to which the fees were applied.

Tab. 4 number of overnight stays by district in the Hradec Králové Region and weighted average accommodation fee by district

Weighted average of fees - compared by number of overnight stays for districts and the region as a whole		
District	Weighted average accommodation fee	Number of overnight stays
Hradec Králové	38,53	203 324
Trutnov	30,54	1 580 435
Jičín	20,33	359 738
Náchod	19,25	344 839
Rychnov nad Kněžnou	20,17	251 109
Total for the region	27,42	2 739 446

Source: The authors

This weighted average is important for further calculations of the theoretical amount of the fee leakage caused by unreported overnight stays and unregistered individual accommodation establishments („IUZ“). The calculated number of nights from which the fee was paid in the Hradec Králové Region in 2024 is 2,739,446. (The fee revenue for each individual municipality was divided by the fee amount valid in that municipality in 2024 according to the decree). Table 5 compares three alternative sources on the number of overnight stays in the Hradec Králové Region in 2024: official Tourdata.cz statistics, GSM-derived estimates, and the number of nights calculated from actually collected fees. The table reveals marked discrepancies among the datasets. While Tourdata.cz reports 4.6 million nights, GSM-based estimates exceed five million, and the calculation from collected fees suggests an even lower effective base. These differences highlight the extent of statistical underreporting and point to structural weaknesses in the fee collection system, where official fiscal data systematically lags behind both statistical and big data sources.

Tab. 5 Number of overnight stays in the Hradec Králové Region in 2024 according to sources

Number of overnight stays according to	Number of person-nights
Tourdata.cz	4,608,488
GSM	5,025,542
According to the above selected fees	2,739,446

Source: The authors

Given the large difference between the number of person-nights from which the fee was paid and the data according to toudata.cz statistics (CZECHTOURISM, b.r.), and subsequently from the calculation based on GSM data (KÜHR & JANEČEK, 2025), it was necessary to determine how significant an impact the ratio of bed capacity in municipalities that collect the fee and those that do not collect the fee has on this difference. The available data provided by the Czech Statistical Office was used for verification, which expresses the percentage of bed capacity in districts and the total in the Hradec Králové Region available in municipalities that collected the fee in 2024 (CZECH STATISTICAL OFFICE, 2024).

To better understand the fiscal implications of underreporting, it is necessary to relate potential fee revenues to the actual distribution of accommodation capacities across municipalities. In the Hradec Králové Region, municipalities that have enacted a decree on the accommodation fee account for approximately 83% of the region's total bed capacity. This concentration means that the effectiveness of fee collection is largely determined by the compliance behaviour in these decree-issuing municipalities.

For municipalities that collected the fee in the Hradec Králové Region in 2024, the following data can be found in the Czech Statistical Office (CZSO) data:

Tab. 6 Availability of data on accommodation capacities in the Hradec Králové Region

Number of municipalities collecting accommodation fee	164
Number of municipalities without data on accommodation capacities	51
Number of municipalities reporting the number of collective accommodation establishments („HUZ“)	112
Of which - number of municipalities reporting bed capacity	52

Source: The authors

52 municipalities, which is 31.90% of municipalities collecting accommodation fee in the Hradec Králové Region, report the number of beds and the number of accommodation providers in their territory in their statistics. In the overall statistics for the Hradec Králové Region, this represents 83.19% of the total bed capacity. The table shows this ratio in individual districts and in the region as a whole.

Tab. 7 Share of beds in municipalities collecting the fee in the total bed capacity of the Hradec Králové Region

DISTRICT	NUMBER OF BEDS	ACCOMMODATION FEE BEDS	COVERAGE %
Hradec	3 588	2 922	81,44%
Jičín	6 308	3 667	58,13%
Náchod	6 039	3 097	51,28%
Trutnov	30 822	28 863	93,64%
Rychnov nad Kněžnou	5 852	5 215	89,11%
Hradec Králové Region - total	52 609	43 764	83,19%

Source: The authors

To make the calculation of unrealized accommodation fee collection amounts more objective, the number of person-nights obtained from Tourdata.cz statistics and from calculations based on residual GSM data was applied only to municipalities collecting accommodation fee through the calculation of bed capacity in these municipalities. (share 83.19%)

Tab. 8 Recalculation of the number of overnight stays according to bed capacity in municipalities with accommodation fee decree

Number of Overnight Stays	Number of Person-Nights	Share According to Bed Capacity (83.19%)
Tourdata.cz	4,608,488	3,833,676
GSM	5,025,542	4,180,612
Amount of fees collected	2,739,446	2,739,446

Source: The authors

3. Discussion

Previous data and calculations show that the volume of unrealized fee collections in the Hradec Králové Region can be estimated in the following way:

- Compared to the number of overnight stays (person-nights) according to Tourdata.cz, no local accommodation fee was paid on 1,094,230 overnight stays (person-nights). $3,833,676 \text{ (Fig.7)} - 2,739,446 \text{ (Fig.7)} = 1,094,230$
- Compared to the number of overnight stays (person-nights) according to residual GSM data, local accommodation fee was not paid for 1,441,166 overnight stays (person-nights). $4,180,612 - 2,739,446 = 1,441,166$

For further calculation, the weighted average of the fees in the Hradec Králové Region of CZK 27.42 (Fig. 3) per night was used, and this fee was applied to the number of person-nights for which no fee was applied. The first model calculates the leakage assuming that fees are collected from 83.19% of the total bed capacity in the Hradec Králové Region. The percentage of uncollected fees is related to the total collection of fees in the Hradec Králové Region in 2024, amounting to CZK 74,990,149 (EUR 2,980,531 by using single exchange rate EUR for 2024 – 25,16 CZK/EUR).

Tab. 9 Unrealized fee collection in the Hradec Králové Region with current coverage by municipalities

Data source	Number of nights - reduced by nights with realized fee	Unrealised fee collection in czk / eur ¹	Volume of unrealised fee in %
Tourdata.cz	1 094 230	30 004 420,60 CZK 1 192 544,54 EUR	40,01 %
GSM	1 441 166	39 517 602,90 CZK 1 570 651,94 EUR	52,70 %

Source: The authors

Tab. 10 Unrealized accommodation fee collection with theoretical 100% coverage in the Hradec Králové Region

Data source	Number of nights - reduced by nights with realized fee	unrealised fee COllection in CZK / EUR ²	Volume of unrealised fee in %
Tourdata.cz	1 869 042	51 250 207,31 CZK 2 036 971,67 EUR	68,34 %
GSM	2 286 096	62 686 068,02 CZK 2 491 497,14 EUR	83,59 %

Source: The authors

The second model assumes a flat-rate collection of accommodation fee from the total bed capacity in the Hradec Králové Region. The percentage of uncollected fees is related to the total collection of fees in the Hradec Králové Region in 2024, amounting to CZK 74,990,149 (EUR 2 980 530,56 by using single exchange rate EUR 2024 - 25,16 CZK/EUR). The following Table (Tab.11) summarizes the potential total revenues for the above defined model examples of the potential fee collection.

Tab. 11 Summary table of potential fee collection amounts in KHK for various models

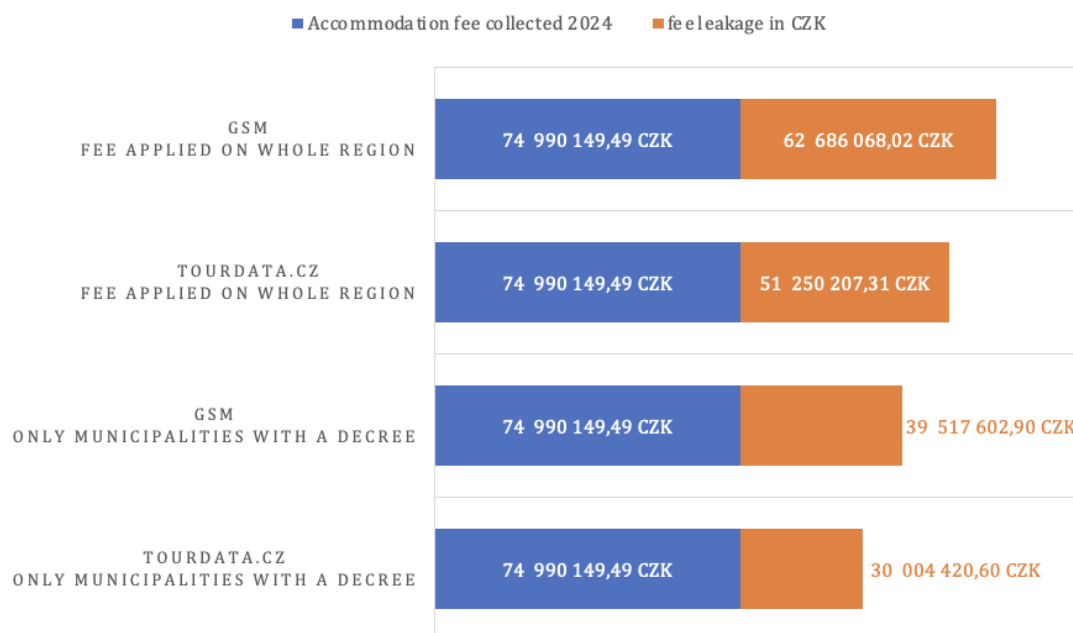
Data	accommodation fee collection realized IN CZK	Unrealized accommodation fee collection in CZK	potential Total fee revenue
Tourdata.cz – only municipalities with decree	74 990 149,49	30 004 420,60	104 994 570,09
GSM – only municipalities with fee decree	74 990 149,49	39 517 602,90	114 507 752,39
Tourdata.cz – region-wide	74 990 149,49	51 250 207,31	126 240 356,80
GSM – region-wide	74 990 149,49	62 686 068,02	137 676 217,51

Source: The authors

¹ Single exchange rate EUR 2024 - 25,16 CZK/EUR

² Single exchange rate EUR 2024 - 25,16 CZK/EUR

Fig. 4 Accommodation fee collection potential models in the Hradec Králové Region



Source: The authors

Conclusion

The availability and quality of data are decisive for assessing the economic impact of tourism on municipalities and, more broadly, for understanding the role of this sector in the Czech economy. Yet, the analysis of local accommodation fee collection in the Hradec Králové Region demonstrates persistent discrepancies between different statistical sources. Our comparison revealed substantial gaps between officially reported data and alternative estimates. For 2024, the Czech Statistical Office (CZSO) reported 57.2 million overnight stays, while GSM-derived data indicated 76.0 million—an unrecorded difference of nearly 18.8 million nights. Eurostat's experimental statistics on platform-based accommodation accounted for 10.7 million short-term rental nights, but this alone cannot explain the full gap. Even within the Hradec Králové Region, the difference between recorded overnight stays and those implied by actual fee revenues exceeded 68–83%, far more than could be explained by the share of municipalities without a fee decree (16.5%). These findings point to systematic underreporting and highlight the structural limits of the current data framework.

From a theoretical perspective, these discrepancies illustrate the dynamics of information asymmetry between accommodation providers and municipalities. Providers hold precise information on visitor numbers, while municipalities rely on self-reported data, with limited capacity to verify accuracy. This asymmetry is reinforced by institutional gaps in the legislative framework and weak inspection mechanisms, especially in the short-term rental segment (PLZÁKOVÁ & STUDNIČKA, 2021; STIGLITZ, 2000). Behavioural economics provides further explanatory insight: the slippery slope model (KIRCHLER et al., 2008) predicts that where enforcement is weak and trust low, voluntary

compliance declines. In the Czech context, trust is undermined by the absence of a general obligation to reinvest accommodation fee revenues into tourism. While Prague has recently committed 50% of its fee revenues to tourism-related purposes (THEMAYOR.EU, 2022), most municipalities provide no such guarantees. This fosters scepticism among entrepreneurs, who perceive the fee as a pure tax rather than a shared investment, and weakens moral motivation to comply. At the same time, local governments often practice blame avoidance (HINTERLEITNER, 2019), shifting responsibility to systemic data limitations or higher authorities rather than enforcing compliance.

These structural and behavioural dynamics have tangible fiscal consequences. In the Hradec Králové Region alone, municipalities may be losing CZK 30–40 million annually under current conditions, representing a potential 40–53% increase over current collections. Expanding the accommodation fee coverage to all municipalities could yield CZK 52–63 million more, an increase of 68–84%. Such revenues could be reinvested into tourism infrastructure, marketing, and community services—directly benefiting both residents and businesses.

Addressing these challenges requires both technical and political solutions. The planned introduction of the eTurista system, mandated by EU Regulation 2024/1028 (EUROPEAN PARLIAMENT & Council of the European Union, 2024), offers a systemic digital tool to improve reporting and data sharing. Yet, its effectiveness will depend on accompanying changes in governance: stronger inspection capacity, transparent reinvestment of revenues, and clearer communication with entrepreneurs. Strengthening both trust (through purposefulness and transparency) and authority (through enforcement capacity) would reduce fiscal evasion and align the Czech practice with the predictions of tax compliance theory (ALM & TORGLER, 2011; KIRCHLER et al., 2008)

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**Trends in Recognition and Valuation of
Intangible Assets from the Financial
Accounting Perspective: A Comparative
Study of the Czech and Brazilian Accounting
Systems**

Abstract

The objective of the research is to evaluate the level of the similarities and differences in recognition and valuation of the intangible assets in financial accounting systems of the Czech Republic and Brazil. In alignment with the study's objectives, the following research questions were formulated to guide the investigation. First, are the standards concerning intangible assets comparable in national settings? Second, to what extent has the process of accounting harmonization influenced the historical development of accounting frameworks in the Czech Republic and Brazil? Third, given the influence of international accounting harmonization, how do both countries incorporate these guidelines into their respective frameworks for the treatment of intangible assets? Methodologically, the study combines a review of relevant literature, an analysis of current regulatory frameworks, and a comparative evaluation of the published statement requirements. The analysis reveals that both the Czech Republic and Brazil have developed their accounting standards over recent years through the process of international harmonization. However, the Czech Republic distinguishes itself by maintaining domestic practices within the international framework, thereby blending local regulations with global standards. In contrast, Brazil has largely aligned itself with international practices as established by IFRS, reflecting a more uniform approach to global standards.

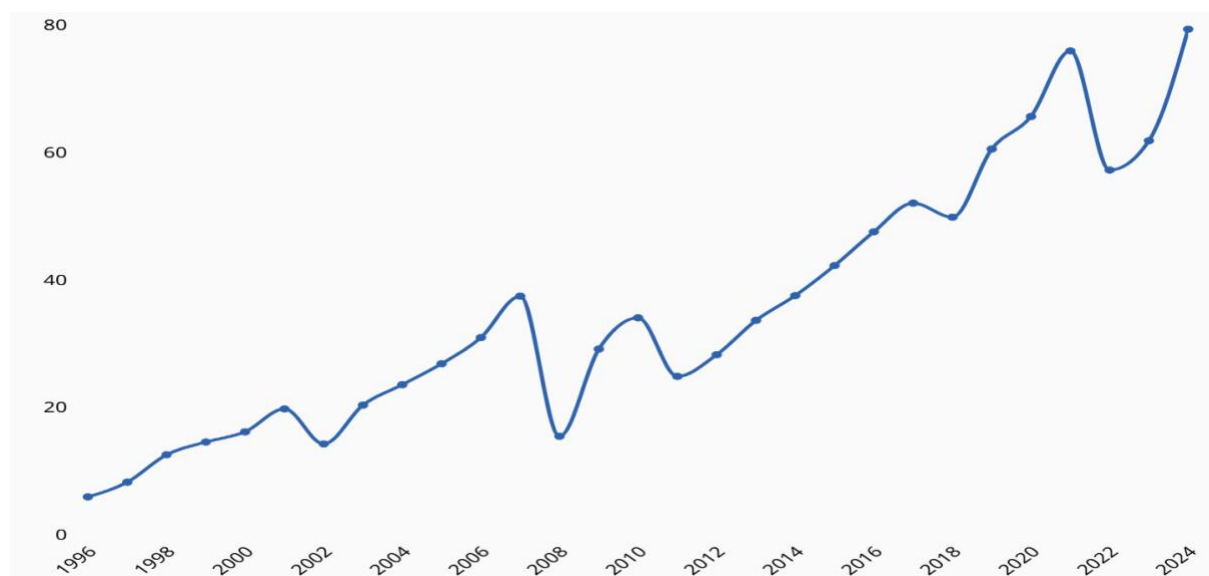
Key Words: Financial Accounting, Intangible Assets, Financial Reporting, Value Measurement, Amortization

JEL Classification: G39, M41, M48

Introduction

Intangible assets are defined as identifiable, non-monetary resources without physical substance that are under the control of an entity as a result of past events or transactions, and from which future economic benefits are expected to be derived (Park et al., 2023). Common examples include registered trademarks, patents, copyrights, proprietary software, goodwill, and organizational know-how. Despite their intangible nature, these assets represent significant economic value and are instrumental in enabling firms to generate long-term revenue streams, consolidate market positioning, and maintain sustainable competitive advantages. In the context of accelerating technological innovation and an increasingly globalized economy, the relevance of intangible assets has become even more pronounced. According to Brown et al. (2025), the World Intellectual Property Organization (hereafter WIPO) reported that, as of 2024, the global valuation of intangible assets held by publicly traded companies reached almost USD 80 trillion, the highest figure recorded since the inception of WIPO's data series in 1996 (see Fig. 1).

Fig. 1: The Value of Intangible Assets of Corporations Worldwide in 2024



Source: (Brown et al., 2025)

As the Fig. 1 shows, global corporate intangible value made a strong recovery in 2024, growing by 28 % from 2023, and surpassing its 2021 peak. As Brown et al. (2025) says, intangible assests include research and development, intellectual property, brands, software, databases, organizational assets, and skills. Brown's research team (2025) also brings data about regional leaders in terms of highest average intangible assets intensity (see Tab. 1).

The United States and Ireland lead their respective regions, reflecting their dominance in knowledge-driven intangibles-rich industries. On the other hand, Brazil, South Africa, India, and Indonesia emerge as top performers in their respective regions – intangible assets are seen there as key drivers of economic progress in middle-income economies (Brown et al., 2025). The central role of intangible assets extends beyond corporate strategy, encompassing broader implications for economic research and policy. A

substantial body of literature has emerged to examine their impact across various organizational and sectoral contexts, particularly with regard to financial performance and value creation. For instance, Qureshi and Siddiqui (2020) conducted a cross-sectional study on technology firms operating in multiple jurisdictions, concluding that firms with a higher concentration of intangible assets tend to exhibit superior profitability indicators. This, in turn, positively influences investor sentiment and contributes to enhanced firm valuation.

Tab. 1: Leaders in Average Intangible Assets Intensity by Region

Rank	Northern America	Latin America, Caribbean	Europe	Sub-Saharan Africa	Northern Africa and Western Asia	Central and Southern Asia	South East and East Asia, Oceania
1	United States	Brazil	Ireland	South Africa	Israel	India	Indonesia
2	Canada	Mexico	Denmark	Nigeria	Saudi Arabia	Bangladesh	Republic of Korea
3		Argentina	Netherlands	Mauritius	Morocco	Pakistan	Australia

Source: (Brown et al., 2025)

The academic discourse surrounding intangible assets also encompasses theoretical and practical challenges, particularly with respect to their definition, recognition, measurement (Van Criecken et al., 2021), and classification in financial reporting. Their findings have also been corroborated across multiple sectors, e.g. industry (Sedláček, 2020), transportation and logistic (Machová et al., 2022), information and communication industry (Malíková et al., 2018), financial sector (Mendes et al., 2018), and in varying regional contexts (Černíková et al., 2021; Lopes et al., 2021; Závodný et al., 2023).

The existing variation in accounting treatments across different regions of the world presents a significant challenge in the process of achieving global accounting harmonization. This phenomenon is not limited to the specific issue of intangible assets but extends to various areas of financial reporting, where differing practices emerge due to distinct factors. In particular, the treatment of intangible assets highlights the complexities inherent in these divergences, as accounting practices are shaped by the unique environments in which they are applied. The academic literature has long addressed this issue, providing a wealth of insights into the reasons behind the adoption of different accounting methods and criteria by various countries. From a complementary standpoint, Lawalata et al. (2024) underscore the decisive role that economic determinants play in shaping the development and implementation of accounting regulations. According to their analysis, a country's level of economic development is directly correlated with its institutional capacity and preparedness to adopt and operationalize international accounting frameworks. Nations equipped with sophisticated financial infrastructures and mature accounting professions are significantly better positioned to integrate these standards effectively. Expanding upon this line of inquiry, Barbosa et al. (2018), Závodný (2023) and Krajňák (2024) draws attention to the considerable financial burdens and operational complexities that

accompany the adoption and implementation of International Financial Reporting Standards (hereafter IFRS). In cases of developing countries, the situation is also aggravated by macroeconomic instability and weak regulatory environments, which collectively erode the political and institutional conditions necessary for a successful standardization process. Such instability poses a significant obstacle to effective alignment with international accounting standards, ultimately hindering the broader goal of global accounting harmonization.

In light of the foregoing discussion, it becomes evident that the heterogeneity of accounting treatments observed across jurisdictions stems not from isolated technical decisions, but from a confluence of historically entrenched, culturally specific, and economically determined factors. The present study aims to conduct a comparative analysis of the accounting treatment of intangible assets within two distinct socioeconomic environments: the Czech Republic and Brazil. This investigation is situated within the broader context of international accounting harmonization, with a specific focus on the alignment of national standards with the IFRS. By examining the respective accounting regulations governing intangible assets in these countries, the study seeks to identify both commonalities and divergences in regulatory approaches, valuation methodologies, and disclosure practices. This comparative perspective not only contributes to a deeper understanding of the role of intangible assets in different institutional contexts but also provides valuable insights into the progress and challenges of global accounting convergence in an information-driven economy.

1. Methods of Research

The methodology employed in this study is qualitative in nature, utilizing both descriptive and comparative approaches to analyze the accounting frameworks governing intangible assets in the Czech Republic and Brazil. The analysis is primarily based on an extensive review of academic literature and normative documents, focusing on the regulatory frameworks and fundamental accounting principles. In addition, a historical research method was partially applied, facilitating the identification of significant developments over time. This approach involved direct engagement with primary sources and a systematic examination of the chronological evolution of institutional and regulatory transformations. The historical perspective thus provided critical context for understanding the current accounting treatments of intangible assets in both countries. Furthermore, the insights gained through this historical approach enabled a reflective consideration of the impact of international harmonization standards and their integration into the domestic accounting practices of each nation.

In alignment with the study's objectives, the following research questions were formulated to guide the investigation:

1. Are the standards concerning intangible assets comparable in national settings?
2. To what extent has the process of accounting harmonization influenced the historical development of accounting frameworks in the Czech Republic and Brazil?

3. Given the influence of international accounting harmonization standards, how do both countries incorporate these guidelines into their respective frameworks for the treatment of intangible assets?

Although this study is based on limiting methods such as the above-mentioned qualitative methodological approach based on secondary data, its results can be seen as valuable, as no similar comparative study dealing with the accounting aspects of intangible assets in the Czech Republic and Brazil has been published so far.

2. Results of the Research

Given the distinct socioeconomic contexts that shape the accounting regulations in both the Czech Republic and Brazil, and recognizing the independent developmental factors in each country, the scope of this analysis is specifically centered on examining the existing frameworks in both countries, while the complex interplay of interconnected factors influencing these accounting practices is acknowledged. It is also important to note that both nations are subject to the global phenomenon of accounting harmonization, which serves as an additional factor considered in this study. By examining the accounting frameworks of two countries with markedly different socioeconomic and institutional contexts, this study offers valuable insights into the varied approaches to the recognition and treatment of intangible assets. In doing so, it not only enriches the broader global discourse on accounting harmonization but also addresses a significant gap in the academic literature, where cross-country comparisons on intangible asset accounting, particularly between nations with such divergent realities, remain largely overlooked.

This section is structured into two main parts. The first part provides a comprehensive overview of the accounting frameworks for intangible assets in both the Czech Republic and Brazil, emphasizing the essential regulatory principles and guidelines that govern their treatment in each country. The second part offers a detailed analysis of the accounting treatment of intangible assets, focusing on the approaches both countries take regarding definition, recognition, measurement, and fluctuations in a value.

2.1 Accounting Frameworks for Intangible Assets in the Czech Republic and Brazil

The accounting framework in the Czech Republic is deeply rooted in the country's historical transition after 1989, when it shifted from a centrally planned economy to a market-driven one. This transition necessitated significant legislative reforms which were enacted by Act No. 563/1991 Coll., commonly known as the Accounting Act which serves as the primary regulatory framework for financial accounting in the Czech Republic (Česko, 1991). Today, it is enforced by the Ministry of Finance of the Czech Republic, which oversees its compliance and application. The Accounting Act forms the basis of the Czech Republic's national accounting framework, which is organized into three interconnected levels. At its core, the Accounting Act establishes the legal foundation for accounting practices, supplemented by implementing six decrees

according to different sector of the economy, and six sets of the Czech Accounting Standards which provide detailed guidance. Both the decrees (Česko, 2002) and the standards are issued by the Ministry of Finance of the Czech Republic, playing a pivotal role in shaping the country's accounting regulations (Malíková et al., 2023). This three level hierarchy of the accounting regulation in the Czech Republic is called Czech Accounting Legislation in this respective study.

Since 2000, the Czech Republic has undergone a significant transformation in its accounting regulations, driven by a series of decrees implementing provisions of the Accounting Act. This transformation has been influenced by the broader international trend toward harmonizing accounting standards, particularly through the adoption of the IFRS (Krajňák, 2024). A major legislative instrument introduced in this context is Decree No. 500/2002 Coll. (for entrepreneurs), which defines the scope, structure, and methodology for preparing financial statements. This decree aligns with the principles established by the European Union, reflecting the Czech Republic's commitment to integrating its accounting practices within the EU's harmonized framework. Notably, Decree No. 500/2002 Coll. (for entrepreneurs) also includes provisions for the reporting of intangible assets which is also followed by accounting treatment incorporated in Czech Accounting Standards (hereafter CAS), namely in CAS No. 013 which solves some accounting policies and procedures with long-lived intangible and tangible assets.

In Brazil, the accounting regulatory framework is primarily based on Corporation Law No. 6,404/76 (CVM, 1976), which underwent significant reforms with Law No. 11,638/07 in 2007. This reform aimed to align Brazil's financial reporting practices with international standards, mirroring the regulatory evolution seen in the Czech Republic. Both frameworks share common features, as Brazilian accounting regulation, like its Czech counterpart, depends on the ongoing issuance of accounting standards. In Brazil, this responsibility lies with the Federal Council of Accounting (hereafter CFC), as outlined in Decree Law No. 9,295/46, and amended by Law No. 12,249/10. Brazilian Generally Accepted Accounting Principles (hereafter Brazilian GAAP) is primarily based on Corporation Law No. 6,404/76, which establishes the legal foundation for accounting practices (CVM, 1976). This framework is supplemented by regulatory decrees and legislative reforms that refine and adapt its provisions, along with Brazilian Accounting Standards, which provide technical and practical guidance. Together, these elements form the core of Brazilian GAAP. A key distinction, however, is that in Brazil, the Federal Council of Accounting (CFC), an autonomous agency, is responsible for issuing accounting standards, operating independently from the government.

A significant milestone in the evolution of Brazilian accounting regulation was the enactment of CFC Resolution No. 1,055/2005, which led to the creation of the Brazilian Accounting Pronouncements Committee (hereafter CPC). Since its establishment, the CPC has played a crucial role in improving the international comparability and consistency of financial reporting, issuing technical pronouncements and adaptations that align IFRS principles with the specificities of the Brazilian context. However, to ensure binding authority, the adaptations made by the CPC to IFRS must be formalized by regulatory bodies overseeing accounting in Brazil, either through the CFC in a general capacity or through other bodies such as the Securities and Exchange Commission of Brazil (hereafter CVM), the National Monetary Council, and the Superintendence of Private Insurance. As

noted by the CFC, since 2010, Brazilian GAAP has been fully converged with IFRS (CPC, 2019). The CPC 04 pronouncement, considered the principal accounting standard regarding intangible assets within the Brazilian framework, is a direct interpretation of IAS 38, first issued in 1998 and revised in 2014. Since 2008, CPC 04 has held official status as an accounting standard, enacted through CVM Resolution No. 553/2008 and CFC Resolutions Nos. 1,139 and 1,140/2008, with its latest revision in 2010. Along with the legislative updates to Brazilian Corporation Law in 2007 and 2009, these provisions form the regulatory core for the treatment of intangible assets in Brazil (CVM, 2021).

2.2 Comparative Analysis of the Accounting Treatment of Intangible Assets

Based on comparative analysis of the approaches of Czech and Brazilian accounting systems, this section focuses on definition, recognition, measurement, and fluctuations in value of intangible assets.

Definition of Intangible Assets in Czech and Brazilian Accounting Systems

The primary focus of the analysis of intangible assets lies in the foundational definitions of this asset category within both the Brazilian and Czech accounting systems. Specifically, it examines how each regulatory framework defines intangible assets. Given the diversity of terminologies used to describe these assets – such as intellectual property, non-physical assets, or intangible resources – the importance of this analysis is underscored when comparing the accounting approaches in the two jurisdictions.

In the Czech Republic, there does not exist any general definition for recognizing the asset's item similarly to IFRS, namely the Conceptual Framework and IAS 38 (IASB, 2025). Intangible assets are defined in Decree No. 500/2002 Coll., Section 6, as "*non-physical development outputs, software, identifiable rights, and goodwill with a useful life exceeding one year, valued according to the accounting entity's assessment, excluding goodwill from this valuation, provided the conditions outlined below are met and the obligations prescribed by law are fulfilled*" (Česko, 2002). This definition is further detailed by specifying that intangible assets must adhere to the principles of materiality and provide a true and fair representation of the asset. Additionally, the category encompasses emission allowances and preferential limits. Czech accounting legislation outlines three key characteristics for recognizing intangible assets: they must lack physical substance, have a useful life exceeding one year, and meet the minimum valuation threshold established by the accounting entity. This prescriptive classification approach emphasizes specific asset categories, such as software and development outputs, rather than offering a broad, interpretative conceptual framework.

Section 6 of Decree No. 500/2002 Coll. also provides a negative definition of intangible assets by explicitly excluding items such as expert assessments, market research, development plans, advertising and promotional proposals, quality system certifications, and software for technology management (Česko, 2002). These items are not recognized

as intangible assets, and they are transformed directly into expenses – which is further illustrating the narrow and prescriptive nature of the Czech framework.

Brazil adopts a more concise and conceptual approach to defining intangible assets. Under CPC 04, item 8, intangible assets are defined as "*an identifiable non-monetary asset without physical substance*" (CVM, 2021). This definition emphasizes the intrinsic characteristics of intangible assets, focusing on their non-physical and identifiable nature. Unlike the Czech model, which relies on predefined asset categories, the Brazilian framework allows for greater interpretive flexibility, permitting entities to assess and recognize intangible assets based on their fundamental attributes rather than adhering to a rigid classification system. This more flexible approach enables a broader range of assets to be considered intangible based on their inherent qualities rather than their categorization in a list (CVM, 2021).

Recognition of Intangible Assets in Czech and Brazilian Accounting Systems

The recognition process of intangible assets is directly tied to the fulfillment of the criteria established within their respective definitions. Whether the definition is based on a predefined list of asset types or a more conceptual approach, it is imperative that all specified requirements are met for the recognition process to be fully supported by the accounting framework.

In the Czech Republic, particularly under Decree No. 500/2002 Coll., Section 6, paragraph 1 outlines the fundamental criteria for recognizing an intangible asset, which include the absence of physical substance, a useful life exceeding one year, and compliance with the minimum valuation threshold set by the accounting entity. Additionally, the asset must align with the examples of intangible assets defined by the applicable regulations in order to qualify for recognition (Česko, 2002).

Furthermore, Section 6, Paragraph 3 (Česko, 2002) specifies the recognition of internally generated intangible assets, particularly those arising from development activities. It clarifies that intangible development results and software that are produced through the entity's own activities for commercialization purposes, or those acquired from third parties, may qualify for recognition. However, intangible assets generated for the entity's own use are not eligible for capitalization under Czech accounting legislation. Development costs related to assets intended for sale, on the other hand, can be capitalized in accordance with the applicable regulatory framework.

In Brazil, the recognition of an intangible asset is governed by Technical Pronouncement CPC 04, particularly paragraph 18. According to this standard, recognition is contingent upon two fundamental criteria: first, the cost of the asset must be reliably measurable, and second, it must be probable that future economic benefits associated with the asset will flow to the entity (CVM, 2019). These criteria are further reinforced by Article 179 of the Brazilian Corporations Law (CVM, 1976), which stipulates that intangible assets must be intended for the maintenance of the company or used in the pursuit of that objective.

In the case of internally generated intangible assets, CPC 04 provides specific guidance, acknowledging the complexities inherent in their recognition. Due to the challenges in assessing whether these assets will generate future economic benefits and whether their costs can be reliably measured, special recognition criteria are outlined. Paragraph 52 of CPC 04 differentiates between internally generated assets in the research phase and the development phase. For recognition, intangible assets must emerge from the development phase, meeting stringent conditions: technical feasibility, the intent and ability to complete and use or sell the asset, clear demonstration of how the asset will generate future economic benefits, the availability of sufficient resources to complete development, and the ability to measure costs reliably (CPC 04, paragraph 57). In contrast, intangible assets arising from the research phase cannot be recognized as they do not meet the condition of demonstrating future economic benefits. As such, all costs incurred in the research phase must be expensed as incurred, in accordance with paragraph 54 of CPC 04 (CVM, 2021).

Measurement of Intangible Assets in Czech and Brazilian Accounting Systems

In the Czech Republic, under Section 25 of the Accounting Act (Česko, 1991), intangible assets must be initially measured at acquisition cost, which encompasses a wide range of directly attributable expenses, if it is required by purchase. These expenses include consulting and brokerage fees, interest, licensing and patent fees, site preparation, project planning, transportation, and installation costs. Moreover, any modification procedures associated with the acquisition of an intangible asset, or part of it, must have all related costs included in the asset's valuation (Česko, 2002, Section 6).

Regarding the measurement of internally generated intangible assets, their value is determined based on internal cost, which encompasses all direct and indirect costs associated with the production of the asset. This includes both production costs and partly indirect costs, provided that the assets are produced internally. If the internal cost exceeds the price common in the market, the accounting unit shall apply the principle "lower of the cost" and evaluate the item by so called replacement cost which reflects a common price of the item at the respective moment (Česko, 1991, Section 25).

In Brazil, according to Brazilian GAAP, the distinction between acquired and internally generated intangible assets is reflected in both the recognition and measurement processes. According to Section 183 of Corporations Law (CVM, 1976), acquired intangible assets must be measured at acquisition cost, less accumulated amortization, in alignment with the historical cost principle. Technical Pronouncement CPC 04 further clarifies that the cost of an intangible asset includes its purchase price, augmented by import taxes, non-recoverable purchase taxes, and any costs directly attributable to preparing the asset for its intended use. Specifically, paragraph 33 of CPC 04 specifies that the acquisition cost corresponds to the fair value of the asset at the acquisition date, reflecting market participants' expectations regarding the likelihood of future economic benefits. As such, the measurement of acquired intangible assets tends to be more straightforward, supported by verifiable financial transactions (CVM, 2021).

In contrast, the measurement of internally generated intangible assets is inherently more complex due to the absence of observable market transactions to support valuation. The

measurement of internally generated intangible assets, while still based on cost, involves determining the total expenditures directly attributable to the creation, production, and preparation of the asset for operational use. These costs should be recognized once the asset meets the criteria for recognition, as outlined in CPC 04, paragraphs 65 and 66. These expenditures include materials, services consumed during the creation process, and any legal registration fees and licenses necessary for the asset's development. However, costs related to training for the asset's operation, losses incurred prior to the asset reaching its expected performance, and indirect costs not directly attributable to its preparation should not be included in the asset's cost measurement (CVM, 2021).

Treatment of Changes in Value and Amortization of Intangible Assets in Czech and Brazilian Accounting Systems

In the Czech Republic, Czech accounting legislation diverges in some aspects significantly from IFRS, particularly also in the amortization of intangible assets. Section 56 of Decree No. 500/2002 Coll. stipulates that intangible assets must be amortized over their useful life according to a predetermined amortization schedule, which can be adjusted to reflect changes in the asset's usage, including its residual value (Česko, 2022). This section explicitly prohibits retroactive adjustments to amortization amounts recorded in previous periods. Moreover, Czech regulations do not allow for the revaluation of intangible assets to fair value after initial recognition, a key distinction from the IFRS framework. In the Czech context, if the useful life of an intangible asset cannot be reliably determined, the amortization period in the case of Goodwill must be set within 60 months, in the case of intangible results of development must be set between 60 and 120 months with a detailed justification provided in the notes to the financial statements (Česko, 2002, Section 56). This requirement causes the differences in comparison with accounting systems that adopted IFRS in full content, as it mandates amortization for all intangible assets, even those with an indefinite useful life, and specifies a fixed time frame. Furthermore, Section 56 does not prescribe a single amortization method, and acknowledges that the component method may be applied, provided that adequate accounting records are maintained for the asset evaluations (Česko, 2002)

In Brazil, the Brazilian GAAP mandates periodic reviews of the amounts recorded for intangible assets to ensure the recognition of impairment losses on invested capital, as well as a reassessment of the criteria used to determine their estimated useful life and to calculate depreciation, depletion, and amortization (CVM, 1976, Article 183). In this regard, Technical Pronouncement CPC 04, in paragraph 74, specifies that after initial recognition, intangible assets must be measured at cost, net of accumulated amortization and impairment losses. Paragraph 75 further states that intangible assets may subsequently be revalued to their fair value, provided that this value is determined based on prices quoted in an active market. In such cases, revaluations must be performed with sufficient regularity to ensure that the carrying amount does not materially differ from the fair value of the asset. Additionally, revaluations must be applied uniformly to the entire class of intangible assets (CVM, 2021). Paragraph 79 of CPC 04 further clarifies that the frequency of revaluations may vary depending on the volatility of the fair value of the intangible assets. Revaluations are not fixed and may be adjusted based on changes in market conditions or the characteristics of the asset itself. Revaluations must be undertaken whenever the fair value of an asset significantly deviates from its carrying

amount. However, the revaluation model is not applicable to intangible assets that have not been previously recognized or those whose initial recognition was based on a measurement other than cost, whether arising from acquisition or internally generated expenditure (CVM, 2021, paragraphs 76 and 77 of CPC 04).

Within Brazilian GAAP, the recognition and amortization of intangible assets must be based on the prior determination of their useful life, which may be classified as either definite or indefinite. Generally, an intangible asset is considered to have an indefinite useful life when there is no foreseeable limit to the period over which it is expected to generate positive net cash flows for the entity (CVM, 2021, paragraphs 88 and 89 of CPC 04). In such cases, the initial carrying amount is not amortized. However, entities must perform impairment tests at least annually or whenever there is any indication that the asset may be impaired, by comparing its recoverable amount to its carrying amount (CVM, 2021, paragraphs 107 and 108 of CPC 04). The indefinite useful life assessment must be reviewed periodically to substantiate its continued validity. If the assessment is no longer valid, the asset must be reclassified to a definite useful life, and the corresponding adjustments should be reflected in the accounts (CVM, 2021, paragraph 109 of CPC 04).

Conversely, intangible assets with a definite useful life must be amortized systematically over their estimated useful life. In accordance with Technical Pronouncement CPC 04, paragraph 97, amortization must begin when the asset is available for use and cease when it is classified as held for sale. The amortization method must reflect the pattern in which the asset's future economic benefits are consumed. If such a pattern cannot be reliably determined, the straight-line method should be applied. While no specific method is mandated when a consumption pattern is identifiable, the chosen method must align with the expected economic benefits derived from the asset. According to CPC 04, paragraph 104, both the amortization period and method must be reviewed annually. The residual value of an intangible asset must be estimated based on the recoverable amount expected from its disposal, utilizing current market prices for similar assets that have reached the end of their useful lives and have been operated under similar conditions. This estimate must also be reviewed periodically, at least at the end of each fiscal year. (CVM, 2021)

3. Discussion

This comparative study supports Krajňák's (2024) argument that the Czech Republic represents a distinctive case in international accounting harmonization. While it does not fully comply with IFRS like Brazil, the Czech model is not entirely disconnected from international standards. In contrast to Brazil's strong alignment with IFRS, the Czech Republic demonstrates both convergence and divergence, reflecting a selectively harmonized accounting system. Both countries engaged in processes of accounting harmonization, although the timing and depth of implementation varied. The Czech Republic began its convergence efforts earlier, in 2000, through a series of decrees issued by the Ministry of Finance (Krajňák, 2024; Malíková, 2018). Brazil, by contrast, initiated its formal alignment with international standards later, through the creation of the Brazilian Accounting Pronouncements Committee by the CFC Resolution No. 1.055 in 2005. Since then, Brazilian accounting standards have been predominantly based on

direct adaptations of the IFRS, resulting in a framework closely aligned with global accounting practices. This convergence extends beyond the treatment of intangible assets and reflects a broader structural alignment with the IFRS conceptual model.

A comparative analysis of the Czech accounting legislation and Brazilian GAAP for defining intangible assets reveals notable differences. Czech accounting legislation primarily follows a list-based definition, identifying specific items as intangible assets and providing a negative list of exclusions, leading to a more rigid and restrictive framework. In contrast, the Brazilian GAAP offers a conceptual definition, similar to IAS 38 of IFRS (IASB, 2025) emphasizing the nature of the asset over predefined categorizations. While both frameworks stress the non-physical nature of intangible assets, Czech accounting legislation combines a prescriptive list with a conceptual approach, making it less flexible compared to the Brazilian framework, which allows a broader interpretation of intangible assets. The treatment of internally generated intangible assets also highlights significant divergences. The Brazilian framework clearly distinguishes between the research and development phases, allowing recognition only for development-phase costs that meet specific capitalization criteria. These phases are defined and treated separately within the framework. The Czech framework, however, integrates research and development activities into a broader category of internally generated or externally acquired items, without offering detailed criteria for capitalizing development costs. Under the Czech model, only development costs related to assets intended for sale are capitalized. This contrasts with the Brazilian approach, where internally generated intangible assets, whether for internal use or commercialization, are recognized based on development costs.

The recognition process of intangible assets is rooted in the conceptual definitions within each framework. Under Brazilian GAAP, recognition is contingent upon an asset fulfilling the definition of an intangible asset fully adopted from Conceptual Framework of IFRS. Conversely, the Czech framework bases recognition on a predefined enumeration of intangible assets, provided they are not excluded by regulation. Additionally, the Czech model requires that recognized intangible assets have a useful life exceeding one year, introducing a temporal criterion not explicitly stated in the Brazilian definition. It is possible to state that the recognition process in both frameworks is largely aligned with IAS 38 (IASB, 2025) particularly in segregating research and development phases. Both frameworks require that costs associated with the development phase be capitalized, provided specific criteria are met. However, the Czech framework is more restrictive, as it only allows the capitalization of development costs for assets intended for sale. It is possible to state, that even both approaches, Czech and Brazilian seem similar, the Brazilian GAAP adopted IAS 38 significantly deeper. The weakness of the present Czech accounting legislation also is in the aspect of still missing general criteria setted for recognizing the asset items.

Regarding the measurement of acquired intangible assets, both the Brazilian and Czech frameworks align with IAS 38, as they value acquired intangible assets at historical cost, which includes the acquisition price and directly associated costs. For internally generated intangible assets, both frameworks base measurement on internal costs, but key differences emerge in the treatment of these costs. Czech accounting legislation seems to be more flexible, allowing some indirect expenses to be included, while Brazilian GAAP

strictly limits recognition to costs directly attributable to the creation, production, and preparation of the asset for its intended use. In practice, the Czech framework requires adding the indirect cost to the value of intangible assets in the same feasible way, but setting such requirement in the Czech accounting legislation is still vague.

The treatment of changes in value and amortization represents a significant divergence between the frameworks. Amortization practices also differ significantly. Under Czech accounting legislation, intangible assets with both finite and indefinite useful lives are amortized according to a predefined schedule ranging in some cases from 60 to 120 months. In contrast, Brazilian GAAP mandates the amortization of intangible assets with finite useful lives, while intangible assets with indefinite useful lives are not amortized. Both frameworks allow for flexibility in selecting amortization methods, but neither prescribes a single method, leaving the choice to reflect the asset's actual pattern of usage. Furthermore, the amortization plan may be revised during the asset's useful life to ensure it aligns with actual utilization. Under Czech accounting legislation, subsequent revaluation of an intangible asset's fair value is not allowed, meaning intangible assets are accounted for at their initial recognized cost, adjusted only for accumulated amortization. In contrast, the Brazilian GAAP permits the subsequent revaluation of fair value, with periodic analysis based on fair value in active markets, similar to assets with comparable characteristics. Alternatively, assets may be maintained at their cost, net of accumulated amortization and impairment losses.

Conclusion

In the context of international accounting harmonization, it is crucial to evaluate accounting frameworks to identify both points of divergence and similarity. Such an analysis not only enhances accounting communication within the corporate world but also contributes to academic literature. This study is particularly valuable as it compares the accounting frameworks of two countries with markedly different socioeconomic contexts, offering significant insights into the ongoing discourse on intangible assets. It follows a pilot contribution (Malíková et al., 2023) and finally it continues in being unique as similar study comparing Czech and Brazilian accounting systems focused on intangible assets was not yet published.

The analysis reveals that both the Czech Republic and Brazil have developed their accounting standards over recent years through the process of international harmonization. However, the Czech Republic distinguishes itself by maintaining domestic practices within the international framework, thereby blending local regulations with global standards. In contrast, Brazil has largely aligned itself with international practices as established by IFRS, reflecting a more uniform approach to global standards. In the Czech Republic, an amendment to the Accounting Act began to be prepared in 2018, which would deepen the alignment with the IFRS, but it has not yet been put into force. Unfortunately, the four-year cycles in which political structures in the Parliament of the Czech Republic are replaced, as well as the crisis caused by the Covid-19 pandemic and the solution to aid to Ukraine affected by the war, have pushed the amendment to Czech accounting legislation into the backdrop. Czech practice, especially entities such as listed

companies, banks and commercial insurance companies, are eagerly awaiting the adoption of changes that will lead to a deeper unification of Czech accounting rules towards international accounting practice (i.e. IFRS). It can be said that Brazil has gained an edge over the Czech Republic in this aspect. It can also be expected that after a deeper acceptance of IFRS in the Czech accounting environment, the differences between the Czech and Brazilian accounting systems will become blurred.

The primary objective of this study was to examine key accounting literature and standards relating to intangible assets, providing a comprehensive analysis of accounting frameworks in both countries, the Czech Republic and Brazil. Future research could expand upon this work by analysis of extended locations, e.g. another countries of Latin America and another member states of the EU. Future research could also be conducting a more focused, in-depth investigation into specific market segments, rather than taking a broad approach as seen in this study. Such an analysis could offer further insights into how different sectors interpret and apply accounting standards even in international level, contributing to a more nuanced understanding of accounting practices used in different countries.

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Generation Z and Financial Literacy: A Comparative Analysis of Generational Competencies

Abstract

This paper examines generational differences in financial literacy and their competencies in the Czech Republic, with a focus on Generation Z. Financial literacy is assessed across three components: financial knowledge, financial behaviour, and an overall financial literacy score. This analysis includes four generations: Generation Z, Millennials, Generation X, and Baby Boomers, based on 984 Czech respondents. Results show that Generation Z scores significantly lower in financial knowledge and overall financial literacy compared to Generation X and Baby Boomers. However, no statistically significant difference is found between Generation Z and Millennials, indicating similar levels of financial literacy between these younger generations. Interestingly, no significant generational differences were observed in financial behaviour.

This might suggest that while Generation Z lacks theoretical financial knowledge, they engage in financial behaviours comparable to older groups of the population. These findings point to a shift in how financial knowledge is acquired among younger generations. As digital natives, Generation Z often relies on informal online sources such as social media and “finfluencers”, which may offer practical tips but lack depth and reliability. Although fintech tools may help support good financial habits, the knowledge gap remains a concern. Given the growing financial autonomy of this generation, this paper highlights the need for better financial literacy to ensure informed decision-making and long-term economic stability.

Key Words: Financial Knowledge, Financial Behaviour, Financial Literacy, Generation Z, Millennials, Generation X, Baby Boomers

JEL Classification: D14, J10

Introduction

Academic interest in financial literacy as a distinct research field began gaining momentum in the early 2000s, when Hilgert et al. (2003) first claimed that “financial education is important not only to individual households and families but to their communities as well.” They have found a positive correlation between financial knowledge and sound financial behaviours like budgeting, saving, investing, and credit management, signalling its importance within consumer behaviour studies. In the following years, Lusardi & Mitchell (2007, 2011, 2014, 2017) helped to establish financial literacy as an independent and intradisciplinary field of research, formally defining the term and providing extensive empirical evidence, linking financial literacy to gender differences, savings behaviour, portfolio choice and retirement readiness. They also contributed to developing and operationalising a standardised measure of financial literacy. With their use of Big Three Questions (testing understanding of interest rates, inflation, and risk diversification), they brought internationally comparable measures of literacy to the emerging field.

Today, financial literacy is widely recognized as essential for navigating increasingly complex financial systems and is routinely assessed in large-scale international surveys (Directorate-General for Communication, 2023; OECD/INFE 2023 International Survey of Adult Financial Literacy, 2023). As a result, it has become not only a prominent focus of academic research but also a critical life skill for individuals seeking to make informed financial decisions in today’s complex economic environment.

Building on this foundation, recent research has turned towards generation analysis. Studies show that there are noticeable differences in financial literacy between generations. Generation Z, also sometimes called iGeneration, post-Millennials or Zoomers, is typically defined as individuals born from 1997 to 2012, and it represents the first generation of true digital natives, now entering financial adulthood and facing complex financial decisions earlier than previous generations (Dimock, 2019). They are becoming an increasingly influential segment of not just the workforce, but also the consumer market. When it comes to their financial literacy, current academic research suggests it is quite modest. For example, a 2023 Bruegel report found that only about half of EU adults could correctly answer three out of five basic financial questions, with 18–24-year-olds performing worse than older groups on core concepts like inflation and interest compounding (Demertzis et al., 2024). Similar patterns emerge across Europe, with Fur & Outreville (2022) reporting that Generation Z university students without formal financial education score very low on basic questions, and that economic education significantly improves the outcomes.

Czechia offers a unique case given its post-socialist context. Before 1989, due to extensive economic nationalisation under socialist regime, people growing up during this period of time lacked experience with private finance (Rameš, 2021). The 1990s coupon privatisation led to mistrust and suspicion with regards to the financial system due to widespread malpractice (Babička, 2022; Rameš, 2021). Therefore, it would seem reasonable to assume that Generation Z, who grew up in the digital age and within the market-driven environment, would score higher in measures of financial literacy than

older generations. Despite this presumption, evidence from Czechia reflects the same trends seen in other European countries. In 2016, Belás et al. (2016) tested high school students from Czechia and Slovakia with regards to savings and found substantial knowledge gaps (only 16.33% of Slovak students and 21.33% of Czech students correctly answered). This evidence of lower financial literacy levels among the younger generations does not have implications only at the individual level, influencing personal financial habits such as spending, saving, borrowing or investing, but also has a potential to become a topic of discussion at a macroeconomic level, influencing trends like increased consumer debt and default risk, investments on capital markets, or long-term economic stability. Hence, the state of financial literacy among younger population can have policy implications. That is why this paper aims to analyse the current state of Generation Z's financial literacy in the Czech Republic, comparing it with older population, and to answer the following research question: "What are the differences between scores of financial literacy among Generation Z and older generations?"

In today's rapidly evolving financial landscape, it remains crucial to better understand and address the needs of this specific generation. Analysing more recent data allows us to more efficiently assess the financial literacy of Generation Z, whose oldest members have been a part of the workforce for a while and actively engage with the financial system. That is why this study aims to offer new insights into how the digital generation navigates financial decision-making.

1. Methods of Research

This paper draws on data from the *Flash Eurobarometer 525: Monitoring the Level of Financial Literacy in the EU*, a survey commissioned by the European Commission, Directorate General for Financial Stability, Financial Services and Capital Markets Union, and coordinated by the Directorate-General for Communication (2023). The data collection for the survey was conducted between March and April 2023, and the findings were published on July 18th, 2023. Data processing was carried out by GESIS – Leibniz Institute for the Social Sciences. The survey was implemented across all 27 EU member states using nationally representative adult samples. It assesses financial literacy through three key components: financial knowledge, financial behaviour, and an overall financial literacy score.

Financial knowledge was measured using two approaches: a self-assessment of the respondent's financial understanding relative to others in their country, and responses to five factual questions. These tested comprehension of: the risk-return trade-off, inflation, investment diversification, simple and compound interest, and the relationship between interest rates and bond prices. Respondents were categorized as having high (4–5 correct answers), medium (2–3 correct), or low (0–1 correct) financial knowledge. *Financial behaviour* was evaluated using a question that asked respondents to indicate their level of agreement with three key statements reflecting responsible financial habits. Specifically, participants were asked whether they carefully consider whether they can afford a purchase before buying, whether they keep track and monitor their expenses, and whether they set long-term financial goals and strive to achieve them. Respondents were

asked to indicate their level of agreement with each statement on a four-point scale (completely agree to completely disagree, with an option for don't know). A behaviour score was calculated based on the number of statements the respondent completely agreed with. Scores were classified as high (three statements), medium (two), or low (one or none).

To calculate the *overall financial literacy score*, financial behaviour scores were rescaled to have a maximum value of 5, ensuring equal weighting with the financial knowledge component. The overall score was then obtained as the sum of the two rescaled scores, yielding a range from 0 to 10. The following Tab. 1 presents a descriptive statistical analysis of the three examined indicators, including minimum and maximum values, mean, standard error, and standard deviation.

Tab. 1: Descriptive statistics of analysed variables

	Minimum	Maximum	Mean	Std. Error	Std. Deviation
Financial knowledge score	0	5	2.63	0.04	1.26
Financial behaviour score	0	3	2.59	0.02	0.64
Financial literacy score	1.67	10	6.94	0.06	1.74

Source: Authors' own calculation, data from (Directorate-General for Communication, 2023)

For the purpose of this study, generational categories were defined using the commonly accepted framework established by Dimock (2019). We have created a new variable in the data matrix, and respondents were divided based on their year of birth and corresponding age as of 2023, in which the data collection occurred:

1. **Generation Z:** Born between 1997 and 2012 (aged 11¹ to 26) - 118 respondents
2. **Millennials:** Born between 1981 and 1996 (aged 27 to 42) - 270 respondents
3. **Generation X:** Born between 1965 and 1980 (aged 43 to 58) - 274 respondents
4. **Baby Boomers:** Born between 1946 and 1964 (aged 59 to 77) - 322 respondents
5. **Silent Generation:** Born between 1928 and 1945 (aged 78 to 95) - 11 respondents

Due to the very small number of respondents from the Silent Generation (only eleven individuals), this group was excluded from the generational analysis, as the sample size was not sufficient for meaningful statistical interpretation. The total sample size of Czech respondents subjected to statistical analysis was 984. The analysed variables will first be presented using relevant descriptive statistical tools. Given the nature of the analysed data, non-parametric tests are employed for comparing the mean values of the sample groups. The independent variable in the tests is the classification of respondents into four age categories, whilst the dependent variables are Financial Behaviour, Financial Knowledge, and overall Financial Literacy Score. To verify the existence of statistically significant differences, the Kruskal-Wallis test is used for manifest variables. Should this

¹ Only individuals aged 18 and above were included in the survey. Therefore, Generation Z respondents in this research were limited to those born between 1997 and 2007.

test demonstrate statistically significant differences between the analysed age groups, it will not be possible to identify between which age groups these differences occurred in based on this result alone. Therefore, in such cases, this test will be supplemented by pairwise Mann-Whitney U tests, which will enable precise identification of statistically significant differences in the evaluation of Financial Knowledge, Financial Behaviour, and overall Financial Literacy Score indicators (Hatcher, 2013; Rabušić et al., 2019). The statistical software SPSS version 25 is used for both descriptive and inferential statistical analysis.

2. Results of the Research

The objective of this paper is to analyse the behaviour of Generation Z in comparison to the behaviour of previous generations. This is accomplished through an analysis of their behaviour from the perspective of *Financial knowledge* and *Financial behaviour*. By combining these two variables, an overall *Financial literacy score* was subsequently calculated for the individual analysed generations. In the following Tab. 2, a description of these variables from the perspective of the four analysed generational groups can be observed. Descriptive statistical tools in the form of achieved mean, standard error, and standard deviation were utilized to describe the individual generations.

Tab. 2: Generational differences in financial knowledge, behaviour, and literacy: descriptive statistics

Analysed variable	Mean	Std. Error	Std. Deviation
Financial knowledge score			
Generation Z	2.36	0.11	1.21
Millennials	2.48	0.08	1.37
Generation X	2.80	0.07	1.22
Baby Boomers	2.70	0.07	1.19
Financial behaviour score			
Generation Z	2.61	0.06	0.64
Millennials	2.54	0.04	0.68
Generation X	2.59	0.04	0.62
Baby Boomers	2.62	0.03	0.61
Financial literacy score			
Generation Z	6.71	0.15	1.68
Millennials	6.72	0.11	1.89
Generation X	7.12	0.10	1.64
Baby Boomers	7.10	0.09	1.69

Source: Authors' own calculation, data from (Directorate-General for Communication, 2023)

Regarding *Financial knowledge*, it can be stated that Generation Z achieved the lowest rating among the four analysed groups, with an average score of M=2.36 out of a

maximum possible score of 5. Millennials demonstrated a slightly higher average score of $M=2.48$. Significantly higher scores were attained by older generations, specifically $M=2.80$ for Generation X and $M=2.70$ for Baby Boomers. In terms of *Financial behaviour*, the average achieved values for the individual analysed generations are very similar. The lowest average score of $M=2.54$ was recorded by the Millennials, while the highest average score of $M=2.62$ was achieved by the Baby Boomer generation. Concerning the overall *Financial literacy score*, the average achieved scores of Generation Z and Millennials are essentially identical, whereas older generations attained higher average scores that were again effectively equivalent.

Analysis of mean scores for the individual analysed generations alone does not allow for determination of whether differences in these means are statistically significant. Therefore, the three analysed variables were subjected to additional statistical analysis in the form of the Kruskal-Wallis test, which is capable of identifying statistically significant differences between the four analysed generations of respondents. The results of this test are described in the following Tab. 3.

Tab. 3: Test of statistical significance for generational differences in financial knowledge, behaviour, and literacy

Variable	Null Hypothesis	Sig.	Decision
Financial knowledge score	The distribution of financial knowledge score is the same across generations	0.001	Reject the null hypothesis
Financial behaviour score	The distribution of financial behaviour score is the same across generations	0.636	Retain the null hypothesis
Financial literacy score	The distribution of financial literacy score is the same across generations	0.007	Reject the null hypothesis

Source: Authors' own calculation

Based on the results of the Kruskal-Wallis test, it can be stated that statistically significant differences exist between the four analysed groups of respondents in terms of their *Financial knowledge*. Conversely, the existence of statistically significant differences was not confirmed for the *Financial behaviour* variable. In the case of the composite variable *Financial literacy score*, which was created by combining financial knowledge and financial behaviour, statistically significant differences between the analysed generations were also confirmed. However, based on the results of the Kruskal-Wallis test, it is not possible to identify between which generations these statistically significant differences occurred.

Therefore, the *Financial knowledge* and *Financial literacy score* variables were subjected to additional analysis using the pairwise Mann-Whitney U test, which can precisely identify statistically significant differences in the achieved scores of Generation Z compared to the other three analysed generations. The results of the pairwise test can be seen in the following Tab. 4.

Tab. 4: Analysis of generational differences in financial knowledge and literacy

Variable	Compared generations	Mann-Whitney U	Z Value	Sig.
Financial knowledge score	Generation Z - Millennials	15059.0	-0.877	0.380
	Generation Z - Generation X	12722.0	-3.455	0.001
	Generation Z - Baby Boomers	15952.5	-2.660	0.008
Financial literacy score	Generation Z - Millennials	15779.0	-0.150	0.881
	Generation Z - Generation X	13720.5	-2.402	0.016
	Generation Z - Baby Boomers	16392.5	-2.233	0.026

Source: Authors' own calculation

For *Financial knowledge*, statistically significant differences were observed between Generation Z and Generation X, as well as between Generation Z and Baby Boomers. In both instances, Generation Z respondents demonstrated statistically significant lower performance relative to older generations. However, no statistically significant differences were detected between Generation Z and Millennials' performance levels. The *Financial literacy score* exhibited an identical pattern of statistical significance, which was expected considering that this composite measure was derived from the integration of *Financial knowledge* and *Financial behaviour variables*.

3. Discussion

The results revealed that there exist statistically significant differences in financial literacy scores across generations. However, Generation Z does not stand apart from all older age groups. Specifically, there is no statistically significant difference between Generation Z and Millennials in either financial knowledge ($p = 0.380$) or overall financial literacy ($p = 0.881$). In contrast, Generation Z scores significantly lower than both Generation X (financial knowledge $p = 0.001$; overall financial literacy score $p = 0.016$) and Baby Boomers (financial knowledge $p = 0.008$; overall financial literacy score $p = 0.026$). These results confirm the most recent findings in the literature, which consistently highlight relatively modest financial knowledge among young adults (Belás et al., 2016; Demertzis et al., 2024; Fur & Outreville, 2022; Yakoboski et al., 2022), reinforcing concerns about Generation Z's preparedness for long-term financial decision-making.

The observed generational pattern might indicate a shift in financial knowledge acquisition among younger people. Generation Z, as digital natives, demonstrates distinct learning behaviours that diverge from traditional educational means. Rudeloff (2019) emphasises that financial literacy is not acquired exclusively in school, but that knowledge and skills are gained through everyday experiences and social interactions. Informal learning environments such as family discussions, peer exchanges, and media

exposure play a crucial role in shaping young people's financial attitudes and habits. This perspective helps to interpret the present findings. The lack of a statistically significant difference between Generation Z and Millennials in financial knowledge and overall financial literacy may reflect their shared reliance on informal learning, particularly via digital media. Hayes & Ben-Shmuel (2024) argue that *"in an era where social media platforms have become the new town squares, financial influencers - have emerged as the modern-day heralds of financial advice"*, representing *"a significant cultural shift in how millions of individuals, especially among younger cohorts, engage with financial information and advice."* They also note that influencers *"reframe financial competence as both accessible and engaging"* through relatable narratives and interactive media. A similar thought was presented by Mölders et al. (2025), when he claimed that Generation Z often engages with financial information through informal digital channels, particularly short-form content produced by influencers on social media. While these platforms make financial topics more accessible and can stimulate engagement, they also present limitations related to inconsistent quality control and questionable accuracy. Hayes and Ben-Shmuel (2024) also caution that the dominance of short, attention-driven content and the absence of robust regulation can lead to oversimplification or even promote risky financial behaviours.

In contrast, older generations were more likely to acquire financial knowledge through structured educational settings or practical experience gained over time. Moreover, age-related life stage effects likely compound these differences. Many Generation Z respondents are still in the process of entering adulthood and have not yet encountered complex financial situations such as long-term investing, mortgage financing, or retirement planning, contexts that often solidify knowledge and improve financial decision-making over time. Financial behaviour was assessed through respondents' agreement with three statements designed to capture prudent financial practices. Specifically, the survey inquired whether individuals carefully consider whether they can afford a purchase before buying, keep track and monitor their expenses, and set long-term financial goals and strive to achieve them (Directorate-General for Communication, 2023). These behaviours align with widely recognized dimensions of sound financial management as described in the literature (Atkinson & Messy, 2012; Lusardi & Mitchell, 2014). Interestingly, although statistically significant differences were found in financial knowledge, no such differences were identified in financial behaviour across the generations. This suggests that Generation Z, despite having lower financial knowledge, engages in financial behaviours that are comparable to those of older generations.

This finding invites several possible interpretations. One explanation may lie in the role of parental influence and financial dependence, particularly given that many members of Generation Z might still be partially or fully supported by their families. As a result, their financial behaviours may reflect family norms or practices, even if their theoretical knowledge is still developing. Another plausible factor is the widespread use of digital tools and budgeting applications among younger people. While Generation Z may lack comprehensive financial knowledge, their behaviours (such as tracking expenses, considering affordability before making purchases, and setting financial goals) may be guided or supported by user-friendly fintech solutions that are natural for them to use. These tools might effectively compensate for gaps in financial education by automating or

simplifying good financial practices (Sconti, 2022). It should be noted, however, that excessive dependence on such tools in the absence of foundational knowledge risks fostering only a superficial understanding of financial concepts, leaving individuals less prepared to navigate complex or unfamiliar financial situations. Moreover, certain financial behaviours may be culturally normalized among Generation Z regardless of their underlying financial understanding. For instance, the use of credit cards, digital wallets, investing platforms, and online banking is not only common but often encouraged through social and digital environments.

Although financial behaviour appears similar across generations, this does not necessarily mean Generation Z manages finances as effectively as older generations. Behaviours like considering affordability or setting financial goals may not translate into sound decisions (Generation Z might still make unaffordable purchases or invest without adequate knowledge). Research suggests Generation Z and Millennials are especially prone to overconfidence and the Dunning–Kruger effect, leading them to overestimate their financial skills (Da Silva et al., 2024). As a result, while their actions may mirror those of older generations, the quality and outcomes of their decisions could be significantly weaker. Given the fact that the financial literacy score is a computed composite variable based equally on both financial knowledge and financial behaviour, the statistically significant differences discovered in the financial knowledge were carried over to this variable as well. There were no statistically significant generational differences observed in financial behaviour. As a result, all significant differences in the overall financial literacy scores across generations are influenced mainly by disparities in financial knowledge. Consequently, it can be reiterated that Generation Z exhibits statistically significant lower levels of overall financial literacy compared to Generation X and Baby Boomers. However, the difference between Generation Z and Millennials was not statistically significant, suggesting that the financial literacy of these two generations is more similar than previously thought.

Conclusion

This paper highlights the importance of understanding generational differences and competencies in financial literacy and behaviour, which carry significant implications not only for individuals and their private finances, but also for financial institutions and policymakers. It focuses on the context of Generation Z within the Czech Republic, and the findings reveal that Generation Z, although growing up with easy access to online information and digital financial tools, demonstrates lower financial knowledge compared to older generations like Generation X or Baby Boomers. This supports previous research suggesting that younger generations often lack the knowledge needed for sound financial decision-making (Belás et al., 2016; Demertzis et al., 2024; Fur & Outreville, 2022; Yakoboski et al., 2022). On the other hand, no significant differences were found between Generation Z and Millennials in terms of financial knowledge and overall financial literacy, suggesting that younger people may face similar challenges. Interestingly, financial behaviour appeared consistent across all, suggesting that while younger individuals may lack deeper financial understanding, their financial practices seem to be comparable.

This topic is particularly relevant in the current economic context, as Generation Z as a whole is still in the process of entering adulthood and the workforce. Their financial literacy will soon have wider economic implications. As they become key participants in the consumer market, investment activities, and housing sector, their decisions will begin to influence macroeconomic trends more significantly. A financially ill-prepared generation may not only struggle individually, but could also pose broader risks for economic growth, financial system stability, and social security systems. That is why a deeper understanding of Generation Z's specific challenges, expectations, and preferences in the financial market is essential. Investigating how they perceive financial services, which products they consider outdated, what features they value the most, and how they prefer to interact with financial institutions can provide actionable insights. This knowledge can help banks and other financial providers adapt their offerings to remain relevant and attractive to this growing customer base. Tailoring product design, improving user experience, and developing communication strategies that resonate with their values and digital habits will be key. These themes could be further explored because supporting this generation is not only a matter of customer retention but a broader strategic move to ensure long-term economic resilience and sustainability.

Despite these findings, the research has several limitations that should be acknowledged. The analysis focused solely on three main variables, financial knowledge, behaviour, and literacy, across four generations. It did not account for other potentially significant factors, such as education level, income, or whether respondents live in urban or rural areas, all of which could influence financial outcomes and attitudes. Without controlling for these variables, some generational differences may be overstated or misinterpreted. Moreover, this study is situated within the specific cultural and historical context of Czechia as a post-socialist country. The legacy of economic nationalisation, the transition to a market-based economy, and the resulting patterns of intergenerational (mis)trust in financial institutions may shape how different generations perceive and interact with finance. This cultural specificity limits the possibility of generalising the findings to countries with different historical and economic backgrounds. Future research should aim to incorporate a broader range of demographic and socioeconomic indicators to create a more nuanced understanding of financial literacy trends and their underlying drivers.

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Creation and Development of a Specialized Tourist Product Based on the Features of Attractiveness, Originality, Authenticity, and Relevance of Content

Abstract

In tourism practice, specialized tourist products are often developed unsystematically, based on various entrepreneurial ideas. Most specialized tourist products created in this way do not achieve satisfactory sales. An analysis of successful, globally recognized specialized tourist markets has shown that they are developed systematically. The systematic development of a specialized tourist product implies that the idea is only the starting point. The idea of a new specialized tourist product needs to be developed using selected features. The paper presents an original model that practice in the development of specialized tourist products. The model is based on the features of attractiveness, originality, authenticity, and relevance of the content.

The paper presents a model based on a business case of tourism commercialization of the Roman general Lucius Artorius Castus, who was born and buried in Podstrana near Split, Croatia. According to the findings of several researchers, the war journey of this Roman general in England inspired the creation of the legend of King Arthur. The research was conducted using a descriptive analysis of secondary data. The research employed a descriptive analysis of secondary data. It focuses on examining the author's model for developing a specialized tourist product. The primary research problem centers around justifying the broader application of this model in tourism practice to support the creation of new specialized tourist products.

Key Words: Tourism, Specialized Product, Artorius, Arthur

JEL Classification: Z32, Z33, M31

Introduction

Recent research has shown that today's tourists give preference to destinations that offer authentic content when choosing where to travel (Buhalis et al., 2019; Cooper, 2021; Hall et al., 2020). Tourists' attention is attracted by offers that are based on historical stories and local legends (Jakšić-Stojanović et al., 2021). Combining history and local legends establishes a platform for the development of new, specialized tourist products (Šerić et al., 2024). The commercialization of historical facts with an original marketing story contributes to the attractiveness of a tourist destination (Šerić et al., 2024). Such contents have the potential to become destination icons (Jakšić-Stojanović et al., 2020). Indigenous destination icons implement local identity in the tourist image, which contributes to the differentiation of the destination in the global tourist market. (Buhalis et al., 2019; Cervova et al., 2021).

In tourism practice nowadays, in the development of specialized tourist products, the focus is most often on the idea (of the entrepreneur), and the final tourist content is rarely developed systematically without adhering to defined characteristics. (Šerić et al., 2024). The importance of historical and other features that contribute to the impressiveness of a specialized tourist product is often neglected (Buhalis et al., 2019; Cooper, 2021; Hall et al., 2020). The subject of this research is the features of a specialized tourist product that contribute to its long-term sustainability and attractiveness among the tourist public. The analysis is based on the project for developing the dual destination icon the dual destination icon of Lucius Artorius Castus and King Arthur in Podstrana near Split, Croatia. The research problem is focused on ranking the importance of features recommended in the development of specialized tourist products. The model's proposed characteristics were validated through their application in a series of specialized tourist product development initiatives (Šerić et al. 2024). For clarity, in this paper the term '**tourist product**' refers to a specific offer (e.g., King Arthur Heritage Museum, Artorius Restaurant); '**tourist content**' refers to the components of that offer (e.g., themed evenings, exhibitions, menu items); and '**destination icon**' refers to the symbolic element, tangible or intangible, through which a destination is identified, such as the archaeological legacy of Lucius Artorius Castus or the legend of King Arthur.

This study adopts a qualitative, exploratory approach, using a case study methodology focused on the Podstrana destination. Such a method is appropriate for identifying and analyzing phenomena that have been underexplored in existing tourism literature. This research serves as a conceptual groundwork for future quantitative studies. The research was conducted through a descriptive analysis of secondary data following the archaeological find of the tombstone of Lucius Artorius Castus in Podstrana, a small town near Split in Croatia. These findings confirmed that this Roman general lived and was buried in Podstrana (Cambj, 2025). The research is further grounded in the proceedings of two international scientific conferences held in Podstrana over the past decade. The first conference examined archaeological findings related to the life and death of Lucius Artorius Castus, while the second explored the potential of integrating King Arthur stories and legends into the tourist offer of Podstrana. These findings were supplemented by research by several scientists from Great Britain, the USA, Italy, and more, who have been engaged for years in researching both the archaeological legacy of Lucius Artorius Castus

and the emergence of the King Arthur legend. The scientific credibility and consistency of these works provided the basis for testing the features of the model presented in this paper (Faggiani, 2025; Gidolow, 2025; Hunt, 2025; Malcor, 2025). Reconnaissance research, carried out through consultation with the Podstrana Tourist Board, involved examining visitor statistics, promotional campaigns, and local development plans. The analysis confirmed that the dual destination icon of Lucius Artorius Castus and King Arthur has been strategically promoted and has contributed to a continuous increase in tourist visits in recent years. The purpose of the research is to demonstrate, through the management of this dual destination icon, the potential of applying multiple features in developing a sustainable, specialized tourist product, rather than relying on sensationalism. Two common ways that are recognized in the practice of creating new specialized tourist products around the Mediterranean Sea (see Fig. 1) (Šerić et al. 2024).

Figure 1. Long-term sustainability of the competitiveness of a specialized tourist product over time, concerning what it is based on



Source: Authors, 2025.

The use of content-driven marketing narratives is a recognized strategy in specialized tourist products that have consistently engaged the tourist public for over a decade (Šerić et al., 2024). Variations observed in the management practices of specialized tourist products point to a set of general principles that should be followed, regardless of the specific strategic approach employed (Buhalis et. al., 2019). The purpose of this research is to methodologically examine and justify the integration of multiple defining features in the development and commercialization of specialized tourist products, with particular emphasis on the strategic use of content marketing narratives as a strategic tool.

Following the research findings, empirical evidence of using an established model in the development and management of a new specialized tourist product is presented. The main research question, **RQ 1** – *Does the use of different features in the development and management of a specialized tourist product significantly accelerate its acceptance and foster tourist loyalty?* – will be tested by auxiliary research questions:

- **RQ 1.1.** *To what extent does a historical or scientific foundation enhance the credibility and effectiveness of the marketing narrative for a new specialized tourist product?*
- **RQ 1.2.** *What is the significance of the originality of the marketing story of a new specialized tourist product?*

- **RQ 1.3.** *What is the significance of the authenticity of the marketing story of a new specialized tourist product?*
- **RQ 1.4.** *What is the significance of the contemporary relevance of the marketing story of a new specialized tourist product?*

In this paper, the case of Podstrana as a dual-destination icon, associated with Lucius Artorius Castus and King Arthur, is analyzed to evaluate the strategic role of various elements used in shaping the marketing narrative and developing specialized tourism offerings. In a subsequent stage of research, the proposed model will be quantitatively validated through surveys among visitors to Podstrana. Such an approach will allow for statistical confirmation of the qualitative findings presented here and enable further refinement of the conceptual framework.

2. Literature review

The development and management of specialized tourist products has been increasingly researched over the past decade (Cooper, 2021; Mugauina et al., 2020; Hall et al., 2020; Ianioglo et al., 2020; Buhalis et al., 2019). Tourism trends, desires, and expectations of tourists are changing (Girish, 2020; Goosling et al., 2020; Hall et al., 2020). Increased competition among tourist destinations requires the innovation of an integrated destination offer with the aim of more intensive differentiation (Šerić et al. 2024). Specialized tourist products are the basis of destination differentiation. Original, new specialized tourist products assume the existence of certain usable resources. Modern tourists are particularly interested in content related to local traditions. Despite originality, not all new specialized tourist products manage to achieve significant commercial potential and encourage the loyalty of tourists who decide to try them (Buhalis et al., 2019; Šerić et al., 2024). This prompted preliminary research to determine the contribution of different features used in the development of new specialized tourist products. Following participation in the design, creation, and commercialization of several different specialized tourist products, and a review of recent scientific literature, it was determined that originality is often used. By using the feature of originality, the new content is attempted to be presented as something new on the market. In addition to this, the feature of historical and scientific foundations, indigenusness, and topicality of the marketing story of the new specialized tourist product have also been recognized in some practice. In this context, each of these features will be theoretically analyzed individually.

2.1. Originality of a new specialized tourist product

The originality of a new specialized tourist product is common in many analyzed business cases (Cooper, 2021; Hall et al., 2020; Buhalis et al., 2019; Melović et al., 2019). It has become a standard because most new specialized tourist products are created in response to a specific entrepreneurial idea to offer something new to visitors during their stay, thereby encouraging additional spending. In doing so, it is often not considered whether originality is sufficient to encourage tourists to spend more. When we add to this the realization that much of the new specialized tourist content is developed unsystematically, it should not be surprising that many of these offers are not adequately recognized or accepted by tourists. Consequently, the income from the sale of a new

tourist product is lower than expected (Šerić et al., 2024). The destination resource that is the basis of a new specialized tourist product is often not a sufficient incentive for the growth of annual visitation to the destination and therefore needs to be commercialized in various ways, but the originality of the new content is not always sufficient in itself to encourage additional spending by visitors (Šerić et al., 2024).

2.2. Historical and scientific foundations, proofs of a new specialized tourist product

The historical basis of a new specialized tourist product has recently been considered during creation (Šerić et al. 2024). In previous decades, many destinations offered were based on cultural and historical resources, but without an appropriate marketing story (Vitner Marković et. al., 2011). Tourists usually visit a cultural and historical attraction only once. After visiting it, they do not show interest in visiting again (Cooper, 2021). It is difficult to particularly fascinate tourists by forcing historical facts related to a cultural and historical destination resource. This does not mean that the historical basis of a new specialized tourist product should be ignored. Younger tourist segments are beginning to predominate numerically in the total mass of consumers, so as visitors in tourism (Holendova et al., 2024; Melović et al., 2024; Milaković et al., 2023; Pranić, 2011). Younger tourist segments are interested in historically based local stories and legends, especially if they represent part of the destination's identity (Šerić et al., 2024).

Good practice in managing the development of specialized tourist products indicates that care should be taken to whom and in what way something is offered, as well as what is important and what is offered (originality). In previous decades, historical and scientific proofs were not considered because basic information about the cultural and historical heritage was often the only basis of destination image, but it was not used as a resource for the development of new specialized tourist products, especially not connecting local legends with that (Šerić et al. 2024). Today, tourism stakeholders are noticing that the historical and scientific foundations of a new specialized tourist product with the identity of a destination strengthen the visibility of the offer on the global tourism market, in addition to attracting the attention of visitors. The historical and scientific proofs of a new specialized tourist product should be used intensively in the promotion of a destination because they contribute to the growth of tourist visits (Šerić et al., 2024).

2.3. The authenticity of a new specialized tourist product

Today, tourism agents are aware that the authenticity of some destination offers contributes to its attractiveness and competitiveness (Ianioglu et al., 2020; Buhalis et. al., 2019). As a result of this, destinations are increasingly encouraging the development of authentic, specialized tourist products. By analyzing several specialized tourist products on the eastern Adriatic coast, the authors determined that in recent times, the content of new tourism offers is sometimes based on authenticity. But it is forgotten that the offer should be adapted to new tourism trends (Šerić et al., 2024). The authenticity of a specialized tourist product contributes to the global visibility of a destination, but not necessarily to the loyalty of visitors to the destination, especially if the alignment of the

integrated destination product with current tourism trends is neglected (Buhalis & Sinarta, 2019; Cooper, 2021).

2.4. The relevance of a new specialized tourist product

The relevance of a new specialized tourist product assumes that it is aligned with recent tourism trends (Buhalis et al., 2019). A systematic approach to the development and management implies that the offer and content are adapted to one (or more) of the current tourism trends. The relevance of a specialized tourist product defined in this way is one of the important prerequisites for its long-term sustainability on the market (Šerić et al. 2024; Buhalis et al., 2019). A systematic approach to the development of a new specialized tourist product assumes the flexibility of its content. The flexibility of the content that will be offered to tourists allows for adaptation to one (or more) of the current tourism trends (Cervova et al., 2021). The content of the tourist offer adjusted to trends is relevant to tourists, which contributes to the growth of demand for it, and indirectly to the competitiveness of the destination where it is offered. This is especially visible today because visitors instantly put their photos as impressions of the destination they are staying in on their social networks (Šerić et al. 2024). Tourists want to present themselves in a trendy way, they want to try out trendy content, and show off their photos on social media. This behavior leads to viral promotion of new destination content, so as the touristic destination (Holendova et al. 2024; Cooper, 2021; Ianioglu et al., 2020).

According to recent research by ignoring the relevance of a new specialized tourist product will have negative consequences on the dynamics of its acceptance by tourists (Šerić et al. 2024). The relevance of the tourist offer should be viewed in the context of links with originality, historical facts, and authenticity. Only such an approach is a prerequisite for sustainable, continuous growth in demand and visits, and thus the sales to the destination (Cooper, 2021; Jakšić-Stojanović et al., 2021; Melović et al., 2019). Growing global awareness of climate change has resulted in increased tourist interest in activities based on the use of renewable energy sources that are offered with high environmental standards (Hall et al. 2020).

Comparable attempts to integrate history and legend into destination development can be observed elsewhere, for instance, in British Arthurian heritage sites (e.g., Tintagel, Glastonbury) and in several Mediterranean destinations where myth and history are combined in tourism narratives. However, these practices usually emerge from individual entrepreneurial initiatives or fragmented strategies rather than from a systematically applied feature-based framework. Similar patterns have been identified in Croatian destinations, where the creation of specialized tourist products often relies on unsystematic approaches driven primarily by entrepreneurial ideas without long-term methodological grounding. In contrast, the systematic integration of multiple features, as proposed in this study, provides a structured and sustainable model for developing specialized tourist products, strengthening both competitiveness and long-term visitor loyalty (Šerić et al., 2024).

3. Research

Given the exploratory and qualitative nature of this study, the research does not include quantitative data but instead relies on descriptive analysis of the Podstrana case to illustrate the role of the identified features in specialized tourist product development. The visibility and tourist image of Podstrana, a small tourist town near Split, have changed significantly over the last decade through the use of the archaeological discovery of the tombstone of Lucius Artorius Castus in local tourist attractions (*events, hiking, climbing, cycling tours, actor plays, gastronomy, etc.*). This archaeological finding proves that this Roman general was born and lived in Podstrana until his death after his military career. He was also buried in Podstrana (*Cambj, 2025*). As a result of these facts, Lucius Artorius Castus has been used as a recognizable destination icon of Podstrana. Based on historical facts, this destination icon was expanded through two scientific conferences where papers and research were presented, proving the authenticity of archaeological findings and the foundation of the legend of King Arthur on the military campaigns of Lucius Artorius Castus in Britain (*Faggiani, 2025; Gidlow, 2025; Hunt, 2025; Malcor, 2025*). By linking it to the legend of King Arthur, a dual destination icon was created, which stimulated additional interest from the global tourist public. The number of visitors is growing, particularly from the United Kingdom, given their emotions related to the legend of King Arthur. This is an argumentation of the key features used in the creation and management of various specialized tourist facilities in Podstrana that are based on this dual-destination icon.

3.1. Originality landmark

The originality of a new specialized tourist product significantly depends on the creativity of the team of marketing experts who develop it. Creativity contributes to originality even more if the content is authentic. Linking some legends created based on the life of a historical person represents an innovative marketing approach of combining history (*reality*) and fiction (*legend*). However, such a marketing story used for various tourist content offers wider possibilities of commercialization and adaptation to tourist trends. In the case of this dual-destination icon, historical facts are not limitations for ideas, because when reality stops, the legend continues. It should only be taken into account that not all tourist segments will be interested in all the offered tourist content (*intensity of physical activities, annual period of visiting the destination, etc.*).

Historical facts related to Lucius Artorius Castus set certain frameworks in the creation of tourist content. By combining history with the legend of King Arthur, everything becomes possible. This dual destination icon confirms the feature of originality of the touristic and marketing story in Podstrana. Lucius Artorius Cast has become a historical part of the Podstrana image thanks to archaeological findings. The potential of a dual destination icon that combines historical facts related to Lucius Artorius Castus with the legend of King Arthur is reflected in the wide possibilities of commercialization (*also a possibility of benchmarking with different tourist attractions offered in the United Kingdom*). Subside differentiation and originality are ensured by the historical link of the legend with a real person whose war campaign inspired the creation of the legend of King Arthur.

3.2. Historical and scientific foundations landmark

The history of a destination is the foundation of its identity. The transformation of historical facts into destination icons often occurs unconsciously in tourism practice. However, for such processes to be economically (tourism) efficient, a multidisciplinary approach is needed in the transformation of historical facts into new destination icons or new tourist content. New specialized tourist products can be developed based on fictitious characteristics of the destination, but the historical foundation of the marketing story contributes more intensively to attracting new visitors to the destination. The example of Podstrana and the use of a dual-destination icon, which is established historically, proves this. Today, Podstrana is also visited by tourists from countries where tourist arrivals were not recorded in previous decades. The number of tourists from the United Kingdom has increased in particular. Thanks to the combination of history and legend, various tourist content is being developed in Podstrana to create attractions. They are based on combinations of historical characteristics and components of the legend. This is how sports, recreational and gastronomic events, festivals, and meetings of followers of the legend of King Arthur, artistic plays, etc., are designed.

The dual-destination icon of Lucius Artorius Castus and King Arthur is growing into the most recognizable destination icon of Podstrana. Archaeological findings are evidence of the origin, life, and death of the Roman commander whose military journey inspired the creation of the legend of King Arthur. Published scientific papers from scientific conferences have argued the historical links of Lucius Artorius Castus with Podstrana and the legend of King Arthur (Faggiani, 2025; Gidlow, 2025; Hunt, 2025; Malcor, 2025). Scientifically proven facts are a relevant assumption for the implementation of the legend of King Arthur in the identity of Podstrana. Compared to the United Kingdom, where the legend of King Arthur is intensively valorized for tourism, Podstrana, by connecting this legend with the historical person on whose war journey the legend was created, enables wider possibilities of tourist attractions. History, defined by concrete facts, limits marketing creations in tourism, but it is an important starting point in the development of Podstrana's tourist offer.

3.3. Authenticity landmark

A dual destination icon that is also historically based is a long-term, sustainable personification of a tourist destination. Evidence of the origin of the marketing story related to the destination icon presupposes the authenticity of the tourist content based on it. The links of history and legend in the example of Podstrana are evidence that today, tourists choose destinations whose icons, image, and content not only stimulate intense emotions and experiences, but are also based on the local history. The local history gives authenticity to a tourist destination. The competitiveness of a tourist destination significantly depends on the impression of its authentic population. Authenticity implies the identity features of a destination in its tourist offer. The content context should be considered by understanding the causes of the aspirations, expectations, and desires of the targeted tourist segments. The tourist product portfolio of Podstrana has been developed for tourist segments that choose authentic destinations. Over the last decade, the average number of days of stay of tourists in Podstrana has increased. The choice of

destination to travel to, the period, and the duration of stay in Podstrana are correlated with the authenticity of the offer. Podstrana has seen an increase in visitors who primarily express interest in sites historically related to the life of Lucius Artorius Castus and events inspired by links to King Arthur. The contribution of these events to annual tourist visits is also evident outside the main tourist season. The destination offer, rich in indigenous content, has contributed to the growth of Podstrana's global visibility, attractiveness, and competitiveness among the tourist and academic public (two international scientific conferences were held).

3.4. Relevance landmark

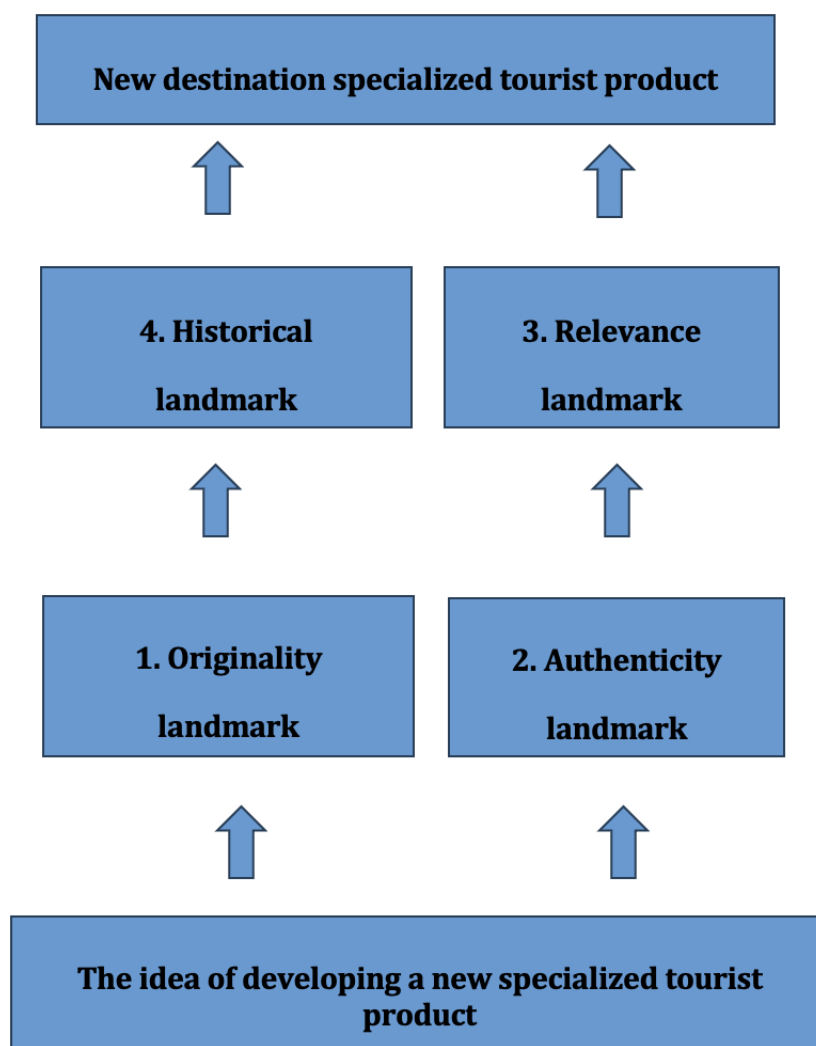
The commercialization of the legend of King Arthur has been confirmed in many destinations in the United Kingdom. The same legend is an example of touristic relevance thanks to extensive media promotion (books, films, events, souvenirs, etc.). The historical landmark of the origin of this legend, on facts related to the war journey of the Roman military leader in Britain (born in Podstrana), has enabled the connection of King Arthur with Podstrana, and thus the characteristic of topicality in the development of tourist content based on the same marketing story.

The characteristic of topicality of a new specialized tourist product implies adaptation to trends, especially in targeted emissive tourist markets. Stories and legends in the development of specialized tourist content are today a global tourist trend. Tourists choose a destination with an impressive identity based on stories and legends. After the archaeological find of the tombstone of Lucius Artorius Castus, there was no rush with tourist commercialization and the development of new tourist content. First, the tourist potential of this archaeological finding was analyzed in a broader marketing context, given the many archaeological artifacts in the Podstrana area (Split with Diocletian's Palace, old Salona, etc.). The tourist commercialization of ideas for new destination contents began after it was discovered that Lucius Artorius Castus's military campaign in Britain was the basis for the legend of King Arthur. The connection with this legend ensured the relevance of the development of specialized tourist content based on this dual-destination icon. The commercialization of the globally known legend in Podstrana also ensured additional differentiation and strengthening of the tourist attractiveness of this destination.

The relevance of specialized tourist content is a prerequisite for creating destination attractions. Combining historical facts with stories and legends in a globally recognizable destination icon ensured the relevance of Podstrana's tourist offer, because tourists are attracted by marketing stories that go beyond the framework of history and reality. The relevance of the development of specialized tourist products is a prerequisite for greater tourist demand. In Podstrana, some specialized tourist products are based on historical facts, others on legends, and others are a combination. Useful ideas for new tourist products can be found in the papers presented at two scientific conferences in Podstrana. Unlike British Arthurian and other Mediterranean heritage sites, where history and legend are combined in less systematic ways, the Podstrana case explicitly applies all four features, as illustrated (see Fig. 2). The use of all the mentioned features in the creation of specialized tourist products, in Podstrana, multiplied tourist visits, extended the average

stay of tourists, and strengthened the dedifferentiation and global visibility of the destination.

Figure 2. An overview of the use of multiple features in the development of specialized tourist products of Podstrana based on the dual destination icon Artorius Lucius Cast/King Arthur



Source: Authors, 2025

In the Podstrana business case, the significance and ranking of landmarks in the development of ideas for new specialized tourist products and their management are defined according to (Fig. 2) – originality about the content form and use of the dual destination icon (differentiation) is used as the primary characteristic. Authenticity, in terms of the links of the new destination icon with local customs and traditions, is ranked as the second most important characteristic. In Podstrana, relevance is practiced as the third most important characteristic for harmonizing new tourist content with tourism trends. The historical and scientific foundations characteristic is ranked as the fourth most important landmark because in this dual-destination icon, history and legend are

combined. In several scientific papers published in the Proceedings of two conferences held in Podstrana, historical findings related to the war path of Lucius Artorius Castus and its links to the emergence of the legend of King Arthur were argued.

The ranking model of landmarks by significance for the Podstrana business case should not necessarily be accepted as a general rule. Every tourist destination is a story for itself, but the experiences of Podstrana have proven that the foundation of each specialized tourist product on these characteristics is a guarantee of its long-term sustainability and good tourist response, and the creation of loyalty of visitors to the destination. In this business case, originality is recognized in the marketing story, the creation of a dual-destination icon, and the concept of joint use of history and legend. Authenticity is recognized by the links of history with local customs of the destination presented in events, gastronomic, and other specialized tourist products associated with this dual-destination icon. Relevance is the foundation of the trend of following the legend of King Arthur. Historical foundation scientifically argues the links of the content with real history and people used in the marketing story, and the held international scientific conferences related to Lucius Artorius Castus and the possibilities of tourist valorization of the legend of King Arthur in Podstrana.

Conclusion

This research aimed to explore whether integrating multiple features: originality, authenticity, relevance, and historical and scientific foundations in the development and management of specialized tourist products accelerates market acceptance and fosters tourist loyalty (RQ 1). The case of Podstrana demonstrated that such integration contributes significantly to the success and sustainability of specialized tourist products. Addressing RQ 1.1, the historical and scientific foundations were shown to enhance the credibility and effectiveness of the marketing narrative, especially by linking the figure of Lucius Artorius Castus to the globally recognized legend of King Arthur. This connection increased tourist interest and strengthened the marketing position of Podstrana. For RQ 1.2, the originality of the marketing story, combining historical facts with local legend, proved crucial in differentiating Podstrana from competing destinations. Originality attracted tourist attention and stimulated curiosity, leading to increased visits and engagement.

Regarding RQ 1.3, the authenticity of the offer, rooted in local history and traditions, was found to enhance the perception of credibility and appeal. Authenticity contributed to tourist satisfaction and loyalty, evidenced by increased repeat visits and growing interest in events tied to local history. Concerning RQ 1.4, the relevance of the tourism offer, ensured by aligning with contemporary trends in cultural storytelling and heritage tourism, maintained the attractiveness and competitiveness of the destination. This alignment supported sustainable interest and tourist demand. Incorporating multiple features into the design, development, and management of specialized tourist products is essential for the effective commercialization of destination resources. This approach also stimulates initial interest from tourists and contributes to the destination's image maintenance. In Podstrana, the integration of these four features has attracted interest from tourist intermediaries and investors, indirectly increasing the global visibility of the

destination. By strategically prioritizing these features, it is possible to harmonize historical facts with related legends, creating a more robust and appealing tourism offering.

A limitation of this research is the absence of quantitative methods. However, as tourism is fundamentally a social phenomenon, qualitative methods are well-suited for this exploratory stage of the research. The case study approach adopted in this study offers valuable insights into the use of originality, authenticity, relevance, and historical grounding in the development of specialized tourist products. Such an approach is suitable for initial exploration in areas that have been only modestly researched. While expanding the study to include quantitative methods, such as surveys of tourist attitudes, could provide further validation, it was beyond the scope of this paper. Instead, this research serves as a pilot phase that provides valuable conceptual and practical insights into a phenomenon that remains underutilized in tourism practice. Future research will build on these findings through the application of quantitative methods, allowing for statistical validation of the conclusions presented here.

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Current Digital Technologies and Their Impact on Marketing: Qualitative Analysis of the Czech Business Environment

Abstract: This article presents a comprehensive analysis of the impact of selected emerging technologies on the transformation of contemporary marketing practices, with a special focus on the Czech business environment. The focus is on the integration of advanced artificial intelligence, distributed data structures (**big data**), Internet of Things (**IoT**), blockchain platforms, robotic systems, cloud computing, and immersive technologies (**AR/VR/metaverse**) into strategic and operational marketing processes. The study aims to conduct a multi-paradigm synthesis of the impact of these technologies on redefining core marketing principles, including value creation, personalization of customer experience, and optimization of decision-making mechanisms. Methodologically, the research is anchored in a systematic literature review (**SLR**) and a qualitative investigation through semi-structured interviews with selected marketing practitioners.

The findings empirically confirm the growing importance of data-driven approaches, predictive analytics, and automation in building customer relevance and campaign effectiveness. They also identify the major ethical, legal, and societal challenges associated with algorithmic decision-making, data management, and transparency of digital processes. Based on the research findings, the paper formulates recommendations for the strategic implementation of digital technologies in marketing with an emphasis on accountability, ethics, and long-term sustainability. The study contributes to broadening the academic debate on the technological transformation of marketing and offers theoretical and practical impetus for further research on digital customer relationship management in the Central European environment.

Key Words: Artificial Intelligence, Digital Marketing, Personalization, Marketing Technology, Ethical Challenges.

JEL Classification: M31, M37

Introduction

The field of marketing has undergone a major transformation in recent decades due to the rapid development of digital technologies (Guhl et al., 2024). Modern technologies, including artificial intelligence (AI), the Internet of Things (IoT), big data analytics, blockchain, and immersive virtual environments, have revolutionized the way companies engage with consumers, develop strategies, and measure the effectiveness of campaigns (Kotler et al., 2021; Plangger et al., 2022). These changes have created new opportunities in personalization, predictive analytics, and content targeting, but have also raised significant ethical and operational challenges (Knihova, 2024; Alijoyo et al., 2025). This study aims to explore how current digital technologies are changing marketing practice in the context of Czech business ecosystems. Based on the analysis of theoretical and empirical perspectives, it seeks to identify the key technologies with the greatest impact on marketing operations and assess their transformative impact on traditional marketing models. Particular attention is paid to AI-driven personalization, predictive marketing, and the role of new technologies in customer segmentation and targeting (Fam, 2024; Lessmann, 2021).

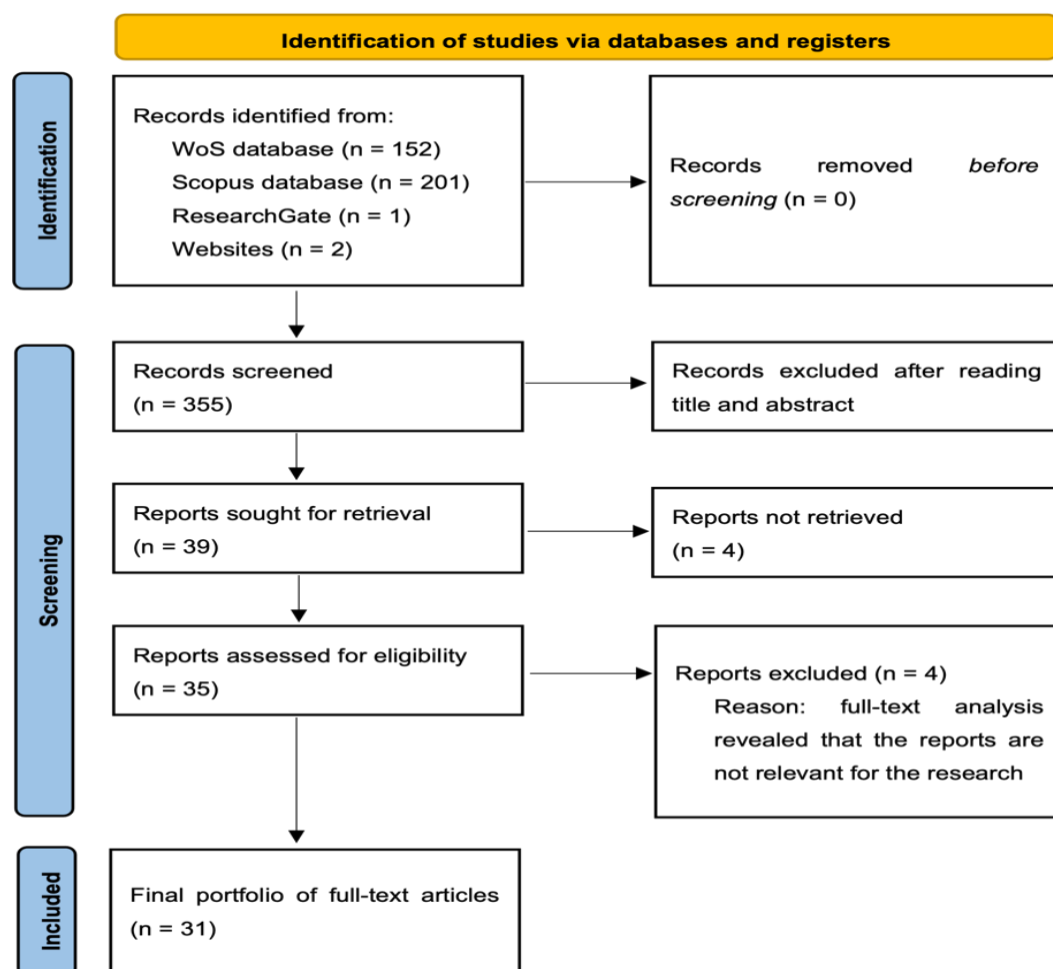
The importance of integrating ethical and socially responsible approaches into digital marketing strategies has increased in response to algorithmic decision-making and large-scale data collection (Sultana et al., 2016; Naz, 2020). Current discourse emphasises the need to balance technological innovation with transparent and responsible data practices, particularly within regulatory frameworks such as the EU's Artificial Intelligence Act (Iyer, 2025). Methodologically, this study combines a systematic literature review (SLR) with qualitative research conducted through semi-structured interviews with marketing professionals in the Czech Republic. This blended approach allows for a deeper understanding of the theoretical underpinnings and practical implementation of modern technologies in marketing management (Yeh et al., 2025; Fam et al., 2024). By synthesizing findings from the literature and practical insights, the paper offers a comprehensive view of the role of digital technologies in marketing and provides practical recommendations for adapting marketing strategies to technological change. It positions contemporary technologies not only as tools of efficiency and engagement but also as socially embedded phenomena that shape brand-customer relationships in fundamentally new ways (Kotler et al., 2021; Naz, 2025).

1. Methods of Research

This study applies a multi-method research framework that combines a systematic literature review (SLR) with qualitative empirical investigation through semi-structured interviews. This combination allows for a deeper understanding of the current use of modern technology in marketing practice and the theoretical concepts that frame this transformation. The theoretical foundation is based on a systematic literature review that serves as a standardized and reproducible tool for synthesizing the findings. The SLR aimed to identify key digital technologies applied in marketing, analyse their applications, and reflect on the related ethical and social implications. The approach was based on the

methodological framework of Eger & Hommerova (2024), including the identification of research questions, selection criteria, and data collection procedures. Database research was conducted in the Web of Science and ScienceDirect platforms using a combination of keywords such as "marketing", "modern techn*", "contemporary techn*", "metaverse", or "disruptive techn*". Due to the dynamics of the field, only studies published between 2023 and 2025 were included in the analysis. From the approximately 350 records found, the 28 most relevant publications were selected based on titles, abstracts, and keywords, taking into account the planned scope of the search. Articles found outside citation databases (e.g., ScienceDirect) were subsequently searched in the WoS and Scopus databases for bibliometric analysis of citation networks. Two web publications and one ResearchGate record were also included to complement specific subject areas, but were not part of the bibliometric analysis.

Fig. 1: The process of selecting articles for the systematic literature review by the PRISMA methodology



Source: own processing based on (Eger & Hommerova, 2024)

The selection procedure is depicted in the PRISMA scheme (Fig. 1). Bibliometric analysis was performed using VOSviewer software to visualize co-citation networks, author

clusters, and co-occurrence of keywords (Eger & Hommerova, 2024). Thematic synthesis subsequently identified seven dominant technology domains: artificial intelligence, Internet of Things, big data, blockchain, robotics, augmented/virtual reality, and cloud computing (Kotler et al., 2021; Plangger et al., 2022). Particular attention has been paid to the ethical aspects of digital transformation, especially privacy issues, algorithmic bias, and transparency (Alijoyo et al., 2025; Sultana et al., 2016). This theoretical framework also served as a starting point for the design of the qualitative part of the research. The empirical phase of the study is based on qualitative research focused on the implementation of selected digital technologies in Czech marketing practice. The data was obtained through semi-structured interviews with ten experts from the field of marketing, strategic management, and data analytics. The respondents were selected purposively with an emphasis on their practical experience with the application of marketing technologies in medium and large enterprises. The interview protocol was designed based on the findings of a systematic literature review and focused on five key areas: (1) technology awareness and adoption, (2) benefits and limitations, (3) impact on traditional marketing models, (4) personalization and targeting, and (5) ethical and regulatory challenges. Interviews were conducted in person or online, lasting between 30 and 60 minutes. Recordings were transcribed and analysed through thematic coding in NVivo software. The coding framework was developed iteratively to enable inductive identification of sub-themes while maintaining consistency with the categories defined in the SLR phase. This procedure ensured high methodological consistency and traceability of the analysis.

The qualitative research focused on the following research questions:

- **VO1:** What current technologies have the greatest impact on the effectiveness of marketing strategies?
- **VO2:** How does the use of current technologies affect the targeting and personalization of marketing campaigns?
- **VO3:** How do new technologies affect traditional forms of advertising?
- **VO4:** What are the challenges and ethical issues raised by the use of modern technologies in marketing?

This dual approach, combining systematic review and qualitative investigation, allows for a comprehensive exploration of conceptual trends and practical implementation of digital technologies in marketing. This methodology also supports the triangulation of data sources, thereby enhancing the credibility and depth of the research (Kotler et al., 2021; Rosario et al., 2023).

2. Results of the Research

A bibliometric analysis was conducted to identify the main thematic areas dominating the discourse on modern technologies in marketing. This approach included an analysis of keyword frequency, source citations, and identification of key authors and journals that have made the most significant contribution to research in the area. Tables of publications were tabulated as part of the analysis, including the country of origin and a summary of the journals where the articles were published.

Tab. 1: Geographical affiliation of authors

Authors	Country
Al-Ali, A., Gupta, R., Zualkernan, I., & Das, S. K. (2024)	UAE (United Arab Emirates), USA
Bakator, M., Čočkaló, D., Makitan, V., Stanisavljev, S., & Nikolić, M. (2024)	Serbia
Bamberger, B., Reinartz, W., & Ulaga, W. (2025)	Germany, UAE
Behera, R. K., Rehman, A., Islam, M. S., Abbasi, F. A., & Imtiaz, A. (2024)	India, Saudi Arabia
Behl, A., Nigam, A., & Vrontis, D. (2024)	India, Cyprus
Besim, R., & Sharma, B. P. (2023)	Nepal
Cheng, C. C., & Shiu, E. C. (2023)	Taiwan, United Kingdom
Duggal, N. (2024)	India
Fam, K., Liu, Y., Wei, S., Edu, T., Zaharia, R., & Negricea, C. (2024)	China, Romania
Guhl, D., Paetz, F., Wagner, U., & Wedel, M. (2024)	Germany, Austria, USA
Hanneke, B., Skiera, B., Kraft, T. G., & Hinz, O. (2024)	Germany, Australia
Horng, J., Liu, C., Chou, S., Yu, T., Chang, Y. E., & Hu, D. (2024)	Taiwan
Iyer, P., & Bright, L. F. (2024)	USA
Joshi, D. (2024)	India
Kim, I., Ki, C., Lee, H., & Kim, Y. (2024)	USA, Hong Kong
Kumar, H. (2024)	India
Kumar V., Ashraf A.R., & Nadeem W. (2024)	India, Canada
Mahr D., Odekerken-Schröder G., & Van Doorn J. (2025)	Netherlands
Mukhopadhyay S., Singh R.K., & Jain T. (2024)	India
Naz, H. & Kashif, M. (2025)	Pakistan
Nikseresht A., Shokouhyar S., Tirkolae E.B., & Pishva N. (2024)	USA, Australia, Turkey, Taiwan, Azerbaijan, Iran
Oklander M., Panchenko M., Pavlishyna N., Larina K., & Boiko R. (2024)	Ukraine
Pedersen C.L. & Ritter T. (2024)	Denmark
Pereira I., Madureira A., Bettencourt N., Coelho D., Rebelo M.Â et al. (2024)	Portugal
Peštek A. & Ejubović H. (2024)	Bosnia and Herzegovina
Rehman, A., Behera, R. K., Islam, M. S., Elahi, Y. A., Abbasi, F. A., & Imtiaz, A. (2024)	Saudi Arabia, India
Ren, G., Chen, Y., & Yang, M. (2024)	China
Rivas, P., & Zhao, L. (2023)	USA
Sun, Y., Bai, Y., & Zhou, Z. (2024)	China, USA
Tukur, M., Schneider, J., Househ, M., Dokoro, A. H., Ismail, U. I., Dawaki, M., & Agus, M. (2024)	Qatar, Nigeria
Yao, K. (2024)	China

Source: own processing

In addition, the software application VOSviewer was used to visualize networks of the most frequently cited authors, references, and their interrelationships. Based on these outputs, partial conclusions were formulated.

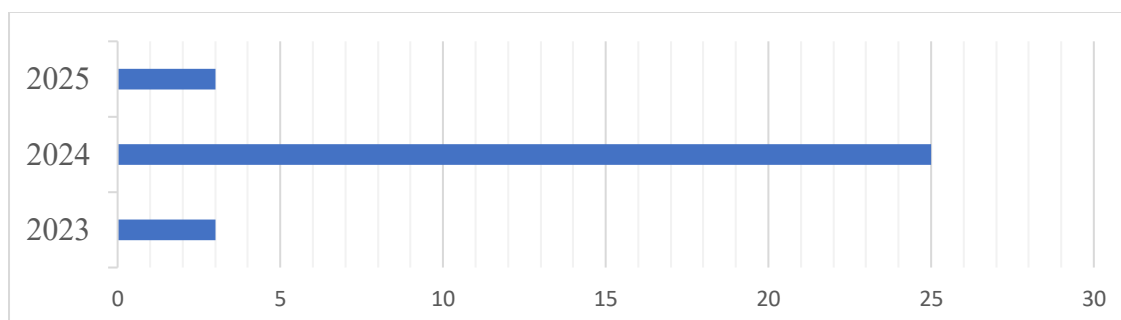
Tab. 2: Publications by the journals in which they were published

Journal / Source	Number of publications	Publications
AAFT Blog	1	Joshi, D. (2024)
AI	1	Rivas, P. & Zhao, L. (2023)
Acta Psychologica	1	Kumar, H. (2024)
Botfed Research Society	1	Besim, R. & Sharma, B. P. (2023)
Heliyon	1	Bakator, M. et al. (2024)
Industrial Marketing Management	1	Pedersen, C. L. & Ritter, T. (2024)
Informatics	1	Pereira, I. et al. (2024)
Information & Management	1	Cheng, C. C. & Shiu, E. C. (2023)
International Journal of Information Management	1	Kumar, V. et al. (2024)
International Journal of Information Management Data Insights	1	Mukhopadhyay, S. et al. (2024)
International Journal of Research in Marketing	1	Hanneke, B. et al. (2024)
Journal of Business Research	4	Bamberger, B. et al. (2025); Iyer, P. & Bright, L. F. (2024); Kim, I. et al. (2024); Mahr, D. et al. (2025)
Journal of Business-to-Business Marketing	1	Fam, K. et al. (2024)
Journal of Cleaner Production	1	Behera, R. K. et al. (2024)
Journal of Contemporary Management Issues	1	Peštek, A. & Ejubović, H. (2024)
Journal of Consumer Behaviour	1	Behl, A. et al. (2024)
Journal of Hospitality Leisure Sport & Tourism Education	1	Horng, J. et al. (2024)
Journal of King Saud University - Computer and Information Sciences	1	Tukur, M. et al. (2024)
OR Spectrum	1	Guhl, D. et al. (2024)
Pacific Business Review (International)	1	Oklander, M. et al. (2024)
Pervasive and Mobile Computing	1	Al-Ali, A. et al. (2024)
Spanish Journal of Marketing - ESIC	1	Naz, H. & Kashif, M. (2025)
Simplilearn.com	1	Duggal, N. (2024)
Technology in Society	2	Rehman, A. et al. (2024); Ren, G. et al. (2024)
Internet of Things	2	Nikseresht, A. et al. (2024); Sun, Y. et al. (2024)
Measurement Sensors	1	Yao, K. (2024)

Source: own processing

The analysis also included an evaluation of the most frequently occurring keywords that help to define the thematic direction of the research field under study. Considering the time aspect, only publications from the last three years were included in the review. Most papers date from 2024, which confirms the high timeliness of the data and minimizes the risk of bias by outdated information (Fig. 2).

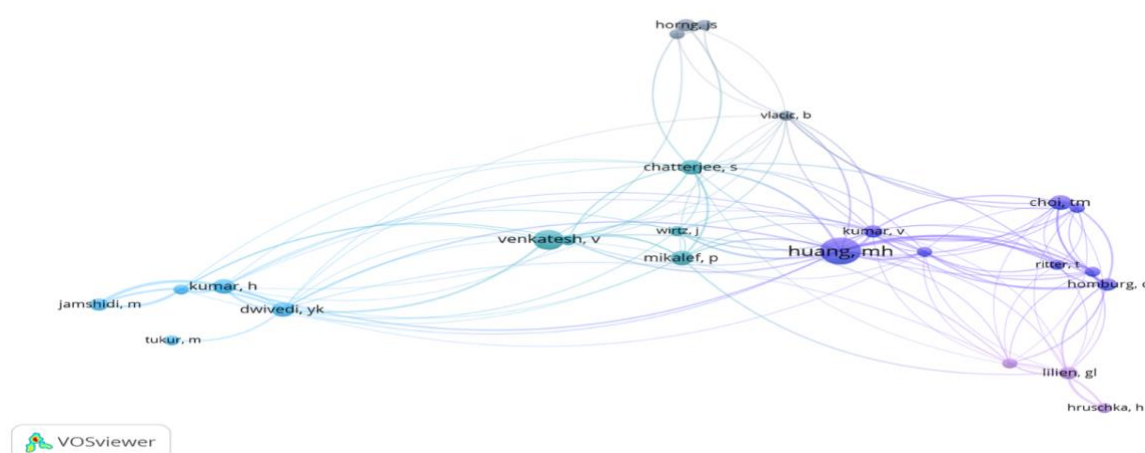
Fig. 2: Analysis of the years in which the articles selected for the SLR were published



Source: own processing

Tables 1 and 2 show that the combination of technology and marketing represents a very broad and multidisciplinary field in terms of topics. Publication activity in this field shows considerable geographical diversity, with articles coming from a wide range of countries. Similarly, the diversity of the journals in which these studies are published is significant. Unsurprisingly, India, whose research base has long been associated with information technology, data analytics, and digital innovation, strongly dominates the set of publications analysed. Among the most important publishing platforms in this context are the prestigious journals *Journal of Business Research*, *Technology in Society*, and *Internet of Things*, which provide a space for multidisciplinary research at the intersection of technology and marketing. Based on the bibliometric analysis, a network visualization of the most frequently cited authors within the sample of articles was then created. Only authors who were cited in four or more publications were included in the analysis.

Fig. 3: Citation network of co-cited authors



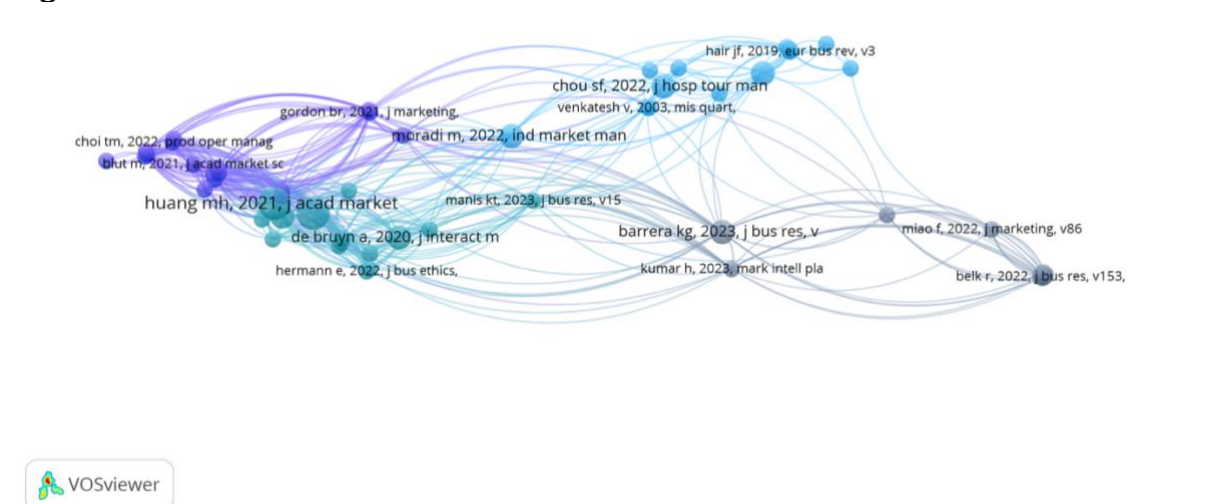
Source: own processing using VOSviewer software

The visualisation (Fig. 3) reveals four thematic clusters representing key research directions in the field of digital marketing.

- **The purple cluster** brings together authors (e.g., Choi, T.M.; Gordon, B.R.; Moradi, M.; Blut, M.) focusing on strategic marketing, brand management, and service innovation.
- **The blue cluster** (Venkatesh, V.; Hair, J.F.; Chou, S.F.) focuses on technology adoption, user behavior modeling, and quantitative methodology.
- **The turquoise cluster** (Huang, M.H.; De Bruyn, A.; Wirtz, J.) emphasizes the topics of customer experience, interactivity, personalization, and marketing ethics, with Huang as the central linking author.
- **The grey cluster** (Belk, R.; Kumar, H.; Miao, F.) brings cultural, value, and behavioural perspectives and addresses the social aspects of consumption and algorithmic marketing.

The second visualization (Fig. 4) shows the network of *co-cited* publications and includes sources cited in at least three cases. The output shows the basic literary framework of the field under investigation and confirms its interdisciplinary nature.

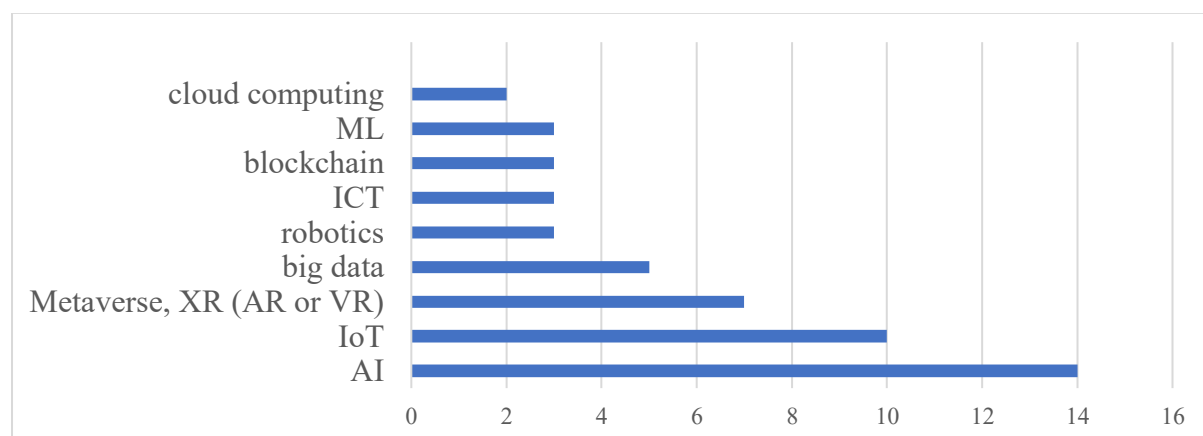
Fig. 4: Citation network of co-cited sources



The visualization of the co-cited sources (Fig. 4) reveals four key thematic clusters.

- **The purple cluster** includes papers (Gordon, 2021; Choi, 2022; Moradi, 2022; Blut) focused on strategic marketing, digital innovation, and service optimization.
- **The blue cluster** represents the methodological pillars of consumer behavior research, including the TAM model (Venkatesh, 2003), PLS-SEM (Hair, 2019), and the contributions of Chou, S.F.
- **The turquoise cluster** includes resources focused on customer experience, value, and ethics (e.g., Huang, 2021; De Bruyn, 2020; Wirtz).
- **The grey cluster** (e.g., Belk, 2022; Miao, 2022) reflects the cultural, ethical, and behavioral dimensions of marketing in the context of digitalization.

Fig. 6: Technologies ranked by the number of articles in which they are the subject (or one of the subjects) of research



Source: own processing using VOSviewer software

As the chart in Figure 6 suggests, the authors focus most on artificial intelligence, followed by the Internet of Things and metaverse (whether VR, AR, or XR). Big data has a fairly prominent presence, and robotics, blockchain, and cloud computing are mentioned the least, but still repeatedly. Based on the findings from the literature search, the practical part of the study focuses on a deeper understanding of the use of modern technologies in marketing through qualitative research among Czech marketing professionals. The aim is to reveal what technologies they use in practice, how they perceive their benefits and limitations, and how they reflect on the ethical, cultural, and contextual aspects of technological transformation in their local environment. Through semi-structured interviews with ten experts in marketing, data analytics, and business strategy, several thematic categories emerged that reflect the complexity of technology adoption, the changing role of traditional marketing, and the ethical dimension of digital transformation.

The empirical phase employed qualitative methods through semi-structured interviews with ten purposively selected experts in marketing, strategic management, and data analytics. Selection criteria prioritised demonstrable expertise in deploying advanced marketing technologies within medium and large enterprises. The cohort encompassed a heterogeneous spectrum of organisational scales and market segments, ranging from SMEs to large corporations, and included agency founders, executive managers, senior consultants, media strategists, and independent specialists. Sectoral representation covered creative design, digital strategy, media planning, performance marketing, and AI-enabled advertising. The extended respondent profile includes the name, surname, company affiliation, and job description, providing essential context for data interpretation and a deeper understanding of the participants' professional perspectives (Nováková, 2025).

The use of technology in Czech marketing practice. In their responses to the first question (see Tab. 3), respondents almost uniformly mentioned the daily use of digital platforms and tools for automation and analysis. Nine of them (R1- R9) work daily with cloud solutions, big data, and language models (custom GPT, Perplexity, Gemini, or internal LLM). Technologies such as big data

(R2-R9), cloud computing (R1-R4, R6-R9), and process automation through no-code platforms (e.g., Make.com - R9), scripts or ad hoc tools (R3) appear repeatedly in respondents' answers. R6 also mentions the use of robotics and Daktel's CCaaS solutions in the context of workflow standardization. Complementary technologies include IoT and eye-tracking (R4, R7-R8), used for multimodal analysis of customer behavior, and the internally developed SeLLMa model (R6) for advanced data analytics. Across the responses, a consensus is emerging on the day-to-day operational role of cloud services, artificial intelligence, and data tools, with individually variable add-ons depending on specialisation.

Tab. 3: Technologies used in the respondent's profession

Category/Technology	Number or	Respondents	Note / Examples
Language models / artificial intelligence	9	R1-R9	E.g., custom GPT, Perplexity, Gemini, Chat GPT, AI models
Big Data / Big Data	8	R2-R9	8 out of 9 respondents mention working with big data
Cloud/Cloud computing	6	R1, R2, R4, R5, R6, R7, R8	Explicitly mentioned as cloud, cloud computing or CCaaS
Data platforms and warehouses, Data processing software	5	R4, R5, R7, R8, R9	R4 - Easy Life data platform, R9 - Make.com no-code platform, statistical software
IoT, sensors, and audio matching	3	R4, R7, R8	Audio matching is performed via sensors and The information is transmitted via IoT
Eye tracking/eye cameras	3	R4, R7, R8	Mentioned in connection with heatmaps
Machine Learning (ML)	2	R2, R4	R2 and R4 more specifically referred to ML
Automation / Robotics	2	R3, R6	Process standardisation
API, scripts	2	R3, R9	Ad hoc scripts, API integration, and scripts to learn AI models

Source: own processing

In response to the second research question (see Tab. 4), respondents consistently identify artificial intelligence, particularly language models, as a core component of contemporary marketing (R1-R3, R7-R9), used to automate, generate content, and personalize messages. Big data analytics also remains a key tool for targeting campaigns and predicting customer behaviour (R2-R5).

Respondents emphasize the use of advanced platforms for predictive analytics and data integration, such as EasyLife (R4), as well as the deployment of internal language models and robotics for process standardization (R6). The consensus is that the synergistic integration of AI, data sources, and cloud services is a key enabler for effective

management of marketing campaigns. They identify personalization of the digital environment through dynamic web elements and algorithmic content customization as the most prominent trend (see Tab. 5) (R1). Custom GPT solutions enabling instant appointment transcription and technical language transformation (R2), or advanced AI agents with memory and basic autonomy (R3), are also finding application.

Tab. 4: The most essential technologies for marketing

Category / Technology	Number resp.	Respondents	Note / Examples
AI and language models	7	R1, R2, R3, R6, R7, R8, R9	E.g., use for graphics, creative process; text generation, strategy, translation, dictation, and transcription of conversations
Analytical tools/links data sources and work big data	3	R3-R5	Big data analytics, specifically, e.g. Easy-life interface (also suitable for predictions)
Machine learning	2	R2, R9	Listed as a recommendation tool offers, personalization
Sensors, an eye-tracking	2	R3, R4	
Automation	2	R3, R9	

Source: own processing

Tab. 5: Current technology trends considered to be the most significant

Category / Trend	Number or	Respondents	Note / Examples
Expanding the use of agents, assistants and robots	5	R2, R3, R6, R8, R9	Assistants for communication, robots for solving query-solving robots, machines combining databases for addressing customers
Content customization, personalization and personalization	3	R1, R4, R7	Automatic addition of descriptions under products, Epsilon platform for creating marketing personas, look-alike cookies
Technical language translation (custom GPT, support)	2	R2, R3	Custom GPT for customer queries, conversion technical language
Data merging, integration data platforms and forecast modules	2	R4, R7	EasyLife, merging data from different sources for easier use
Creative use of AI (generation of visuals)	1	R5	Generating visuals and support in inventing campaign

Source: own processing

Large-scale projects are dominated by the use of data-driven platforms (e.g., EasyLife, Epsilon) to benchmark and create marketing personas (R4), while the creative area works with AI-generated visuals and tools supporting campaign conception (R5). Other identified trends include the use of robotic assistants in customer care, prompt engineering, automated content summarization (R6), data merging and look-alike cookies (R7), and database linking for targeted outreach on LinkedIn (R8). Respondent R9 states that the concept of metaverse does not currently show practical relevance in the Czech marketing context. Respondents agree that automation and AI tools significantly increase efficiency and allow redirecting capacities to strategic activities. For example, a task that used to require 60 hours of programming is now completed in 30 minutes thanks to LLM (R3), while AI can generate advertising copy in minutes (R8).

Tab. 6: Barriers and challenges associated with technology implementation

Barrier categories	Number or	Respondents	Note / Examples
AI hallucinations/error rate	4	R3, R6, R7, R8	Problem with unreliability of AI outputs
Need for human validation and control	3	R1, R2, R4	Need for supervision and manual intervention when using AI
Problems with data quality	3	R2, R5, R9	Data preparation, lack of quality data, need for data pipelines
Financial constraints/investment costs	2	R3, R5	Higher investment for the implementation of specialized solutions
Data protection and contractual security	1	R4	Need for signed contracts, NDAs, and staff training

Source: own processing

Respondents also mention the impact of AI on creative outputs (R1, R5), automated communication summarisation (R6), and closing the gap between marketing professionals' experience (R9). The main barriers to technology implementation (see Tab. 6) are identified by some respondents as the lack of good quality and consistent data (R9), the so-called hallucination of AI, and the need for human validation of outputs (R2, R3, R6). Another barrier is the lack of trust and low willingness to adopt new tools (R1, R3), which some respondents address through training and internal education programs (R1, R4).

Respondent R2 stresses the critical importance of data preparation and building data pipelines as a prerequisite for effective use of AI, while R6 adds that it is essential to know the technological limitations and adapt internal processes to their operational compatibility. On the issue of personalisation and targeting (see Tab. 7), respondents agree that these activities are dependent on the synergy of big data and machine learning. R1 gives the example of grammatical modification of name addressing in emails to increase relevance, while R2 uses the Prophet model to predict purchase behavior and

optimize the site according to user segmentation. R3 and R9 apply RFM analysis and historical data for customer value and behavioral profiling.

Tab. 7: Use of technology for personalization, targeting, and prediction

Usage category	Number resp.	Respondents	Note / Examples
Personalisation and targeting with AI and ML	5	R1, R2, R3, R4, R8	E.g., personalization of emails, offers, and auction advertising space for immediate targeting
Predicting purchases, campaign success rates using large data and ML	4	R2, R3, R4, R6	Using Prophet, optimizing websites for internal analysis, finding trends and correlations based on data
Creating personas and targeting based on data	3	R3, R7, R9	Using customer data to create personas and target campaigns, RFM analyses, and the MML-TGI data set
Relying on advertising systems (S-click, Meta...) and their algorithms	2	R5, R8	Use of existing advertising systems with frequency and estimates, relying on the correct settings of their algorithms

Source: own processing

Respondents describe advanced personalization approaches based on a combination of data sources and automation. R4 combines anonymized sales data with video monitoring for real-time targeting at the point of sale; R7 uses MML TGI to create personas; R8 relies on algorithms from Meta and Google platforms to dynamically personalize campaigns. R6 introduces internal analysis of emails and calls to detect trends or employee performance potential. The most common risk is identified as GDPR breaches and misuse of personal data. R2 and R5 highlight the need for legal compliance, including proper cookie settings and client education; R3 highlights the legal risks associated with uploading personal data to LLM in light of the EU AI Act. R4 notes that regulatory requirements are slowing down opportunities for deeper personalisation, while R6 warns of the unclear labelling of AI chatbots and the risk of inadvertently sharing sensitive data; R7 highlights the risk of uncritical reliance on AI predictions, while R9 calls for respecting ethical limits, such as the prohibition of targeting by health status. All respondents agree that the processing of personal data must be transparent, lawful, and ethically sustainable to avoid legal and reputational impacts. The findings confirmed that Czech marketers are increasingly integrating technologies such as artificial intelligence, big data analytics, and automation tools into their daily activities. AI-driven personalisation was identified as the most commonly used feature, particularly in the areas of customer segmentation, product recommendation tools, and automated customer communication. Respondents emphasized the role of machine learning in improving the accuracy of targeting and content delivery (Cheng et al., 2023; Yeh et al., 2025).

While larger companies exhibited a higher degree of technological maturity, several mid-sized companies reported that they had limited resources when implementing more advanced tools, especially those that require significant data infrastructure or integration with legacy systems. Cloud computing, which offers scalable and cost-effective access to

computing resources, has often been cited as a means to overcome these limitations (Vemula et al., 2025; Zhang et al., 2023). Internet of Things (IoT) applications have so far been rare in the Czech context, but have been noted as an emerging area in retail and logistics, especially in inventory tracking and customer behaviour monitoring (Javaid et al., 2021). Augmented and virtual reality (AR/VR) solutions were seen as promising but underutilized due to high implementation costs and limited customer readiness.

Interviewees consistently reported that the use of data-driven tools and artificial intelligence had significantly changed their approach to marketing strategy. Campaigns are no longer based solely on intuition or experience, but increasingly rely on predictive analytics and behavioral modeling (Lessmann et al., 2021). Several respondents cited the ability to create dynamic, hyper-personalised content as a competitive advantage that increases customer satisfaction and conversion rates. Personalization strategies are primarily implemented through customer data platforms (CDPs), CRM systems, and dynamic email automation. Marketers stressed the importance of handling data ethically, noting that customers are increasingly sensitive to how their information is used. They shared concerns that excessive personalization can lead to perceptions of tracking or manipulation unless transparency and consent are ensured (Alijoyo et al., 2025; Lo & Campos, 2018).

Findings also show that traditional marketing practices have not been completely displaced. Rather, they coexist with digital methods in a hybrid model. Offline campaigns, emotional storytelling, and personal relationships remain key, especially in B2B marketing and in industries where digital adoption is still lagging. Respondents noted that digital tools enhance rather than replace traditional approaches by enabling more precise targeting and performance tracking (Kotler et al., 2021; Fam et al., 2024). Some participants expressed concerns about over-reliance on automation and algorithms, arguing that the human element in marketing - empathy, creativity, and contextual judgement - is irreplaceable and increasingly valuable in an AI-dominated environment (Scholda et al., 2023; Ngo et al., 2025).

A major theme identified in the research is the growing awareness of ethical issues associated with the use of technology. Respondents were aware of emerging legal frameworks such as the General Data Protection Regulation (GDPR) and the EU Artificial Intelligence Act, and several companies were actively adapting their practices to comply with these regulations (Book, 2024; Sultana et al., 2016).

The main ethical issues include:

- Ensuring data transparency and customer consent.
- Avoiding algorithmic bias in targeting and recommendations.
- Establishing clear accountability in automated decision-making.

Several marketers highlighted the need for internal guidelines and ethics training to complement legal compliance. While some firms have developed formal codes of ethics for digital marketing, others have relied on informal standards and managerial discretion.

3. Discussion

The findings of this study confirm that the integration of digital technologies into marketing practice is not a transient trend, but a major structural transformation with implications for the strategic and operational levels of marketing management. The results reflect the current scientific consensus that artificial intelligence, big data, and automation technologies represent the core of innovation processes about customers, optimization of communication strategies, and decision rationality (Kotler et al., 2021; Plangger et al., 2022). Empirical data reveal a significant correlation between technology adoption rates and firm competitive performance. Firms that have been shown to integrate predictive analytics and AI-based personalization mechanisms report increased efficiency at all stages of the customer cycle, from acquisition to retention (Guhl et al., 2024; Lessmann et al., 2021; Scholdra et al., 2023). These findings support the thesis that digital marketing enables firms to move from generic outreach to individualized interactions, thereby significantly increasing ROI.

At the same time, the adoption of these technologies appears to be uneven, with medium-sized firms in particular facing significant barriers in terms of resourcing, technological infrastructure, and professional capacity (Surur et al., 2025). These differences reflect a known asymmetry in the pace of digital transformation outside of multinational settings. The interviews also revealed a tension between technological automation and human creativity. Interviewees repeatedly expressed the belief that despite the high analytical capacity of AI, human judgment remains crucial, especially in the context of interpreting ambiguous situations, emotional signals, or culturally conditioned behaviors. These findings are consistent with the concept of augmented marketing, where AI is seen as a support tool, not a replacement for human decision-making structures (Kotler et al., 2021; Horng et al., 2022). Especially in areas such as dynamic ad targeting or price optimization, over-reliance on algorithmic decisions without human supervision can lead to ethical failures (Alijoyo et al., 2025). Thus, the study highlights the need to maintain a balance between performance rationality and ethical judgment.

The theme of the ethics of working with data resonated across all responses. Respondents emphasised the need for transparent, fair, and lawful handling of personal data, which corresponds with increasing regulatory requirements and public expectations (Sultana et al., 2016; Hanneke, 2024). Although existing legislation (e.g., GDPR and the upcoming AI Act) provides a framework, compliance with legal standards alone is insufficient - companies should actively build internal ethics policies, audit mechanisms, and accountability architecture (Horng et al., 2024). Ethical digital marketing thus becomes not only a compliance issue, but a strategic imperative and a key element of reputation management (Fam et al., 2024). Furthermore, research shows that digital and traditional marketing are not in a relationship of substitution but of complementarity. Hybrid models, integrating human creativity and digital capabilities, are expressions of the new marketing normal. This approach is in line with the "Marketing 5.0" paradigm, which promotes technological maturity linked to a human-centric value framework (Kotler et al., 2021).

Future-ready marketing strategies are likely to be characterized by a high degree of adaptability, technological-ethical balance, and an emphasis on the integration of data analytics, emotional intelligence, personalization, and transparency (Plangger et al., 2022; Alijoyo et al., 2025). The main limitations of this study include the limited scope of the respondents, the qualitative design, and the geographic anchoring of the research in a specific national context (the Czech Republic, 2024-2025), which limits the generalizability of the findings. Nonetheless, this work provides valuable insights into the real-world practice of digital marketing and makes a significant contribution to understanding the current challenges of technological transformation. Due to the formal limitations of a conference paper, only the most relevant sources are listed in the reference list, although the systematic review included a wider range of scholarly publications.

Although this study is anchored in the Czech business environment, its findings have potential applicability across other Central and Eastern European (CEE) markets, such as Slovakia, Poland, and Hungary. These economies share comparable structural characteristics, including the prevalence of SMEs, gradual digital transformation trajectories, and similar regulatory pressures under EU frameworks such as the GDPR and AI Act. The observed patterns of technology adoption, barriers related to infrastructure and expertise, as well as the hybridisation of traditional and digital marketing practices, are therefore likely to be relevant beyond the Czech Republic, while still requiring adaptation to local cultural and market conditions.

Conclusion

This study presents a systematic and multi-layered analysis of the impact of current digital technologies on marketing practice in the Czech business environment. By combining a systematic literature review with qualitative research among practitioners, the paper provides a robust understanding of how technologies such as artificial intelligence, big data, the Internet of Things, blockchain, augmented and virtual reality, and cloud computing are redefining marketing management paradigms. The findings empirically confirm that digital technologies no longer serve only a supporting function, but are a structural pillar of marketing strategies. Tools based on artificial intelligence and machine learning enable advanced personalization, data-driven decision making, and process automation, thereby fundamentally transforming customer interaction, campaign optimization, and brand value creation (Kotler et al., 2021; Guhl et al., 2024). At the same time, however, work highlights asymmetries in the ability to adapt, particularly for SMEs, which face limits in technological infrastructure, human resources, and organisational readiness (Surur et al., 2025; Yasar et al., 2025).

A crucial dimension that emerges from the research is the question of ethical integration of technology into marketing practice. With the growing influence of algorithmic decision-making structures, there is increasing pressure for transparency, privacy, and responsible management of the risks associated with personalisation. Legal regulation (e.g., GDPR or the EU AI Act) forms the necessary minimum here, but real trust and legitimacy can only be maintained by businesses through proactive ethical frameworks and value-anchored leadership (Mukhopadhyay et al., 2024, 2025; Sultana et al., 2016; Alijoyo et al., 2025).

The convergence of traditional and digital approaches to marketing is also an important conclusion. The work confirms the relevance of so-called hybrid models that combine human creativity with algorithmic efficiency and correspond to the concepts of "augmented marketing" or "marketing 5.0" (Kotler et al., 2021). This integration is particularly relevant in industries where customer experience, storytelling, and emotional engagement retain strategic weight (Fam et al., 2024).

Based on the analysis, several managerial recommendations can support the effective and sustainable integration of digital technologies into marketing practice. Foremost is the ethical adoption of technologies through internal guidelines ensuring transparency, fairness, and compliance with regulatory frameworks such as the GDPR and AI Act. Equally vital is investment in scalable digital infrastructure, including cloud-based and modular solutions, to bridge capacity gaps, particularly in SMEs. Leveraging artificial intelligence for personalised, value-driven communication, combining machine learning capabilities with human oversight, can enhance relevance while safeguarding customer trust. Finally, adopting hybrid marketing models that balance the efficiency of digital tools with human creativity can optimise operational performance and strengthen emotional brand connections.

The study makes an important contribution to the debate on the digital transformation of marketing in the Central European context. It opens up new research lines, especially in exploring algorithmic accountability, culturally conditioned technology acceptance, and the hybridization of human and artificial decision-making in marketing processes. Future research should also analyse the impact of these technologies on customer value creation, loyalty, and ethical credibility of brands in the long run. For practitioners, the article offers concrete guidance: successful digital transformation does not only require technological investment, but above all a change of mindset towards an interdisciplinary, ethically grounded, and customer-centric approach. In conclusion, the future of marketing will be defined by the ability to balance between performance rationality and human empathy, between automation and value anchoring. Companies that manage this complexity strategically and ethically will gain a decisive competitive advantage in the digital marketing era.

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Adoption of Artificial Intelligence Tools in Small Enterprises in the EU and the Czech Republic: Barriers, Opportunities and Implications for Marketing Strategies

Abstract

This paper focuses on analyzing the adoption rate of artificial intelligence (AI) tools in small enterprises in the Czech Republic and the European Union. It utilizes secondary quantitative data from Eurostat databases, the Czech Statistical Office, and other relevant sources. The aim is to identify current trends, cross-country differences, and key factors influencing small businesses' decisions to implement AI technologies, with an emphasis on their application in marketing. The findings show that despite growing interest in AI technologies, their adoption among small firms remains low. While 41% of large enterprises in the EU implemented at least one AI tool in 2024, only 12% of small enterprises did so, and in the Czech Republic, the figure was just 9%. This confirms the persistent digital divide between companies of different sizes and highlights the potential decline in small firms' competitiveness. The main barriers to the adoption of AI technologies include high costs and a lack of expertise. The analysis includes correlation and regression analysis, which demonstrated a statistically significant relationship between the level of employee training in information and communication technologies and the level of adoption of AI technologies in small enterprises. Small firms most often implement more accessible tools focused on natural language generation, text analysis and automated customer support. The paper also provides an overview of possible support measures, which can contribute to more effective implementation of AI technologies in marketing and other business processes of small enterprises.

Key Words: Small Enterprises, Artificial Intelligence, Marketing, Digital Transformation, AI Barriers

JEL Classification: C21, R13

Introduction

Small and medium-sized enterprises (SMEs) make a significant contribution to the European Union (EU) economy. In 2024, approximately 26.1 million companies were registered, employing a total of 89.4 million people and accounting for approximately 99.8% of all business entities, which generated almost 52% of total added

value (Eurostat, 2025a). In terms of business categorization, micro-enterprises with fewer than 10 employees dominate. In 2024, there were 1.38 million small enterprises employing between 10 and 49 people registered in the EU (European Commission, 2003; Eurostat, 2025a). Small and medium-sized enterprises also play a key role in the Czech Republic. According to data from the Czech Statistical Office, there were 1.3 million micro-enterprises, 62,257 small enterprises, and 16,625 medium-sized enterprises registered in 2024. Currently, small businesses face a number of challenges related to digital transformation, particularly when it comes to implementing AI technologies, due to their size and limited capacities.

Although the adoption of AI technologies in the EU and the Czech Republic is growing significantly across all categories of businesses, large enterprises still show the highest rate of AI use. In 2024, at least one AI tool was adopted by 41.2% of large enterprises in the EU, while only 11.2% of small enterprises did so (Eurostat, 2025a). Data from the Czech Republic confirms a similar trend. AI technology was used by 40.5% of large enterprises (ČSU, 2024), but only 8.7% of small businesses, which often lack the necessary financial resources, technological infrastructure, and internal expertise (European Commission, 2003; OECD, 2024). These figures confirm the persistent digital divide between companies of different sizes, which can lead not only to a loss of competitiveness, but also, on a broader scale, to negative impacts on the overall performance and economic development.

The aim of this paper is to analyze the adoption rate of AI technologies in small enterprises in the Czech Republic based on secondary data and to compare the situation with other EU member states. The study maps the types of AI tools used, focusing on marketing applications and identifying key barriers that prevent wider practical application.

The research questions were defined:

1. How does the rate of adoption of AI technologies in small enterprises vary across EU countries and what is the situation in the Czech Republic?
2. What specific AI tools are used by small enterprises in the Czech Republic and the EU for marketing purposes, and how are they being applied?
3. Which factors influence the decision of small businesses to use AI in their marketing activities?

The answers to these questions can contribute to a deeper understanding of current trends and provide a basis for support measures, training programmes and recommendations for small businesses seeking effective digital transformation in both marketing and other business activities.

1. Methods of Research

The study is based on quantitative secondary analysis, with the main data sources being:

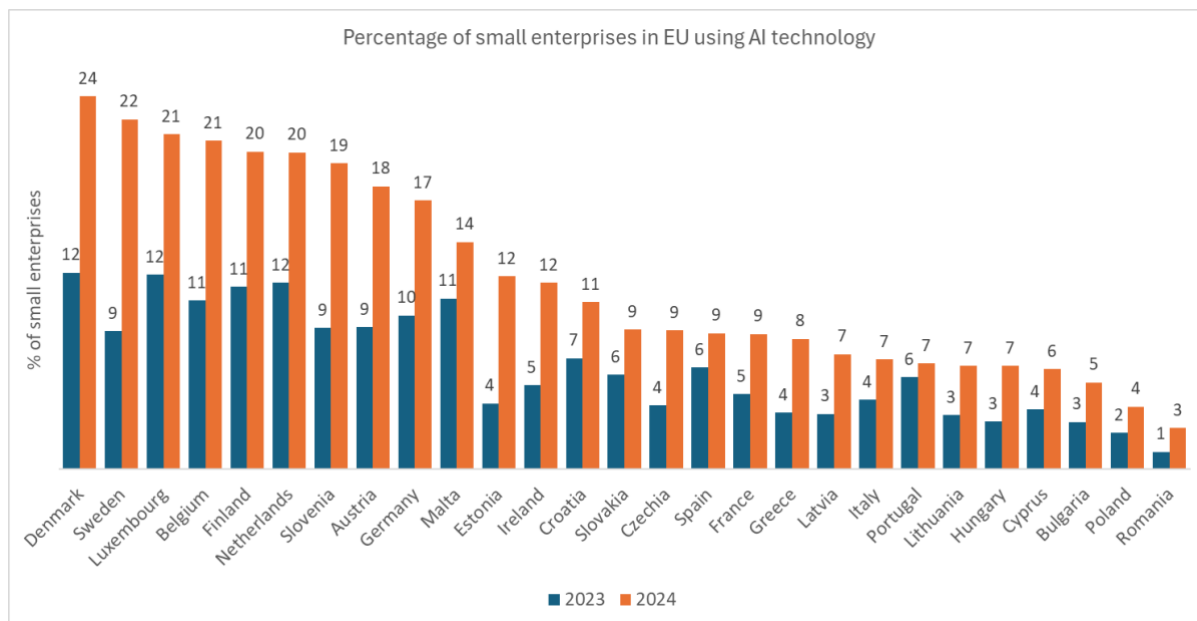
- Eurostat - "Digital Economy and Society Statistics" module (2023-2024)
- Czech Statistical Office (CZSO) - data on business demographics and ICT usage in enterprises
- European Commission - categorisation of enterprises and other expert studies (European Commission, 2003)
- OECD expert studies and other expert articles published in international scientific journals focused on artificial intelligence, marketing and SMEs.

The study primarily focuses on the second category of enterprises: small enterprises with 10–49 employees. This classification is based on Commission Recommendation 2003/361/EC (European Commission, 2003). The analysis is based on the most recent secondary data available, which is from 2024 or, in some cases, 2023. Descriptive statistics and bar charts are used to present the results comparing the adoption of AI technologies in the Czech Republic with that in other EU countries. The data represent the percentage of small businesses, which used at least one AI tool in a given year. The research question focusing on identifying the barriers using AI in small businesses was answered based on a systematic review of professional articles and studies on AI, marketing and SMEs that have been published in recent years. Furthermore, a correlation analysis was performed to test the hypothesis that there is a relationship between the level of ICT training of employees and the adoption of AI tools in small businesses. Due to the abnormal distribution of the variable 'Used AI' (Shapiro–Wilk test, $p = 0.013$), Spearman's coefficient was chosen. To examine the impact of ICT training on the use of AI technology, an ordinary least squares (OLS) model with robust standard errors was created. The data were analysed using Microsoft Excel and the statistical software GRETL.

2. Results of the Research

Significant regional differences in the adoption of AI by small businesses can be seen across the EU. Denmark (24%), Sweden (22%) and Luxembourg (21%) have the highest adoption rates, while Romania (3%), Poland (4%) and Bulgaria (5%) lag behind. With a value of 9% (8.7%), the Czech Republic is below the EU average and significantly behind Western European leaders. This shows different levels of digital readiness and economic conditions for the use of AI (see Fig. 1). Despite a 5% increase in the number of small businesses compared to 2023, the Czech Republic still ranks 15th out of 27 EU countries. As illustrated in Table 1, the mean value for 2023 was 6.53%, while in 2024 it increased almost twofold to 12.03%. The maximum value, which reached 12.37% in 2023 (in Denmark), rose to 23.52% in 2024, with Denmark remaining the leader in AI technology adoption for the second consecutive year. The lowest adoption rates were recorded in Romania. In 2023, the value was 1.07%, rising to 2.57% in 2024. The increasing standard deviation in 2024 (6.28 compared to 3.40 in 2023) points to growing inequality in AI implementation across member states.

Fig. 1: Significant differences in the adoption of AI by small enterprises in the EU – Denmark is a leader, the Czech Republic is below average.



Source: own elaboration based on Eurostat 2025

Tab. 1: Descriptive statistics on the adoption of AI by small businesses in the EU

	Number	Mean	Max	Min	Standard deviation
2023	27	6.53	12.37	1.07	3.40
2024	27	12.03	23.52	2.57	6.28

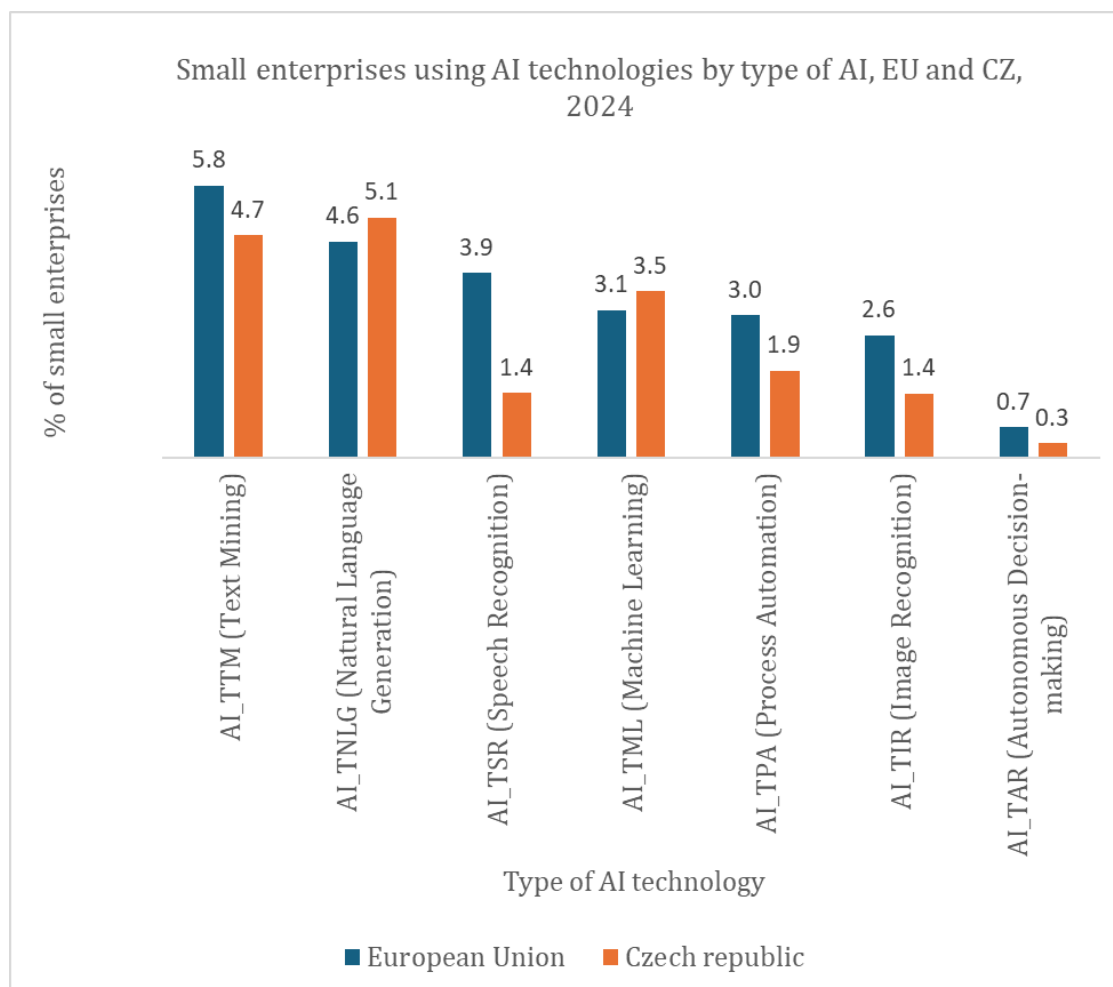
Source: own elaboration based on Eurostat 2025

Tab. 2: Classification of AI tools

AI_TTM	Text Mining	Performing analysis of written language
AI_TSR	Speech Recognition	Converting spoken language into machine-readable format
AI_TNLG	Natural Language Generation	Generating written or spoken language
AI_TIR	Image Recognition	Identifying objects or persons based on images, image processing
AI_TML	Machine Learning	Machine learning, e.g. deep learning for data analysis
AI_TPA	Process Automation	Automating different workflows or assisting in decision making
AI_TAR	Autonomous Decision-making	Enabling physical movement of machines via autonomous decisions based on observation of surroundings.

Source: own elaboration based on Eurostat 2025

Fig. 2: Differences in the use of specific AI tools by small enterprises in the EU and the Czech Republic – Text Mining and Natural Language Generation are the most common.



Source: own elaboration based on Eurostat 2025 and CZSO 2024

Eurostat and the Czech Statistical Office (ČSU, 2024; Eurostat, 2025b) provide data on the use of AI technologies in business environments, based on a survey of companies. The survey monitors seven main categories of AI tools (see Tab. 2). Within the EU, AI_TTM technology was the most widespread among small enterprises (5.8%), primarily used for text data analysis. In the Czech Republic, the proportion was slightly lower (4.7%), with AI_TNLG (5.1%) dominating and focusing on content generation (4.6% in the EU) (see Fig. 2). Both tools are relatively accessible and do not require significant initial investment, which is important for small businesses. A significant difference can be seen with the AI_TSR (speech recognition) tool. It was used by 3.9% of small businesses in the EU compared to just 1.4% in the Czech Republic. AI_TAR is the least widespread technology, as its implementation is more capital and technology-intensive. The reported percentage values include the use of AI across all business activities of companies. According to Eurostat data, in 2024, approximately 34% of small enterprises that utilised AI technologies in their operations did so for marketing and sales purposes (ČSU, 2024;

Eurostat, 2025b). In marketing, small businesses primarily use generative AI (AI_TNLG), text mining (AI_TTM), machine learning (AI_TML) and process automation (AI_TPA).

The low adoption rate of AI technologies in small businesses is usually the result of a combination of economic, technological, organisational and socio-psychological factors (Maroufkhani et al., 2020) (see Tab. 3).

Tab. 3: The key barriers to the adoption of AI in small businesses

Barrier	Brief description
Financial constraints	There are high initial costs for software and infrastructure, as well as maintenance, and limited financial resources.
Lack of expertise	There is a shortage of IT specialists, and the ability to interpret data and manage AI models is limited.
Low digital literacy	Staff have limited digital skills for working with AI tools.
Data protection and cybersecurity	There are concerns about legal risks (GDPR), system security and the potential for data breaches.
Ethical and social aspects	There are concerns about customer manipulation, personalisation without consent, and a resulting loss of trust.
Lack of trust in technology	There are concerns about the quality of outputs, return on investment, and the measurability of AI effectiveness.

Source: own elaboration

An overview of the key barriers to the adoption of AI technologies in small businesses was created based on the professional literature (Borges et al., 2021; Cubric, 2020; Maroufkhani et al., 2020; Wamba-Taguimdje et al., 2020). The analysis examined the hypothesis that there is a statistically significant relationship between the level of ICT training among employees and the level of use of AI tools in small businesses. For each country, two values were obtained: the percentage of small businesses that had provided ICT training to their employees, and the percentage of those businesses that used at least one AI tool ($n = 27$). The hypotheses were formulated as follows:

(H₀): *There is no statistically significant relationship between the level of ICT training and the level of AI use in small businesses.*

(H₁): *There is a statistically significant relationship between the level of ICT training and the level of AI use in small businesses.*

The data were processed using the GRETl statistical system. First, the distribution of the two continuous, quantitative, ratio variables was verified. The normality test showed that the independent variable (the proportion of small businesses training employees in ICT) has a normal distribution (Shapiro-Wilk $p = 0.68$), whereas the dependent variable (the proportion of small enterprises using AI) does not (Shapiro-Wilk $p = 0.013$). Therefore, Spearman's correlation coefficient was used for the correlation analysis. The results

revealed a moderately strong positive correlation ($\rho = 0.523$; $p = 0.005$), indicating that a greater emphasis on ICT training is linked to a greater adoption of AI technology.

$$\rho = 1 - \frac{(6 * \sum d^2)}{(n * (n^2 - 1))} = 1 - \frac{(6 * 1562)}{(27 * (27^2 - 1))} = 0.523 \quad (1)$$

where ρ is Spearman's correlation coefficient, $\sum d^2$ is the sum of the squares of the differences in rank, and n is the number of pairs of values.

Linear regression analysis was performed using Gretl to quantify the relationship between the variables. First, an ordinary least squares (OLS) model was used, and its assumptions were checked. While the normality of the residuals was confirmed using a chi-squared test ($\chi^2(2) = 2.391$; $p\text{-value} = 0.30249$), autocorrelation was detected using the LM test ($LM = 4.189398$; $p\text{-value} = 0.040678$). Consequently, the OLS model with robust errors (HC1) was used. The resulting model has the following form:

$$\text{Used AI} = 2.0369 + 0.5482 * \text{ICT training} \quad (2)$$

where:

Used AI is the dependent variable, representing the percentage of small enterprises using AI technologies in 2024,

2.0369 is the intercept,

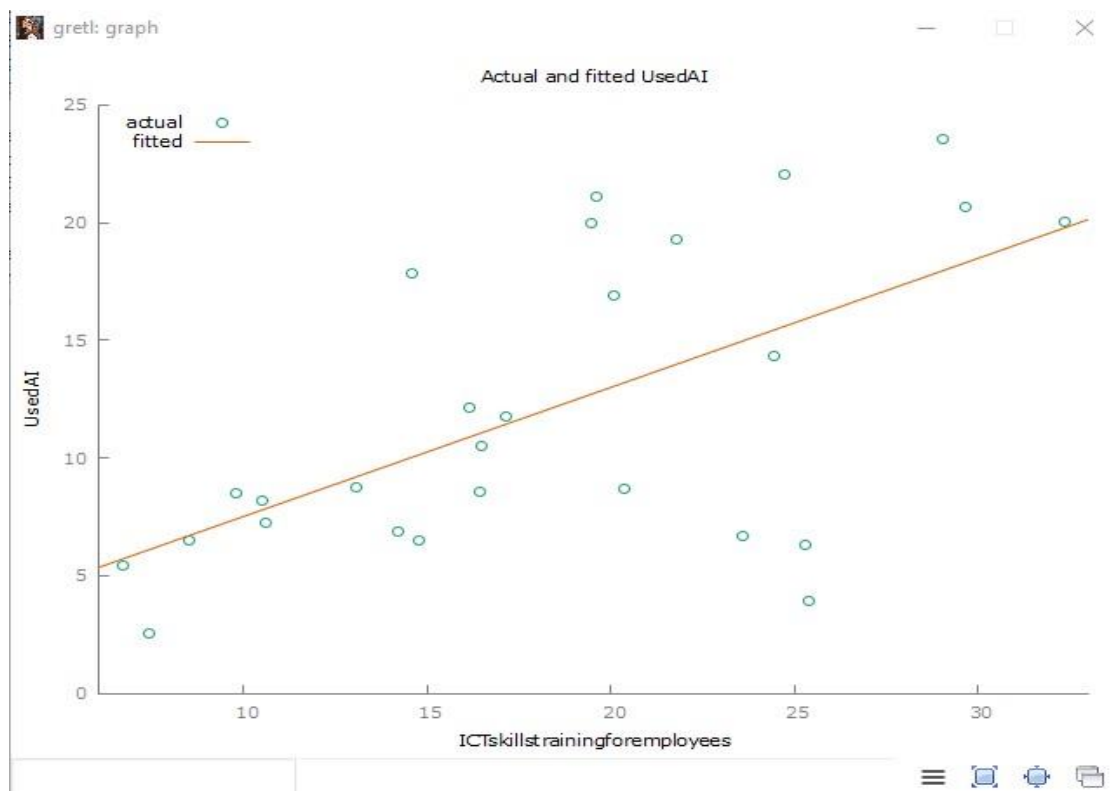
0.548 is the estimated regression coefficient for the ICT training variable,

ICT training is the independent variable, representing the percentage of small enterprises that provided ICT training to employees.

This model demonstrates that ICT training has a statistically significant impact ($\beta = 0.548$; $p = 0.002$). It explains 36.6% of the variability in AI use among EU member states ($R^2 = 0.366$). The F-value (1.25) = 19.73 ($p = 0.00016$) indicates that the model as a whole is statistically significant. The obtained values can be interpreted as follows: if no companies trained their employees in ICT, we would expect the average use of AI to be around 2.04%. Each 1 percentage point increase in the proportion of companies providing ICT training to their employees is associated with a corresponding increase in the proportion of companies using AI of around 0.55%.

Based on the results of the correlation and regression analysis at a 5% significance level, we can reject the null hypothesis and conclude that there is sufficient evidence for the alternative hypothesis (H_1). *There is a statistically significant relationship between the level of ICT training and the level of AI use in small businesses.* Figure 3 illustrates the relationship between the degree to which artificial intelligence (AI) tools are used in small enterprises and the proportion of small enterprises that train employees in ICT. The regression line shows the dependence trend of the data.

Fig. 3: Statistically significant relationship between ICT training and AI adoption in small enterprises across the EU.



Source: own elaboration by GRETL

3. Recommendations for Marketing Strategy

In marketing, integrating AI into business management can directly impact customer satisfaction, sales and small businesses' competitiveness. Newly emerging generative AI tools, such as ChatGPT and Canva, represent a relatively unexplored area with significant potential. Given their resource constraints, small businesses should prioritize AI tools with high value and low complexity. These criteria are met, for example, by AI_TNLG and AI_TTM technologies, which are most commonly used in the Czech Republic (Fig. 2). Using generative AI for creating texts for websites, social networks, emails, and chatbots allows small businesses to maintain high-quality content without the need to hire large marketing teams (Leung et al., 2015).

For small businesses, the gradual adoption of AI technologies is advisable, depending on employees' level of expertise. Companies can start by automating routine tasks, such as customer support via chatbots and then move on to data-driven applications, including demand forecasting and inventory optimization (AI_TML, AI_TPA). More advanced predictive models can then support decision-making in marketing campaigns and pricing strategies. Based on data analysis and professional literature (Kühl et al., 2020; Leung et

al., 2015; Tang et al., 2015; Theodoridis & Gkikas, 2019) recommendations for adopting AI technologies in marketing by small businesses have been compiled (see Tab. 4).

Tab. 4: Recommendations for the adoption of AI in marketing strategies for small enterprises.

AI Application Area	Brief description	Main AI Technologies
Content Generation	Automated creation of website content, social media posts, emails, and chatbot dialogue.	AI_TNLG, AI_TTM
Customer personalization and segmentation	Analysing data to personalise offers based on customer behaviour, preferences and feedback.	AI_TML , AI_TPA
AI-assisted social media marketing (AISMM)	Maintain a continuous online presence and automate customer interactions and real-time feedback processing.	AI_TNLG, AI_TSR, AI_TPA
Demand forecasting and inventory optimization	Predictive analytics for demand forecasting and inventory management.	AI_TML

Source: own elaboration

The statistically significant relationship between the level of ICT training and the rate of AI adoption ($\beta = 0.548$; $p = 0.002$) confirms that the successful implementation of these technologies is closely related to the development of employees' digital competencies. Therefore, investment in training, continuous upskilling and collaboration with external experts should be essential components of any long-term strategy (Basri, 2020). When implemented effectively, AI technology enables companies to reduce marketing costs, increase campaign effectiveness, gain a better understanding of customers and respond more flexibly to market changes. Ultimately, these effects translate into revenue growth and improved overall business performance (Chatterjee et al., 2023; Singla et al., 2023).

4. Discussion

The results of the analysis confirm that the rate at which small enterprises in the Czech Republic adopt AI technology remains significantly lower than in many other EU member states, with differences between countries widening further in recent years. While the adoption rate ranges between 20% and 24% in Nordic and Western European countries such as Denmark and Sweden, it reached only 8.7% in the Czech Republic in 2024. (Eurostat, 2025b). This development is related to not only the level of digital literacy, but also the financial capabilities of small businesses, the availability of support services and government policy. The barriers identified in this study align with findings from previous research (Cubric, 2020; Maroufkhani et al., 2020; Wamba-Taguimdje et al., 2020). The statistically significant relationship between ICT training for employees and AI adoption rates highlights the importance of education as a key factor in supporting the digital

transformation of small businesses. Additionally, concerns have been raised about the ethical implications of using AI in marketing, as well as occasional scepticism regarding the advantages of these technologies. (Borges et al., 2021; Wamba-Taguimdje et al., 2020). In line with the results of previous studies (Eloundou et al., 2023; Erdil & Besiroglu, 2024; Parteka & Kordalska, 2023) it can be concluded that AI's contribution to overall productivity growth is limited. This is particularly true in areas where the benefits of technology are difficult to quantify, and where human factors and complex decision-making processes are important, such as working with people, management, and creative activities. Nevertheless, there is considerable potential for further development, particularly with regard to ensuring more equal access to data, education, and investment resources (Erdil & Besiroglu, 2024; OECD, 2024). In the field of marketing specifically, small businesses can use AI tools that offer high returns despite relatively low investment requirements. This analysis shows that the most commonly implemented tools are natural language generation (AI_TNLG), text mining (AI_TTM), machine learning (AI_TML) and process automation (AI_TPA) technologies. These technologies enable companies, for example, to create personalised content, predict demand and streamline customer support (Leung et al., 2015; Chatterjee et al., 2023; Singla et al., 2023). From a practical implementation perspective, it is recommended that AI is adopted for marketing activities gradually, starting with the automation of routine tasks and moving towards the introduction of advanced analytical tools.

This study is limited by the use of secondary quantitative data, the availability and structure of which are somewhat restrictive. Not all EU Member States provide data to the same extent, and some data is only available in aggregate form. For example, in the Czech Republic, data on the number of employees by enterprise category was only available for 2023. Another limitation is the possible differences in data collection methodologies between countries, which may affect the international comparisons that can be made. Moreover, the quantitative approach does not allow for the capture of subjective experiences, attitudes, and motivations of companies, which play an important role in decisions about AI implementation. For a deeper understanding of this decision-making process, it would be appropriate to follow up with qualitative research, for example in the form of in-depth interviews with owners or managers of small businesses, or by conducting case studies. These approaches could provide more detailed insight into the context in which companies decide for or against the use of artificial intelligence technologies.

Conclusion

The introduction of AI technologies presents a significant opportunity for small businesses in the EU and the Czech Republic to increase their efficiency and competitiveness. However, there is still a pressing need to remove ongoing barriers to accessing finance, expertise and infrastructure. The further development of AI adoption will depend on targeted support measures and the establishment of a stable regulatory environment. Only then will small businesses be able to keep pace with large companies and the dynamic developments expected in the field of AI. As (Erdil & Besiroglu, 2024) point out, *„It is difficult to rule out explosive growth from AI, but that this should happen is*

far from certain". To fully exploit the potential of AI in small enterprises, it is essential that policymakers, business support organisations and educational institutions cooperate.

Acknowledgment

The ChatGPT artificial intelligence tool was used for language editing. It was not used for expert analysis or as a source of content.

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Digital Marketing Risks for Aging Populations: The Threat of Online Scams to Older Adults

Abstract

This study provides a systematic concept of how digital marketing practices intersect with the older adults' vulnerability to financial digital scams and misleading online advertisements. Although digital platforms offer convenience, they are also used to deliver deceptive content that exploits the cognitive, emotional, and technological limitations. Following the PRISMA methodology, over 230 articles from Web of Science database in 2000-2025 period were initially screened. After applying inclusion and exclusion criteria based on relevance, language (English), peer-review status, and topical focus, 87 studies were included in the analysis. The majority of the selected studies originated from the United States (41%), China (14%), and Japan (8%). Interest in the examined topic has gradually increased over time, with a notable peak in 2024. The results suggest that older adults face growing threats from deceptive digital marketing, worsened by low digital literacy, cognitive decline, and limited awareness of online risks. Although financial and educational digital scams remain common, emotional manipulation has become more frequent through personalized targeting. The findings highlight the need for stronger policy frameworks, improved digital education, and ethical standards in online advertising to better protect vulnerable consumers.

Key Words: Digital Marketing Risks, Older Adults, Deceptive Digital Marketing, Vulnerable, Financial Digital Scams

JEL Classification: M31, O33

Introduction

Digital marketing has transformed how goods and services are promoted and consumed, using data-driven personalized targeting, algorithms, and data tracking. However, these innovations have also brought new risks – especially for older adults who may lack the digital skills or cognitive agility to spot fraudulent or misleading content (Burnes, 2017; DeLiema, 2018). Older adults are increasingly online, often using platforms like Facebook, YouTube, and Google to stay informed and connected. This makes them frequent targets

for digital fraud, phishing, and manipulative ads (Hanoch et al., 2017). Unlike younger, digitally native consumers, many older individuals struggle to interpret online messages, recognize deception, or manage digital security tools (Watanabe, 2016). According to a report by the U.S. Consumer Financial Protection Bureau (CFPB, 2019), seniors lose billions of dollars annually to financial digital scams – much of happening online. Yet most cases go unreported, often due to fear, stigma, or shame. Research by Lichtenberg et al. (2016) shows that even small financial losses can hit older adults hard, given their fixed incomes and limited ability to recover. This review looks at why and how older people are more vulnerable to online scams, both financial and consumer-related. It integrates a systematic literature review with bibliometric analysis to understand the scale, focus, and direction of research in this area.

1. Methods of Research

The objective of this systematic review is to uncover the extent, patterns, and implications of deceptive digital marketing risks affecting aging population. A systematic review was conducted in accordance with PRISMA guidelines, utilizing the Web of Science (WoS) database recognized for its comprehensive and peer-reviewed academic content across various disciplines. The search strategy focused on two key thematic areas: (1) the visual representation of deceptive digital marketing risks affecting the elderly, and (2) the research trends and patterns observed over the review period. To capture studies relevant to both themes, the search query incorporated a combination of keywords drawn from each domain, namely::

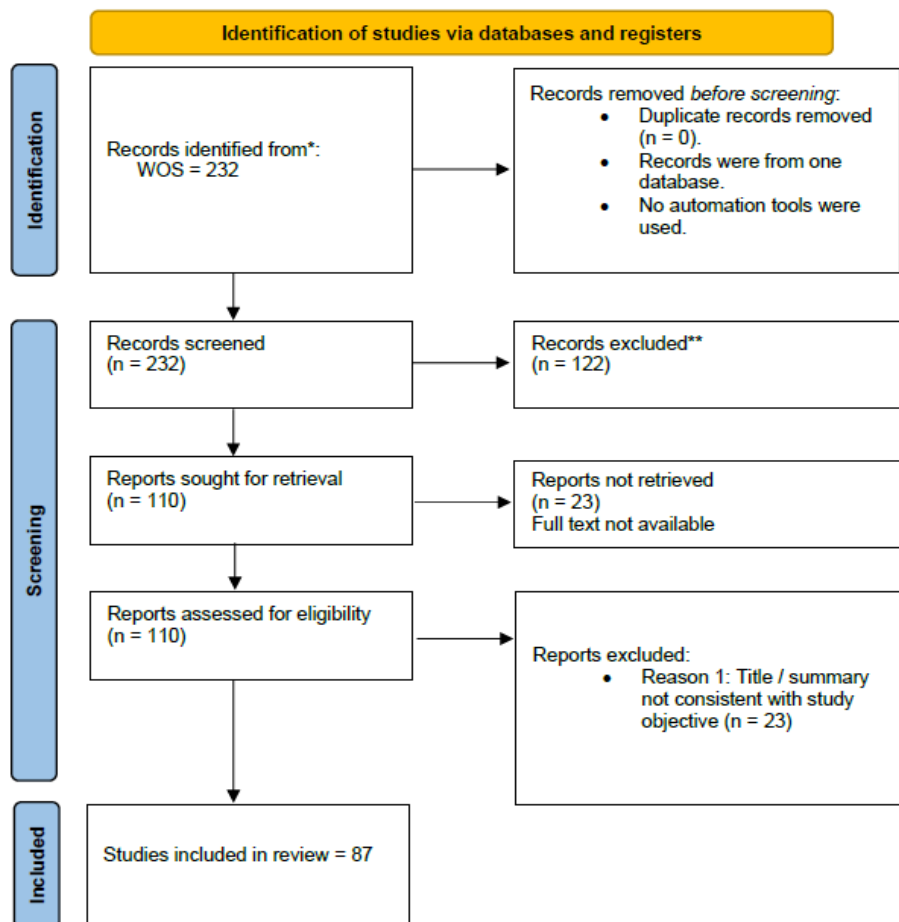
("deceptive digital marketing" OR "online advertising" OR "social media marketing") AND ("elderly" OR "older adults" OR "senior citizens") AND ("financial scams" OR "fraud" OR "deceptive ads").

The final search was completed on 25 June 2025. To maintain the rigor and relevance of this systematic review, a comprehensive and structured search strategy was implemented. The search produced an initial dataset of 1,057 records. These entries encompassed a broad range of publications related to deceptive digital marketing, digital scams risk, and the older adults population. A keyword filtering phase was first applied to refine the dataset based on topic relevance. This process reduced the total number of records to 232 by excluding studies that were clearly unrelated based on title and indexed keywords. Subsequently, a detailed inclusion and exclusion screening was conducted. To be eligible for inclusion, studies had to meet several predefined criteria: they must have been published between the year 2000 and the first quarter of 2025, be written in English, and appear in peer-reviewed journals. Most importantly, the selected studies had to focus on individuals aged 60 and above, and explicitly examine the relationship between digital marketing activities such as social media promotions, email campaigns, or online advertising and exposure to financial digital scams or deceptive digital content.

Studies that failed to meet these requirements were excluded. Opinion based works (e.g., editorials, commentaries, and opinion pieces) were removed, as were studies that did not directly focus on the elderly demographic. Additionally, any literature that addressed general

digital literacy without linking it to risk or deception, as well as non-peer-reviewed or duplicate publications, was excluded from further consideration. From the original amount of 1,057 record we specifically excluded: in the stage of identification 97 duplicates (*identical conference or journal publication*), in the stage of screening 728 studies (*214 not focused on older adults, 186 not directly addressing digital marketing risks, 328 non-empirical studies as opinions, news reports and policy briefs*), in the stage of retrieval 122 studies as not available in full-text, and in the stage of eligibility 23 studies (*7 due to lack of methodological detail, 4 due to insufficient relevance to research objectives, 10 due to focus on general fraud without age-specific analysis, 2 due to in-accessible translation*).

Fig 1: PRISMA flow diagram



Source: Authors own processing based on PRISMA template (Prisma, 2021)

After the application of these stringent criteria, a total of 87 studies were deemed eligible and retained for full-text review and systematic analysis. This final dataset forms the foundation for the current investigation into the digital vulnerabilities of aging populations and the systemic responses to deceptive digital market risks. The entire process of study identification, filtering, and selection is documented in accordance with

the PRISMA guidelines (Page et al., 2021). A corresponding flow diagram (Figure 1) visually represents each phase of the selection process.

The reviewed studies demonstrate a diverse methodological landscape (Table 1) in addressing digital marketing risks among older adults. Quantitative methods were used in 32 studies, offering statistical insights, while 17 studies adopted qualitative approaches to explore personal experiences and perceptions. A notable 38 studies employed mixed methods, combining both data-driven and narrative analysis to provide a holistic understanding.

In terms of research orientation, 46 studies were empirical, grounding their findings in direct data collection and observation. Theoretical contributions were made by 17 studies, which offered conceptual frameworks for understanding digital scam susceptibility. Case study methods were prominent in 61 studies, showcasing real-world examples of fraud victimization or deceptive digital marketing. Additionally, 26 studies used survey-based techniques to capture behavioral patterns and attitudes. Together, this methodological variety underscores the complexity of risks faced by older adults and the value of integrating multiple research strategies to inform effective interventions.

Tab. 1: Methodologies and Research Approaches in the reviewed studies

Category	Subcategory	Number of Studies
Methodology	Quantitative	32
	Qualitative	17
	Mixed Methods	38
Approach	Case Study	61
	Empirical	46
	Survey-Based	26
	Theoretical	17

Source: Authors' processing

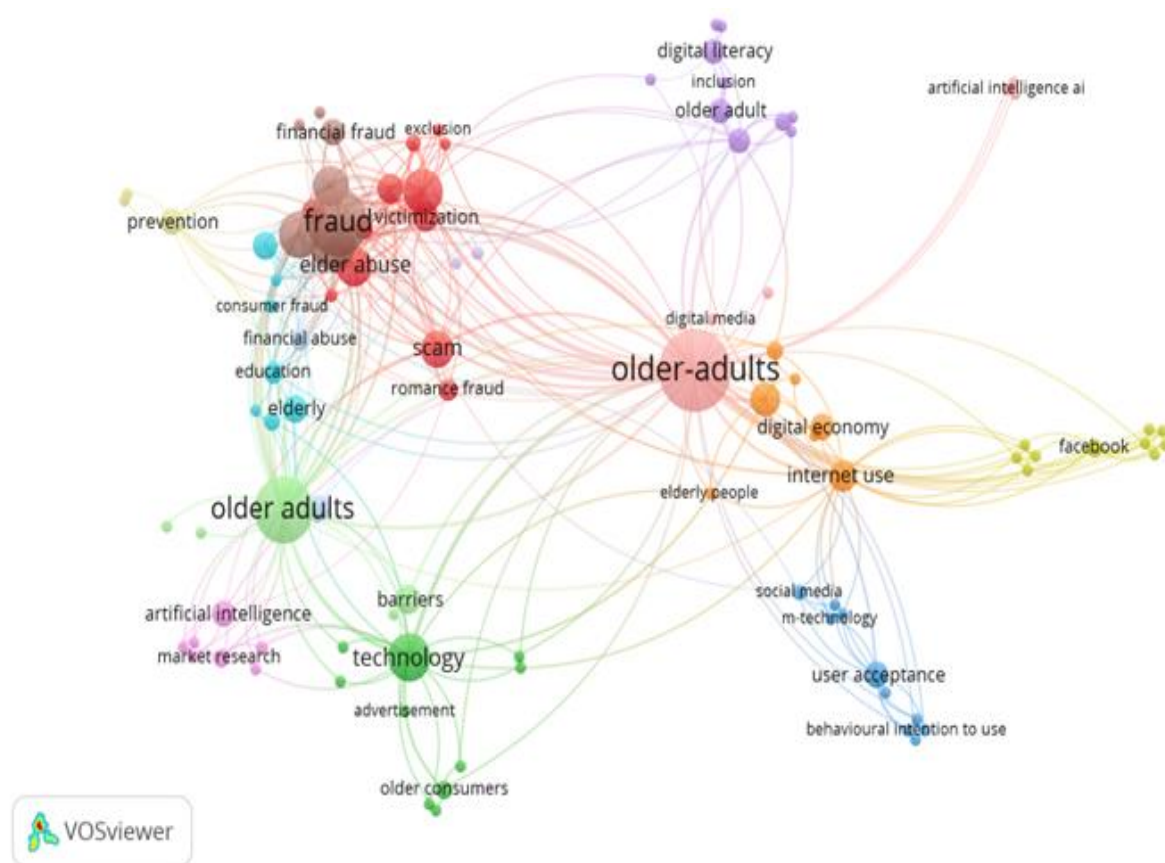
2. Results of the Research

To deepen the understanding of scholarly trends in deceptive digital marketing risks affecting older adults, a keyword co-occurrence analysis was conducted using VOSviewer (Fig 2). This bibliometric tool identifies and visually maps the relationships between frequently occurring terms, offering the conceptual structure in the field. In the resulting visualization, each node represents a keyword extracted from the analyzed publications. The size of the node corresponds to the frequency of the keyword appears, while connecting lines (edges) indicate co-occurrence within the same articles. The spatial proximity of nodes reflects the strength of association, with closer terms typically sharing thematic or conceptual overlap. Color-coded clusters group together keywords that from distinct thematic areas, enabling the identification of dominant research directions and subfields. As shown in the figure, the main clusters include fraud victimization (brown and red), older adults and their relationship with technology (green), their involvement in the digital economy (pink and orange), digital literacy (purple), and social media (blue).

Fraud Victimization as a Core Theme. One of the most prominent clusters, highlighted in red, centers on fraud victimization. This theme reflects the primary academic concern with online scams targeting older adults. Its strong presence in the network indicates growing scholarly attention to financial exploitation and scam vulnerability among aging populations. The intensity and size of this cluster suggest that fraud remains a cornerstone in the literature on deceptive digital marketing risks faced by older adults.

Older Adults and Technology. A major cluster represented in green is associated older adults and technology use. This area explores how digital platforms serve as a channel for marketing to seniors. While digital engagement can support inclusion and access, it also introduces risks due to the absence of adequate digital safeguards. The frequent co-occurrence of these terms illustrates sustained research interest in how technological interaction may increase vulnerability among older adults.

Fig 2: VOSviewer visualization



Source: Authors own processing based on VOSviewer

Older Adults Participation in the Digital Economy. Pink and orange clusters emphasize terms like digital media and digital economy, reflecting the growing role of older adults in online economic environments. As seniors engage more with digital marketplaces, they are increasingly exposed to targeted marketing tactics – some of which may be

manipulative or deceptive. The prominence of these terms signals a critical area of inquiry: the economic impact of digital inclusion on aging population.

Digital Literacy as a Protective Factor. The purple cluster focuses on digital literacy, underscoring the widely acknowledged link between limited digital skills and increased fraud vulnerability. Research consistently shows that improving digital competence among older adults is essential for reducing susceptibility and supporting safer online behaviour.

Social Media With Dual Function. Finally, the blue cluster highlights social media usage among older adults. This theme reflects the complex role of social platforms: they enable connection, information sharing, and active participation in digital spaces. On the other hand, it also acts as a conduit for fraudulent schemes often via deceptive digital advertisements or AI-driven content designed to manipulate emotions or trust. The close relationship between social media and digital scam-related keywords signals that this platform is a critical area for both risk and intervention.

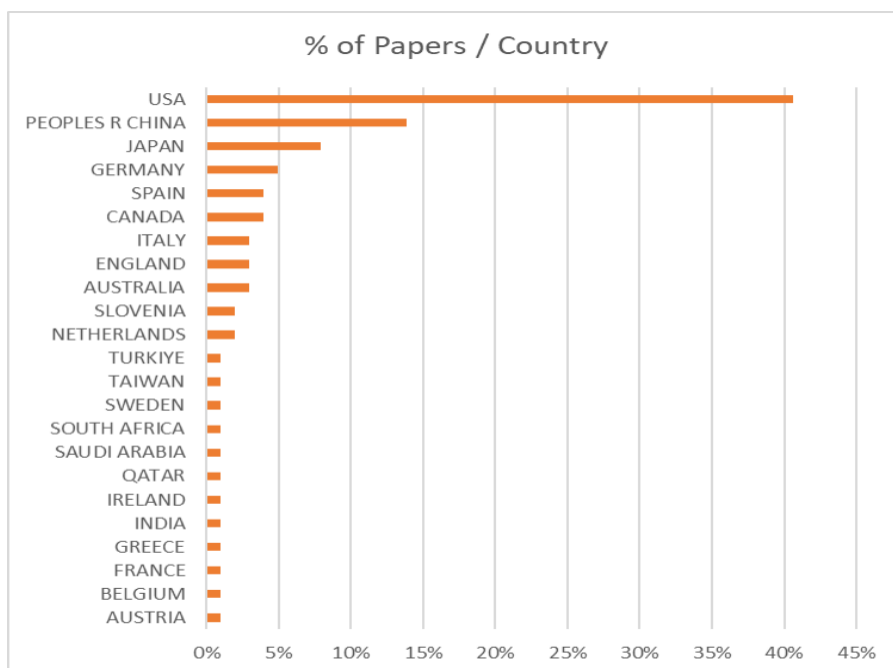
Overall, the keyword map highlights digital scams as a central concern, while also showing how related themes – such as digital literacy, technology and economic participation, and social media use – shape broader landscape of digital vulnerability among older adults. These findings underline the importance of combining protective measures with inclusive digital engagement strategies.

Figure 3 shows a significant concentration of research on digital marketing risks among older adults in the United States, which accounts for over 40% of all studies. China and Japan follow, though with much smaller shares. Most other countries, including several in Europe, Australia, and parts of Asia, contribute minimal proportions. This imbalance suggests a lack of global representation, indicating a research gap in regions like Africa, the Middle East, and South America. Expanding studies in these underrepresented areas is crucial for developing more inclusive and globally relevant insights.

Figure 4 illustrates the temporal development of research on digital marketing risks among older adults between 2000 and 2025. Annual publication counts remained relatively low until around 2015, after which interest began to rise, reaching a current peak. The cumulative number of studies has grown significantly since 2015, approaching 90 publications by 2025.

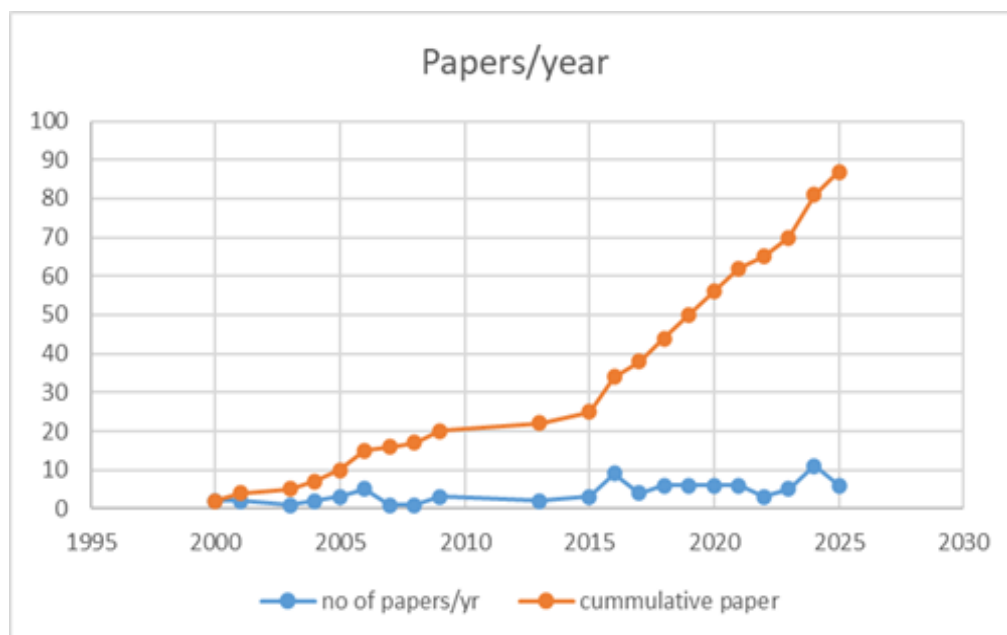
Similarly to previous trends, also Figure 5 representing the number of publications and citations shows that the field of marketing risk on aging population has matured significantly over the past decade. From a relatively obscure topic, it has transformed into a highly active and impactful research area, especially since 2015. The high number of citations demonstrates the significant contribution and relevance of this research to understanding and addressing the vulnerabilities faced by older adults in marketing contexts. The current year's data (2025) should not be seen as a decline but rather as an ongoing accumulation of research output and impact

Fig 3: Percentage of publication per country



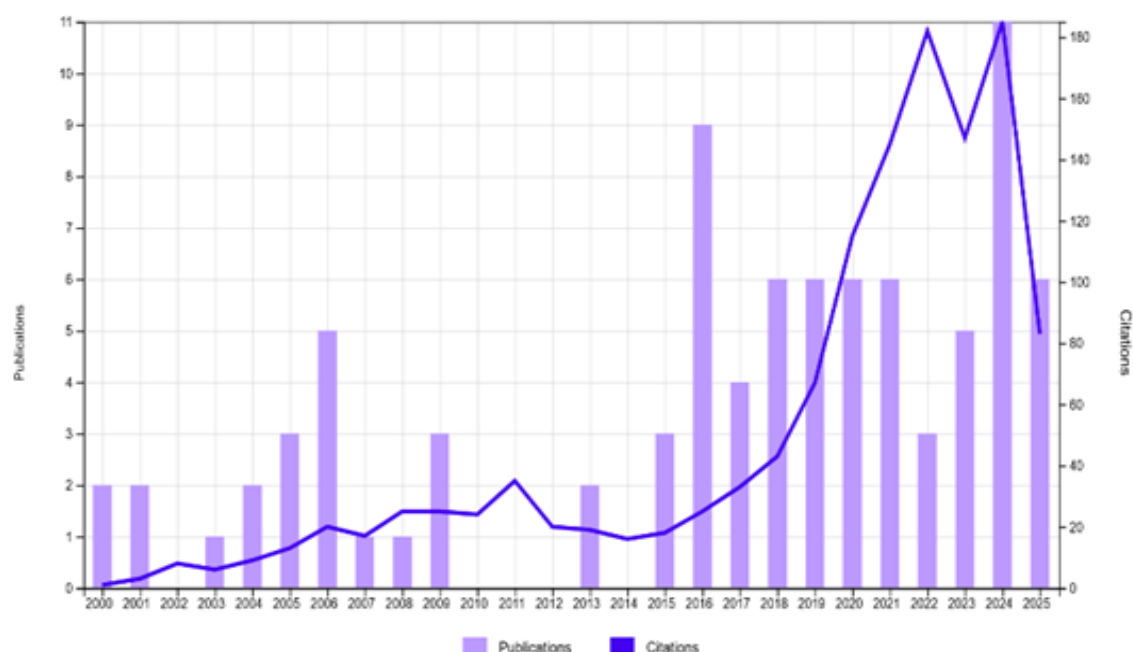
Source: Authors own processing using MS Excel

Fig 4: Number and cumulative count of publications (2000–2025)



Source: Authors own processing using MS Excel

Fig 5: Publication / citations by year (2000–2025)



Source: Web of Science

3. Discussion

This review highlights a growing public health concern: older adults face significant risks from deceptive digital marketing. These ones are compounded by low awareness of online fraud, limited digital skills, and cognitive decline. While educational and financial digital scams remain widespread, emotionally manipulative schemes – such as romance scams – are becoming increasingly common due to personalized targeting and algorithmic content delivery. AI and social media further complicate detection and response. As the global population ages, older adults are becoming more active in digital spaces, where they encounter both opportunities and risks. Our review of currents research literature brings several following important domains which should be carefully addressed in future.

Psychological and Cognitive Vulnerabilities. Older adults are often targeted by scammers due to a factors such as low technological awareness, cognitive decline, social isolation, emotional vulnerability, and high levels of social trust (Hanoch 2007; Ueno, 2016). These make them more susceptible to digital scams tactics like persona targeting and social engineering, where scammers impersonate trusted institutions or individuals.

Cognitive decline, particularly dementia, impairs financial judgement and increases vulnerability (Ueno et al., 2021; Watanabe, 2016). Tools such as the Alzheimer's Disease Assessment Scale – Japanese Cognitive version (ADAS-Jcog) and psychological profiling methods have been proposed to identify high-risk individuals. Emotional factors including loneliness, fear of aging, and low self-efficacy further reduce critical thinking and can lead to risky online behaviour in search of emotional comfort (Moschis 2003).

Educational and Technological Interventions. Digital literacy and financial education are effective in reducing scam vulnerability, particularly in rural and low-income communities with limited access to support (Miller 2024; Alwanain 2020). Broader strategies include digital education programs and technology-based tools such as AI-driven scam detectors, phishing awareness campaigns, and interactive games. Emotion-focused and trust-based interventions help older adults build emotional resilience and confidence, enabling them to better recognize and resist manipulation.

Health-Related Fraud Risks and Detection Tools. Older adults are vulnerable to health fraud, often believing unverified product claims in pursuit of emotional comfort and well-being. Poor judgement in assessing product authenticity frequently leads to exploitation (Alves, 2008).

To address this, researchers have developed analytical pipelines and verification tools for detecting healthcare and food-related digital scams. These improve authentication and reduce likelihood of failing. Advanced AI techniques – such as GANs, neural networks, and supervised learning – have been applied to detect Medicare and healthcare fraud involving older adults (Naidoo & Marivate, 2020; Bauder & Khoshgoftaar, 2018). However, their effectiveness depends on proper model selection and threshold tuning, and progress is limited by lack of transparency and publicly available datasets. *Social Vulnerability and Support Systems.* Older adults with limited social networks, low education, poor adaptation to aging, or single marital status are more susceptible to fraud (Çelikkanat et al., 2024; Nguyen et al., 2013). Support systems that strengthen community ties and reduce isolation can help, but must be paired with financial literacy training to improve digital financial management. Scammers exploit these vulnerabilities through investment fraud, health scams, phishing, and telemarketing – often using predictable patterns and channels like the darknet or traditional postal systems (Lazarus et al 2025).

Legal Barriers and Policy Challenges. Despite advances in detection, digital scam prevention faces systemic barriers. Low reporting rates, complex legal processes, and frequent misclassification contribute to its persistence (Aplin, 2022; Carey et al., 2018). Mandatory reporting laws exist in some jurisdictions, but with mixed results. There is a clear need for legal frameworks tailored to digital fraud, along with training for healthcare workers, police, and other frontline professionals to improve identification, reporting, and victim support. *The Role of Trust and Interface Design.* A key factor in digital marketing scams is the exploitation of user trust on service platforms, especially in ecommerce and online healthcare. Older users are particularly at risk when platforms lack transparency or user-friendly design (Chen et al., 2025; Dodd, 2017). Poor UI/UX design can lead to confusion, mistaken clicks, and an inability to distinguish legitimate services from malicious ones. Reducing these risks requires regulation and age-sensitive design, including clear labeling, simplified navigation, and secure authentication.

This study has several limitations. First, it includes only English-language publications indexed in the Web of Science database, which may exclude relevant findings from other regions or sources. Second, older adults were often treated as a homogeneous group, despite differences in age, background, and digital experience. Lastly, the rapidly changing nature of digital marketing and fraud tactics may limit the long-term applicability of the findings. An additional limitation is the geographic imbalance in existing research. Most of the researched studies originates from high-income regions such as North America, Western Europe, and parts of East

Asia, while Africa, Latin America, and Eastern Europe remain underrepresented. Older adults in these regions may face distinct vulnerabilities shaped by lower digital literacy, uneven internet access, region-specific technologies, and varied cultural and socio-economic context. Moreover, the regulatory protections and reporting practices also differ widely, influencing both scam prevalence and detection.

Conclusion and Implications

Older adults are increasingly targeted by misleading digital advertisements and scams, posing serious threats to their financial and psychological well-being. This systematic review reveals significant associations between low digital literacy, cognitive vulnerability, and susceptibility to online fraud. Protective measures such as policy reform and targeted digital education are essential to safeguarding aging populations in the digital environment. The findings align with previous research showing that older adults often struggle to distinguish between sponsored content and genuine information (Hanoch et al., 2017). The digital divide – both in access and literacy – plays a central role. Older adults are less likely to use ad blockers, check URLs, or verify the legitimacy of offers (Tamut & Dutta 2024). Moreover, manipulative advertising techniques such as urgency cues, fake testimonials, and visual deception often escape their attention.

There is an pressing need for regulatory bodies to develop and enforce ethical guidelines that limit deceptive digital marketing targeting older consumers. Community-based digital literacy programs, including those run by AARP and local libraries, can play a vital role in equipping with critical digital skills (Perera 2025, Watanabe, 2016). Future research should include longitudinal and intervention-based studies to assess the long-term effects of digital marketing on older consumers. Greater focus is also needed on culturally diverse populations and platform-specific vulnerabilities, including the implications of emerging technologies like AI and virtual reality.

Acknowledgment

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Regulation of the So-Called Sharing Economy in Accommodation Services in the Context of Negative Externalities

Abstract

This paper investigates the impact of regulatory measures on the short-term accommodation sector within the sharing economy, with a focus on the challenge of mitigating negative externalities. Using comparative analysis, the study examines Germany—a country that has introduced increasingly strict regulations—and the Czech Republic, which lacks systemic regulatory controls. Drawing on data from Eurostat, STR Global, and Czech statistical offices, the research applies Pearson's correlation coefficient to assess the relationship between the number of short-term rental offers in both countries between 2018 and 2025. The results show a statistically significant and strong positive correlation, indicating that Germany's regulatory measures have not led to a meaningful reduction in the supply of short-term rentals. The discussion explores potential explanations for this limited effectiveness, such as circumvention by providers, enforcement challenges despite high fines, and the structural underinvestment in affordable rental housing that regulation does not address.

Moreover, while local measures such as registration requirements and annual limits may offer some control, they often fail to prevent market adaptation. The findings highlight the complexity of managing negative externalities in the sharing economy and question the sufficiency of regulation as a standalone policy instrument. The paper concludes that effective solutions require a coordinated approach combining improved data sharing, local enforcement capacity, and broader housing policy reforms. Without these complementary measures, regulatory efforts risk remaining largely cosmetic, offering only limited and temporary mitigation of the negative externalities associated with short-term rentals.

Key Words: Sharing Economy, Short-Term Rentals, Negative Externalities, Regulation

JEL Classification: L83, R31

Introduction

The sharing economy in accommodation services offers financial benefits for property owners but also generates non-economic consequences in the form of so-called negative externalities. A negative externality occurs when an individual or group does not bear the full cost of their actions without being penalised, shifting these costs to other actors (Mankiw, 1999). In short-term rentals, this issue is especially pronounced because the costs are not directly created by the provider but by the guest, typically someone temporarily residing in a property. In practice, conflicts arise between long-term residents and short-term guests. These groups have different preferences, and problems often revolve around noise, lower maintenance standards, and similar issues. There are essentially two approaches to addressing negative externalities in economic practice: private and public solutions. The private approach is based on the Coase theorem, assuming costless negotiation and space for agreement. The second option is regulation, grounded in A. C. Pigou's concept of externality taxation (Mankiw, 1999). In the sharing economy, regulation has become the dominant approach. The aim of this paper is to assess the impact of regulations on the volume of short-term rental offers in the sharing economy. First, the situation in the Czech Republic is described, followed by a comparison with Germany, chosen as a suitable comparator.

1. Methods of Research

The research focuses on comparing the number of short-term rental offers using data from Eurostat (short-stay rentals, number of stays, occupancy), STR Global (number of stays and occupancy in traditional markets), and the Czech Statistical Office (general data about accommodation). The comparison is performed via Pearson's correlation coefficient, testing significance with the hypotheses:

H0: $\rho = 0$

H1: $\rho \neq 0$

We assume at a 5% significance level ($\alpha = 0.05$) that there exists a statistically significant correlation between the two time series, which are the number of short-term rental offers in Germany (first series) and the Czech Republic (second series) between 2018 and 2025 (data for 2025 available until March).

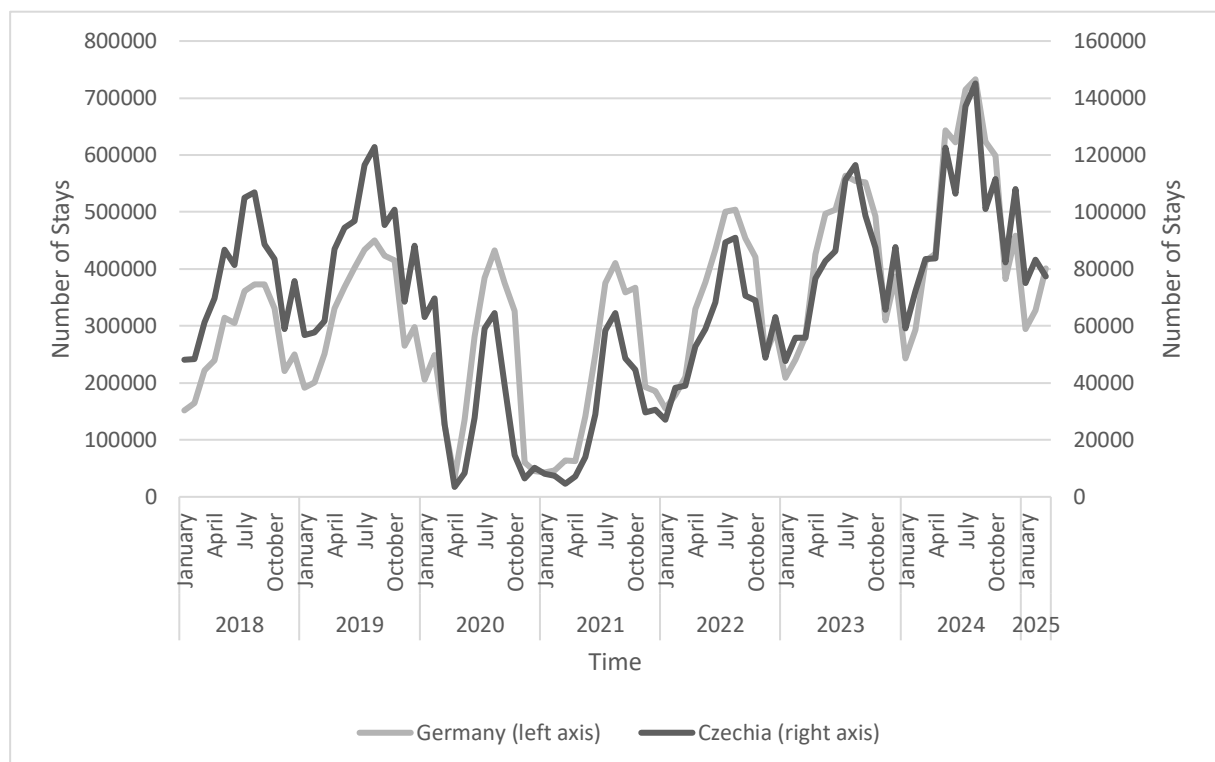
2. Results of the Research

In early 2022, the Czech Republic introduced a draft law aiming to establish enforceable rules for online-platform-mediated accommodation. The law targeted residents, providers, guests, homeowners' associations, and local governments. It introduced definitions such as "professional accommodation provider" and "online accommodation intermediary," with broad coverage beyond just Airbnb-type platforms. Criteria for

professional providers included income thresholds or operating at more than one address. The proposal addressed resident protection and imposed fines of up to one million CZK. Compliance responsibilities largely fell on property owners. It also significantly expanded the data-sharing obligations of online platforms, aligning with European approaches (Ministry for Regional Development, 2022).

Criticism of negative externalities in Prague has come notably from the association "Livable Housing in Prague's Centre," which produced a critical report (Čeněk, 2022) highlighting issues such as noise, lower building care, and impacts on local communities. While some arguments (e.g., tax effects) are debatable, the report notes real negative externalities. Prague City Tourism's analysis (2020) highlights overtourism and other negative aspects of the sharing economy (e.g., scooter clutter). The Prague Institute of Planning and Development (Marianovská & Němec, 2018) documented growth in listings, cases of professionalised hosts, and examples of regulation in other European cities. From 2023 to 2025, measures were adopted in the Czech Republic, but these were not traditional regulations. They included allowing municipalities to collect a local stay tax (up to 50 CZK/person/night), requiring guest records, and implementing EU Regulation 2024/1028 on data sharing between platforms and authorities. Despite ongoing debates, no traditional regulatory restrictions have been introduced in Prague or elsewhere in the Czech Republic.

Fig. 1: Number of Short-term Rental Offers



Source: authors' own calculations

Compared to the Czech Republic, foreign regulation is typically more developed. Cities such as Amsterdam (30 days/year, 4 guests), Paris (120 days), Brussels (120 days), and London (90 days) have annual limits as stricter forms of regulation (Colomb & Souza, 2021). Germany, especially Berlin, has rules more stringent than those in Prague or Vienna. Providers must register and obtain a license with a unique ID. For secondary residences, there is a 90-day annual limit. Operation requires a permit that can be denied, with compliance strictly enforced and fines up to €500,000 (Colomb & Souza, 2021). Chronologically, Germany began tightening regulations in 2021 with annual day limits. By 2023, registries of hosts were introduced, and platforms like Airbnb were compelled to share data. By 2024, German cities had well-developed control and enforcement systems with varied models for limits, registration, and primary-residence conditions. A key question is whether these rules have affected the number of rental offers in 2023–2024. The following comparison assesses this using the approach described above. For comparing the possible regulatory impact, the Czech Republic was selected due to its historically strong positive correlation with Germany in short-term rental market trends. Initial outputs are shown in Figure 1, depicting the number of short-term rental offers in Germany and the Czech Republic from 2018 to March 2025.

The graph suggests no significant change in trend or deviation for Germany relative to the Czech Republic after 2023. This is consistent with the high Pearson's correlation coefficient of 0.857. Hypothesis testing showed a p-value = 0.01599, indicating rejection of the null hypothesis at $\alpha = 0.05$ and confirming a statistically significant correlation between the time series. This suggests that Germany's regulatory measures have not had a meaningful impact on reducing the number of short-term rental offers. Analysis of length of stay (LoS) also reveals differences: the average LoS in the Czech Republic is 3.13 nights versus 4.22 in Germany. Both countries saw increased LoS in 2020–2021 (COVID-19 effects). In Germany, LoS rose from 3.74 in 2018–2019 to 4.05 after 2022. Differences are visible but not dramatic or conclusively linked to regulation.

3. Discussion

This research suggests that regulation does not always achieve its primary objective, namely, the reduction of short-term rental supply. Empirical studies from Berlin demonstrate that the ban on unregulated rentals of entire apartments led to a temporary decline in supply, but the long-term effect on the market remained limited (Kholodilin et al., 2021). Landlords frequently circumvent regulations through new accounts, alternative platforms, or informal networks. Persistent enforcement challenges, despite the imposition of substantial fines, confirm that without robust administrative capacity at the municipal level and active cooperation from digital platforms, the effectiveness of such measures remains relatively low.

Another significant factor lies in the fact that short-term rental regulations primarily target the symptoms of the problem rather than its underlying causes. Structural underinvestment in the rental housing sector, low dynamics of residential construction, and increasing demand for urban housing generate pressures that mere restrictions on short-term rentals cannot sustainably alleviate. In this respect, it becomes evident that the regulation of short-term rentals may serve more as a complementary rather than a key instrument of housing policy. A comparison

between Germany and the Czech Republic further highlights the limited role of regulation in an environment where the market follows broader European and global trends. The significant correlation in the number of listings in both countries, even after the introduction of stricter German rules, suggests that other factors—particularly tourist demand, macroeconomic conditions, digitalisation, and shifts in consumer preferences—exert a decisive influence on market developments. Regulation may only slightly slow down or temporarily divert the market, but it cannot alter the underlying trend. In conclusion, the effectiveness of short-term rental regulation cannot be understood in isolation but only as part of a broader housing policy strategy that combines regulatory, fiscal, and urban planning instruments. Only within such an integrated framework can regulatory measures meaningfully contribute to mitigating negative externalities while ensuring a balance between the interests of providers, guests, and local communities.

Conclusion

This study examined the potential impact of regulation on the sharing economy in short-term rentals, comparing Germany (with relatively strong regulation) and the Czech Republic (where systemic regulation is largely absent). The analysis revealed a strong correlation in the number of short-term rental offers, with Germany's regulatory measures not having a meaningful effect on reducing the supply or the associated negative externalities. Despite different approaches, the effectiveness of regulating short-term rentals in addressing negative externalities remains debatable. A key future challenge lies in harmonising data sharing, strengthening local enforcement capacity, and adopting a comprehensive housing policy that goes beyond the sharing economy. Without these steps, regulation will remain largely cosmetic rather than a tool for systemic change.

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Sports Services of a Selected Academy in the Ötztal Ski Resort

Abstract

The aim of this study is to analyse the sports services provided by the Snowlines ski and snowboard school during the 2023/2024 winter season, focusing on the perception of service quality, customer satisfaction, and their loyalty. Additionally, the influence of the image of the Sölden ski resort on clients' relationship with the Snowlines school is examined. To achieve the results, this study uses an electronic data collection method, specifically an electronic survey in a standardized format with precisely defined questions and response options. The statistical software MiniTab is used for the analysis and interpretation of the collected data, offering a wide range of functions for statistical analyses and advanced graphical tools for data visualization.

To compare differences between selected customer segments, the Test of Equal Variances and One-way ANOVA are used. The research results showed that the services provided by the Snowlines ski and snowboard school are generally of a very high quality, although some areas received lower ratings. The critical groups identified were clients aged 18 to 29, those with a master's degree, individuals with the employment status of "self-employed," and those who had their first experience with the Snowlines school and ski or snowboard for less than 5 days per season.

Key Words: Sport Services, Destination Image, Customer Satisfaction, Customer Loyalty, Ski Tourism

JEL Classification: L83, Z33, Z20

Introduction

The ski and snowboard school Snowlines represents a significant entity in the field of winter sports, continuously striving to enhance the quality of its services and meet the needs and expectations of its customers. The perception of service quality, customer satisfaction, and loyalty are key factors influencing the school's success and its ability to maintain a competitive advantage. Studies (Parasuraman et al., 1988; Chi & Qu, 2008; Lee et al., 2011) indicate that service quality and customer satisfaction significantly impact customer loyalty, which directly affects the long-term success of an organization.

In building a relationship with satisfaction, it is not only the quality of the service or product that is decisive; rather, the key factor in the entire process of forming customer satisfaction is the perception and evaluation of the product by the customer. This is the result of a subjective process where the customer compares their expectations with the perceived reality (Zamazalová, 2009). Zamazalová (2009) also believes that higher product or service quality does not necessarily lead to greater customer satisfaction. Nový and Petzold (2006) address the issue of measuring satisfaction in their publication. Since it is a subjective mix of rational and emotional considerations, the authors state that it is always necessary to consider what the person is most likely comparing their satisfaction to. The research results of Jiang and Rosebloom (2005) showed that post-delivery satisfaction has a much stronger influence on overall customer satisfaction and their intention to return than satisfaction during the purchase. In this case, it is assumed that the customer is implicitly able to recall a range of experience variants obtained through product or service consumption combined with the perception of emotions (Permatasari et al., 2017).

Every tourism sector strategically focuses on positively creating the destination's image in the minds of actual and potential tourists (Fakaye & Crompton, 1991). Hájková (2010) believes that the destination image is formed slowly and gradually and can be both positive and negative. The image can arise naturally, for example, based on previous visits, or artificially, for example, through television advertising or other media reports (Hájková, 2010). The key to the destination's image is how strong these associations are, regardless of their positive or negative nature (Hájková, 2010). According to Chi and Qu (2008), positive tourist experiences with services, products, and other resources provided by tourist destinations can lead to repeat visits and positive word-of-mouth among friends and/or relatives. The destination image positively influences perceived quality, satisfaction, and tourist behavior.

Positive image resulting from positive travel experiences leads to positive destination evaluation and a higher likelihood of returning to the same destination (Chi & Qu, 2008). Qu et al. (2011) divided the construction of the destination image into three dimensions: cognitive destination image, affective destination image, and unique destination image. In their study, Qu et al. (2011) demonstrated that the overall image of the destination is positively influenced by both cognitive and affective evaluations. Cognitive evaluation refers to beliefs and knowledge about the object, while affective evaluation concerns feelings towards the object (Baloglu & Brinberg, 1997). The uniqueness of the destination

image provides a compelling reason why travelers should choose a particular destination over alternatives (Qu et al., 2011).

It is expected that a customer with an overall positive image, as a general impression of cognitive, affective, and unique images of a given destination, is more likely to reuse services at that destination and recommend it to others (Qu et al., 2011). The intention to revisit a specific destination has been extensively studied in tourism research as a signal of customer loyalty (Qu et al., 2011). This model originates from the English term "revisit intention" and refers to "*the intention of customers to relive the same tourist destination or product*" (Rasoolimanesh et al., 2021, p. 7). Managers of service-oriented companies consider understanding the intention to revisit a specific destination or relive a given service as a key issue, as it can lead to increased revenues and reduced operating costs (LoveLOCK & Wirtz, 2011).

1. Methods of Research

The aim of this study is to analyse the sports services provided by the ski and snowboard school, focusing on the perception of service quality, customer satisfaction, and their loyalty. Additionally, the influence of the Sölden ski resort's image on clients' relationship with the ski school is examined. A quantitative questionnaire survey was used for the research. For this research, an electronic data collection method was chosen to ensure respondent anonymity and confidentiality, objective data collection, standardized question format, and response quantification. The target population includes all clients of the ski and snowboard school, totaling approximately 1200 throughout the season from November to April. Participation criteria included having attended at least one lesson with an instructor and being over 18 years of age.

The research sample consists of 123 clients who met these criteria. These clients were contacted via social media and direct messages containing a link to an online survey on the survio.com platform. Except for demographic questions, all questions were evaluated using a qualitative five-point Likert scale, ranging from (1) "strongly disagree" to (5) "strongly agree," allowing respondents to express their level of agreement or disagreement with the statements. The questions were posed in English. The focus of the questionnaire was divided into two main parts: respondent identification data and their visit frequency, and questions measuring service quality, destination image, customer satisfaction, and loyalty. The questions were adapted from previous studies (Parasuraman et al., 1988; Chi & Qu, 2008; Lee et al., 2011):

1. Service Quality: Questions adapted from the SERVQUAL method (Parasuraman et al., 1988).
2. Destination Image: Questions based on the work of Chi and Qu (2008), focusing on transportation accessibility, accommodation selection, restaurants/cuisine, entertainment offerings, the number of slopes, snow quality/grooming, infrastructure safety, and price/performance ratio.

3. Customer Satisfaction: Questions adapted from the work of Lee et al. (2011), evaluating the ordering process, the quantity and quality of offered services, availability, price/performance ratio, and overall satisfaction.
4. Customer Loyalty to the Ski School: Questions adapted from the research of Lee et al. (2011), focusing on recommending the school to others and their intention to order another service in the future.

The collected data were transferred to Microsoft Excel and subsequently analyzed using the statistical software MiniTab. To compare differences between selected customer segments, the Equality of Variances Test (Levene's test) and one-way ANOVA were used. Before conducting the tests, their assumptions were verified using normality tests. If the p-value is less than the chosen significance level α (0.05), the null hypothesis is rejected (Kozel et al., 2011).

2. Results of the Research

A total of $N = 123$ clients participated in the survey, meeting the criteria of having attended at least one lesson and being over 18 years of age. Of these, 58.5% were female and 41.5% were male. The age distribution revealed that the largest group of participants (34.1%) were aged 30-39, followed by the 18-29 age group (22%). The majority of participants were highly educated (40.7% held a master's degree), employed (65.0%), and could be classified as irregular tourists (47.2% skied less than 5 days per season). The complete structure of the resulting research sample is presented in Table 1.

The perception of service quality is overall very positive, as indicated by the percentages of responses "strongly agree." A total of 95.1% of respondents encountered customer-oriented services, 91.9% noted effective communication, and 91.1% received sufficient information. However, the advisory service was rated slightly lower (79.7%). Customer satisfaction is rated somewhat lower. The ordering process received 79.7% "strongly agree," the quantity of offered services 78.9% "strongly agree." Availability (75.6%) and the price/performance ratio (73.2%) are areas for improvement.

The image of the Sölden destination is the lowest-rated category. Transportation accessibility (95.9% "strongly agree") was positive, while accommodation selection (52.8% "strongly agree") was average. The most critical area was the selection of restaurants/cuisine (31.7% "strongly agree"). The quality of snow and slope grooming (52% "strongly agree") was average. Regarding customer loyalty, respondents would recommend the ski school (94.3% "strongly agree") and 73.2% plan to use the school's services in the future. Since the initial data testing using a normal probability plot in the statistical software MiniTab indicated that the data were not normally distributed, Levene's test for equality of variances was used for data analysis. The results showed that only nine out of twenty-four tests for equality of variances had a p-value less than 0.05, which implies that in nine cases, the null hypothesis was rejected. These results (see Table 2) with p-values less than 0.05 will be further interpreted. Subsequently, one-way ANOVA was used to compare the means.

Tab. 1: Structure of respondents

VARIABLES	Responses	Frequency	
GENDER	Female	72	58.50 %
	Male	51	41.50 %
AGE	18-29	27	22.00 %
	30-39	42	34.10 %
	40-49	24	19.50 %
	50-59	23	18.70 %
	60+	7	5.70 %
EDUCATION LEVEL	Less than high school	1	0.80 %
	High school or equivalent	20	16.30 %
	Apprenticeship certificate	25	20.30 %
	Bachelor's degree	23	18.70 %
	Master's degree	50	40.70 %
	Doctoral degree	3	2.40 %
SOCIOECONOMIC STATUS	Other	1	0.80 %
	Student	2	1.60 %
	Working student	6	4.90 %
	Employed	80	65.00 %
	Unemployed	1	0.80 %
	Entrepreneur/self-employed	28	22.80 %
VISIT FREQUENCY	Retired	6	4.90 %
	First visit	96	78.00 %
NUMBER OF SKI DAYS PER SEASON	Repeat visit	27	22.00 %
	Less than 5 days	58	47.20 %
	6 to 10 days	43	35.00 %
	More than 10 days	22	17.90 %

Source: authors' calculations

- Service Quality vs. Age: Both p-values are less than 0.05, indicating a statistically significant difference. The critical group consists of clients aged 18–29, who exhibit the greatest variability (standard deviation 0.498) and the lowest average service quality rating (mean 4.847).
- Service Quality vs. Education: Both p-values are less than 0.05. The critical group consists of clients with a master's degree, who exhibit the greatest variability (standard deviation 0.437) and the lowest average rating (mean 4.866).
- Service Quality vs. Visit Frequency: Both p-values are less than 0.05. The critical group consists of clients on their first visit, who exhibit higher variability (standard deviation 0.374) and an average rating of 4.890.
- Satisfaction vs. Age: Both p-values are equal to 0.05. The critical group consists of clients aged 18–29, who exhibit the highest variability (standard deviation 0.520) and the lowest average satisfaction rating (mean 4.735).

- Satisfaction vs. Socioeconomic Status: Both p-values are less than 0.05. The critical group consists of entrepreneurs, who exhibit the highest variability (standard deviation 0.541) and the lowest average satisfaction rating (mean 4.732).
- Destination Image vs. Education: Both p-values are less than 0.05. The critical group consists of clients with a bachelor's degree, who exhibit the second highest variability (standard deviation 0.709) and the lowest average rating (mean 4.401).
- Destination Image vs. Gender: Levene's p-value = 0.063 (>0.05, variances do not differ). ANOVA p-value = 0.016 (<0.05, means differ). The critical group consists of males, who exhibit a lower average rating (mean 4.407) than females (mean 4.509).
- Destination Image vs. Number of Ski Days per Season: Levene's p-value = 0.184 (>0.05, variances do not differ). ANOVA p-value = 0.002 (<0.05, means differ). The critical group consists of clients skiing less than 5 days per season, who exhibit the lowest average rating (mean 4.366).
- Loyalty vs. Number of Ski Days per Season: Both p-values are less than 0.05. The critical group consists of clients skiing less than 5 days per season, who exhibit higher variability (standard deviation 0.580) and the lowest average loyalty rating (mean 4.733).

Tab. 2: Differences between selected customer segments

Variables	M	SD	Levene's p-value	ANOVA p-value
Service Quality vs. Age	4.847	0.498	0.011	0.011
Service Quality vs. Education	4.866	0.437	0.013	0.013
Service Quality vs. Visit Frequency	4.890	0.374	0.048	0.048
Satisfaction vs. Age	4.735	0.520	0.05	0.05
Satisfaction vs. Socioeconomic Status	4.732	0.541	0.012	0.012
Destination Image vs. Education	4.401	0.709	0.027	0.027
Destination Image vs. Gender	4.407	0.636	0.063	0.016
Destination Image vs. Number of Ski Days per Season	4.366	0.661	0.184	0.002
Loyalty vs. Number of Ski Days per Season	4.733	0.580	0.027	0.027

Note: $p < 0.05$; Likert scale 1=strongly disagree, 5=strongly agree.

Source: authors' calculations

3. Discussion

This section provides a concise overview of the empirical study results, along with their evaluation based on the literature used. The study's limitations are also identified, and possible directions for future research are outlined. According to the theory (Kotler & Keller, 2007), the key factor in achieving high service quality and customer satisfaction is meeting or exceeding customer expectations. Data analysis showed that 95.1% of respondents indicated that Snowlines school services are customer-oriented, and 96.7% rated the quality of the staff as very satisfactory. However, some areas, such as advice on

selecting the most suitable service, received lower ratings (79.7%). Statistical tests revealed that critical groups include clients aged 18 to 29, those with a completed master's degree, and those who had their first experience with Snowlines school. These groups showed the greatest variability and lower average service quality ratings. Younger clients or those with higher education may have higher expectations, and new clients may have greater uncertainty. The discrepancy with the assertion that high service quality leads to complete customer satisfaction (Kotler & Keller, 2007) suggests that even high-quality service delivery can have weaknesses.

According to Zamazalová (2009) and Oliver (1997), customer satisfaction results from a subjective process where the customer compares their expectations with the perceived reality. The research results showed that customer satisfaction with Snowlines school services reached 84.6%. However, there is still room for improvement, especially in the ordering process (79.7%) and the quantity of offered services (78.9%). Statistical tests revealed that the age group 18 to 29 years shows the lowest average satisfaction, and the group of entrepreneurs showed a statistically significant difference in variability and satisfaction averages. This result supports the theory that customer satisfaction depends not only on service quality but also on other factors such as emotions and individual expectations (Carroll, 2004).

The destination image is crucial for its success and competitiveness (Morgan et al., 2011; Chi & Qu, 2008). A positive destination image should lead to repeat visits and positive word-of-mouth (Chi & Qu, 2008). The research results showed that the image of the Sölden destination was rated the lowest compared to other categories, especially in the area of restaurant and cuisine options (31.7% "strongly agree") and the price/performance ratio (41.5% "strongly agree"). Statistical results revealed three critical groups: clients with a bachelor's degree, men, and respondents who spend an average of 6 to 10 days skiing or snowboarding per season. The first group consisted of individuals with a bachelor's degree, which may suggest that this segment holds higher expectations regarding the destination or that the image of Sölden does not align with their perceptions. The second group comprised male respondents, indicating that men may perceive the destination less positively than women, potentially due to an insufficient number of adrenaline-oriented attractions that meet their preferences. The third group included respondents who spend an average of 6 to 10 days per season skiing or snowboarding. Although this is not the lowest possible response category, it may reflect certain deficiencies in the destination image of the Ötztal region, which could also negatively affect clients of the Snowlines school. The discrepancy between theory and research results suggests that even though the destination may provide quality sports services, it may suffer from low ratings due to weaknesses in other areas, supporting Žáková's (2018) assertion that the destination image must align with reality.

Customer loyalty is essential for the long-term success of a company and is influenced by positive experiences and the quality of provided services (Lovelock & Wirtz, 2011). A potential mediating relationship arises from the observation made by Chi and Qu (2008), who noted that positive tourist experiences with services, products, and other resources offered by destinations can lead to repeat visitation. Subsequently, the intention to revisit a specific destination has been widely examined in tourism research as an indicator of customer loyalty (Qu et al., 2011). The research showed that 73.2% of respondents plan

to use Snowlines school services again in the future. Statistical tests revealed that the group with less than five days spent on snow shows lower loyalty. This indicates the need to create an environment that clients will want to return to. Customer loyalty is also influenced by other factors, such as the length of stay, and is not automatically guaranteed by high service quality alone.

Study Limitations and Future Research

One of the main limitations of this study is the relatively small and non-representative sample of respondents (only 123). This limited number reduces the possibility of generalizing the results to a broader population. The research was also conducted in a specific time period which may also constrain the ability to capture long-term trends and shifts in customer behavior across different phases of the season. Perceptions of service quality and destination image can vary significantly throughout the season, influenced by factors such as snow conditions, occupancy levels relative to resort capacity, and psychological determinants shaping consumer behavior. The absence of data on nationality may have influenced the perceived quality of services and the destination image, particularly in terms of comparing expectations with the services and overall product offerings across different countries. This is especially relevant in the context of ski and snowboard schools, as well as the technical, natural, and tourism-related conditions that shape the feasibility and attractiveness of engaging in these activities. Despite using standardized tools such as the Likert scale and the statistical software MiniTab, there are methodological limitations. Another limitation may be cultural differences among respondents, as their nationality was not specified, which could have influenced the perception of service quality and satisfaction.

For future research, it would be appropriate to focus on specific aspects of service quality, for example, using the SERVQUAL method. It could be beneficial to use various methodological approaches, such as focus groups and in-depth interviews with school employees. In the area of customer satisfaction research, it would be possible to identify specific factors and compare them among different demographic and cultural groups over a longer period. The use of digital technologies, such as social media and mobile applications, could provide better insights into the impact of these tools on customer loyalty. Furthermore, it would be possible to conduct more detailed research on factors influencing the destination image and collaborate with resort managers.

Conclusion

The aim of this study was to analyze the sports services provided by the Snowlines ski and snowboard school during the 2023/2024 winter season, focusing on the perception of service quality, customer satisfaction, and their loyalty. Additionally, the influence of the image of the Sölden ski resort on clients' relationship with the Snowlines school was examined. The research revealed that despite the high quality of service delivery and positive client evaluations, there are areas that require regular monitoring and improvement. The study results indicate that service quality received high ratings in areas such as customer orientation, communication with staff, information provision, problem-

solving, instructor quality, and overall trust. These results were achieved thanks to the highly professional services provided by the school's employees.

The findings highlighted the crucial role of satisfaction in the relationship between perceived service quality and customer loyalty, as well as the intention to revisit the school. According to the expectation-disconfirmation model (Oliver, 1993), it was confirmed that met expectations lead to positive disconfirmation, resulting in high levels of satisfaction and an increased likelihood of repeat visits. This underscores the significant role of satisfaction in influencing customers' intentions to share positive experiences and recommendations (Qu et al., 2011), as well as their likelihood of returning to use the sports services of the Snowlines school. The final part of the study examined how the image of the Sölden ski resort affects clients' perceptions and their loyalty to the Snowlines ski and snowboard school. Empirical results revealed that the resort suffers from certain deficiencies, such as the price/performance ratio and the quality of snow grooming on the slopes, which reduce the likelihood of customers returning to the resort and, consequently, to the Snowlines school.

Based on the analysis of statistical data and the limitations of the current research, it is clear that there is room for further improvement in all monitored areas. Considering the specific requirements of clients aged 18 to 29 or those with higher education levels regarding service quality, the school should consider introducing more personalized services that better meet their expectations. Simplifying the ordering process and expanding the range of services would represent significant improvements for these clients. In conclusion, it can be stated that the Snowlines ski and snowboard school has a solid foundation in its current strategy and a well-chosen customer-oriented approach.

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Esports – an Avenue for the Future of Economic Research

Abstract

Esports is a rapidly growing industry with structural and behavioral characteristics that closely resemble traditional sports, positioning it as a promising arena for empirical economic research. Building on the premise that sports serve as valuable natural laboratories for testing economic theory, this study argues that esports may present an even more compelling setting for such research. A bibliometric analysis was conducted, collecting all articles from the Web of Science Core Collection that included the terms *esport*, *e-sport*, *esports*, or *e-sports* in their title, abstract, or keywords. Each publication was categorized by disciplinary domain, with particular focus on economics and its adjacent fields. The findings reveal that while esports research has expanded across various disciplines, economics research remains relatively sparse, with fewer than two publications per year over the past two decades, despite the fact that esports data is abundant, high-quality, and increasingly accessible. The study emphasizes the unique advantages of esports data, such as its precision, scale, and quality, and argues that esports offers a largely untapped opportunity for economists to study decision-making and incentive structures in highly controlled yet naturalistic environments. This article further highlights potential sources of esports data, encouraging economic researchers to consider esports in their future scientific endeavors.

Key Words: Esports, Bibliometric Analysis, Sports Economics

JEL Classification: Z20, C8

Introduction

In their aptly named article, Bar-Eli et al. (2020) argue that sports offer a unique opportunity to test economic theories, or, as they put it, *an excellent laboratory to study human behavior in real competitive environments*. They also add that this idea, which is the backbone of the field of sports economics, is shared by Nobel Prize Laureates Daniel Kahneman and Gary Becker. Sports are great natural experiments as they present high-stakes outcomes, and the data sports tend to generate is of high quality with near-complete information. These advantages make sports data valuable for testing economic theories and exploring divergences from classical economic models.

Researchers have used sports data to test foundational economic theories, such as the effect of stakes on performance, market efficiency, optimality of decision-making, intentional underperformance, or sabotage. Similarly, sports data has been used to study deviations from *optimal* performance and other behavioral economics phenomena, such as choking under pressure, the hot hand, discrimination, loss aversion, reference-point effects, or over-optimism. However, sports might not be unique in this regard, as esports might provide similar or even bigger advantages. Despite those potential advantages, esports economics research seems to be rare, as this article will try to demonstrate.

1. Methods of Research

This study conducts a bibliometric analysis of recent trends in esports research and research utilizing esports data. To gather relevant publications, the Web of Science (WoS) Core Collection database was employed. The search focused on journal articles, conference papers, and editorial materials indexed in WoS that featured any of the terms *esport*, *esports*, *e-sport*, or *e-sports* in the title, abstract, author keywords, or keyword-plus fields. Furthermore, retracted publications and duplicate records, which can happen when a single article is indexed in multiple WoS databases, were removed.

The collected articles were then categorized into six groups: Economics; Business & Management; Psychology; Other Social Sciences & Humanities; Sport Sciences & Medicine; and Computer Science, Natural Sciences & Engineering, based on WoS categorization. Articles from miscellaneous fields and subfields (e.g., *Multidisciplinary sciences*, *Interdisciplinary applications*, *Applied mathematics*, or *Leisure, sport & tourism*) were categorized manually, based on the author's best judgment. If an article falls under the umbrella of multiple fields, the following priority relations were applied: Economics > Business & Management > Psychology > Other Social Sciences & Humanities > Sport Sciences & Medicine > Natural Sciences & Engineering > Computer Science. Therefore, for instance, to maximize the possible size of esports economics research, if an article is categorized into both Economics and Psychology, it gets put into the Economics category.

2. Results of the Research

Esports can be broadly defined as organized, competitive digital gaming (Formosa et al., 2022). What began as a small subculture of passionate enthusiasts has evolved into an industry barely recognizable from sports such as football, ice hockey, or tennis, with events rivaling some of the biggest sporting events in their prize pool or viewership (Bavelier & Green, 2019).

While the classification of esports as sports remains a topic of ongoing debate, Wagner (2006) noted that the answer to that question is not relevant to whether esports could or should be studied. Whether esports and sports are different categories of human endeavor or not, they definitely share some key characteristics that should also make

esports an excellent laboratory to study human behavior. Esports also contain competitive environments and present high-stakes outcomes, employ similar league or tournament structures and formats, and provide high-quality data.

Despite Wagner's (2006) call for esports research and the fact that video games became the leading revenue-generating sector in the entertainment industry a decade ago (Bavelier & Green, 2019), deeply ingrained in the daily lives of millions, Shengjie (2019) and Xenopoulos et al. (2020) expressed the view that esports had been under-researched and under-utilized, despite esports data often being readily available and easily obtainable.

Tab. 1, which shows the number of esports-related publications, supports this view, at least when it comes to economics, as categorized by WoS. There have been 1,776 articles in the WoS that have esport, esports, e-sport, or e-sports in either the title, abstract, author keywords, or keyword plus fields, 1,584 of which were published in 2005 or later. While comparing the categories is difficult due to their heterogeneity, it is abundantly clear that economic research in esports is quite rare, with fewer than two articles a year, even in the last two decades.

Tab. 1: Esports publications by category

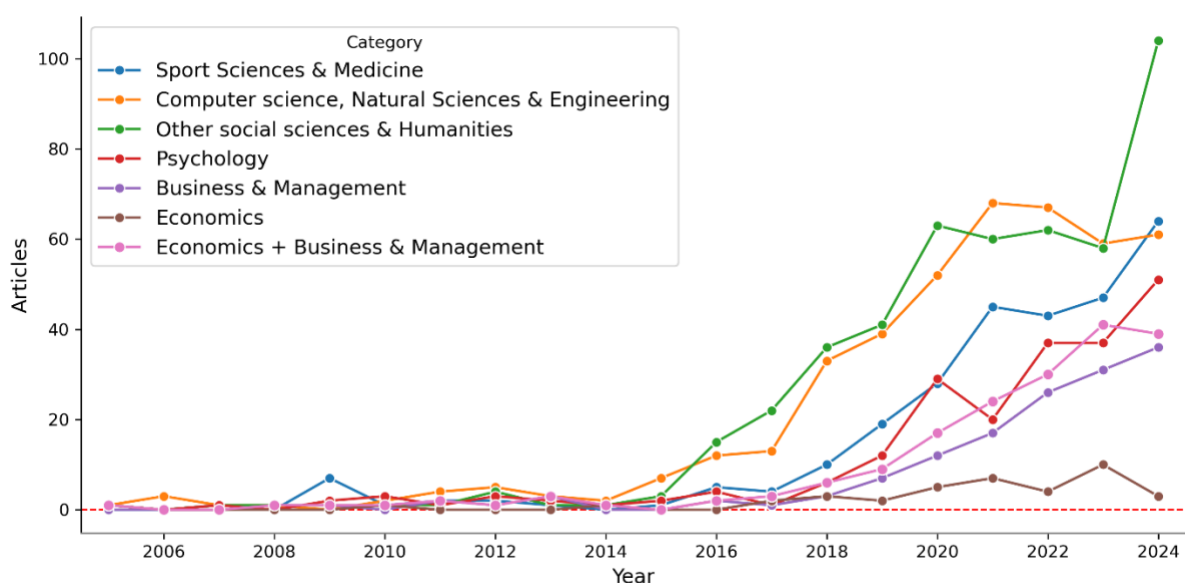
Indicator	All time	Since 2005	Topic examples
Economics	41	39	Tournament theory, superstar effect, attention economy
Business & Management	173	143	Brand evaluation, industry forecasting, marketing integration
Psychology	251	213	Stress, arousal, self-determination theory
Other Social Sciences & Humanities	525	476	Social media usage, esports definition, esports media analysis
Sport Sciences & Medicine	319	280	Injury prevention, practice regimens, rehabilitation
Computer Science, Natural Sciences & Engineering	466	433	Anti-cheat, computer graphics, bot detection
All articles	1,775	1,584	

Source: authors' own calculations, data from (Web of Science, 2025)

Fig. 1 shows that scientific interest in esports has been steadily rising in recent years in all categories, although the growth in economics is quite flat. While the esports economics research has been growing slowly, an increasing number of authors have been considering esports to be a relevant setting for studying economic theory. Esports have been used to study or test various economic theories and economics-related phenomena, such as tournament theory (Shenkman et al., 2024), the spillover effect (Parshakov et al., 2020), choking under pressure (Naidenova et al., 2024), contestable markets (Parshakov et al., 2022), the hot hand phenomenon (Rejthar & Kavřík, 2025), attention economy (Watanabe et al., 2021), or the superstar effect (Ward & Harmon, 2019).

WoS classifies Economics and Business as separate domains. However, there are broader perspectives of what constitutes Economics, such as the JEL classification, which treats Business, Management, Finance, or Industrial organizations as part of the broader field of economics. To take that perspective into consideration, Fig. 1 also shows the number of publications in esports through the lens of the broader view of Economics, which puts Economics on par with Psychology. By broadening the scope, the depiction of esports economics is more optimistic, showing a higher level of engagement with economic topics within the esports literature than might initially appear when viewing the data through the narrower lens.

Fig. 1: Evolution of esports publications by category in 2005–2024



Source: authors' own calculations, data from (Web of Science, 2025)

Building on Bar-Eli et al. (2020), it could be argued that esports may present even greater opportunities than sports do for testing economic theory, as there are three key advantages of esports and esports data over sports and sports data.

First, esports is not merely supported by computers the way sports are; they are inherently integrated into the digital landscape as its byproduct. As a result, esports produce large and varied amounts of data that are often easy to obtain, allowing the study of a wide range of problems and the utilization of a broader range of methods.

One interesting example of benefits stemming from the digital nature of esports is that some games, such as Counter-Strike: Global Offensive (CS: GO) or Quake, use what is called *demos* to store information from every match. Demos are replay-like files containing serialization of the data transferred between the game server and its players, stored as a text of a sequential set of events. Demos contain all the information necessary for the game to recreate the match from start to finish. Therefore, it contains information such as position coordinates, pitch, and yaw of each player, state of their inventory, their actions, and so on, many times a second (e.g., 64 times a second, or with 64Hz frequency). None of the Economics articles in the WoS took advantage of demos in any capacity.

Another interesting example is the case of aim trainers, specialized software designed to enhance and benchmark players' aiming abilities in shooter games, or so-called mouse control, and they are also used to compete. Rejthar (2024) shows that aim trainers produce real-world data of experimental quality, making them a promising source of usable data, especially for research where experimental design (especially laboratory experiments) bends human decision-making, such as the famous Hawthorne effect.

Several studies have leveraged large-scale esports datasets to investigate various aspects of player behavior and competition dynamics. For example, Xenopoulos et al. (2020) used demos of 4,682 professional CS: GO matches, amounting to 73 million states, to study value of individual player actions; Shenkman et al. (2024) used data from 74,632 CS: GO matches, amounting to 149,264 observations, to study the incentive effects of tournament prize dispersion; and Rejthar & Kavřík (2025) used data from 19,272 CS: GO matches amounting to 74,451 observations, to study whether incentives affect the presence of the hot hand phenomenon. These studies exceed the previous literature on the respective topics in terms of the amount of data used.

Second, if available, esports data should be more precise with fewer mistakes due to a lower chance of human error occurring. For instance, the aforementioned match demos are created programmatically, do not require any human intervention, and can be used to extract results, or player actions and statistics. In contrast, sports data gathering often involves much manual labor or requires specialized, expensive tracking tools, which vary in reliability and can produce a considerable number of errors (Pifer, 2024).

Third, partially related to the first point, according to Hinnant (2013), the role esports play in the 21st century reflects the role sports played in the 20th century. Hinnant argues that video games and esports encompass values that are relevant to life in the digital age and that esports thus offer an environment to adopt relevant values, such as insistent individualism, digital culture, or large variance in choices and ideals. For instance, liquipedia.net, a commonly used esports archiving website, is a volunteer-run wiki, a model that has become very common for information archiving (Kalinichenko et al., 2024). Similarly, both in-game and out-of-game esports markets tend to operate 24 hours a day, 7 days a week, supported by a variety of digital systems. These markets are globally accessible, allowing all participants from different regions to participate at any time. Due to the relatively low physical demands, minimal upfront investment, and low transaction costs, players have the flexibility to allocate their time more freely, which makes it easier for them to switch between different esports titles or participate in multiple of them simultaneously (akin to many parts of the current labor market). The inherent digital and global nature of esports enables a more dynamic form of participation that is less constrained by traditional barriers found in physical sports or past labor markets.

As Shengjie (2019) and Xenopoulos et al. (2020) noted, esports data are often readily available. Besides the aforementioned Liquipedia, there are many other archiving sites, such as hltv.org or esportsearnings.com, and various developers, and many sites and

game publishers provide public APIs¹. To work with CS demos, researchers can use, for instance, awpy, a free and open source Python CS demo parsing and analytics library (Xenopoulos et al., 2022). There are also available esports research datasets, such as SC2EGSet, an open-access dataset comprising data from 17,895 StarCraft demos (Białecki et al., 2023), or ESTA, a CS dataset comprising data from 1,558 demos (Xenopoulos & Silva, 2022). There are also video game datasets that are freely available on Kaggle or Github². Additionally, unlike traditional sports, where access to game footage may be restricted or require expensive subscriptions, esports events are frequently streamed on platforms such as Twitch, YouTube, and others. Therefore, high-quality recordings of major (and even minor) events are very often freely accessible online.

Discussion and conclusion

This study builds on Bar-Eli et al. (2020) and argues that esports serve as excellent laboratories for studying economic behavior. While traditional sports have long been utilized in behavioral economics and sports economics for testing economic theory, esports offers certain advantages that may give them even greater potential than traditional sports.

Esports offers a unique combination of advantages. First, its digital infrastructure inherently produces massive, and often publicly accessible datasets, some of which are unique to esports, such as match demos or aim trainer logs, that far exceed the granularity and scale available in traditional sports research for no monetary costs. Second, the automation and precision of data capture minimize measurement error and reduce research costs. Third, the global and decentralized nature of esports markets reflects key characteristics of contemporary digital economies, providing a natural setting for testing modern economic theories.

The bibliometric analysis confirms that esports research has grown substantially across disciplines over the past two decades, but the field of economics research on esports remains sparse. However, since only WoS was used for the bibliometric analysis, the overall counts may be skewed, as newer journals, which may be more likely to publish esports research, might not have had enough time to accrue enough prestige to appear in WoS. Similarly, non-English journals might more frequently publish esports research if esports is more established in some non-English-speaking countries (e.g., Brazil, South Korea, or China), resulting in potential biases.

Given the similarities between sports and esports, taking advantage of the benefits of esports should be straightforward. Despite this, it seems like relatively few economic

¹ See, for instance, a community github signpost for esports APIs at <https://github.com/Strift/awesome-esports>.

² See, for instance, a community github signpost for gaming datasets at <https://github.com/leomaurodesenv/game-datasets>.

studies take advantage of these features, which represents a missed opportunity for economists to conduct experimental-quality analyses using naturalistic data. Tools such as *awpy* and datasets such as *SC2EGSet* and *ESTA* are publicly available and ready for application in economics research, lowering the entry barrier significantly.

Moreover, switching attention towards esports might, in certain situations, reduce costs significantly, which might make some research easier to fund. Future research should, therefore, consider taking advantage of the rich and unique data that esports provide.

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Decarbonisation of Business Logistics: The Role of Electromobility in the Machinery and Equipment Industry

Abstract

The decarbonisation of business logistics is becoming a strategic necessity to support sustainability within the machinery and equipment manufacturing sector. This paper examines electromobility as a key instrument for reducing carbon emissions in business logistics processes. The paper draws on a structured literature review, which evaluated current knowledge and trends relating to electromobility and its application in logistics, and builds upon primary empirical research carried out through a questionnaire survey involving 62 companies operating in Slovakia. This combined methodology enabled a comprehensive exploration of current adoption practices, anticipated benefits, and the main barriers associated with the implementation of electromobility in business logistics. The findings reveal that adoption drivers differ by enterprise size: medium-sized enterprises place greater emphasis on environmental sustainability and CO₂ reduction, while large enterprises prioritise long-term cost savings, although both recognise the value of environmental benefits. Implementation is still in an early phase, with partial deployment being most common and a substantial proportion of enterprises actively planning future integration. The most promising application areas are local and short-haul transport, alongside intra-company material handling, reflecting current technological capabilities. Key challenges include insufficient charging infrastructure and limited vehicle range, while high investment costs remain the primary financial barrier. Overall, the findings of the paper confirm that coordinated policy action, infrastructural development, and technological advancement are essential for accelerating the transition to low-carbon logistics in this industrial sector.

Key Word: Decarbonisation, Sustainable Logistics, Electromobility, Machinery And Equipment Industry

JEL Classification: O33, Q55, R41

Introduction

Business logistics in the machinery and equipment industry is characterised by the movement of both heavy and delicate components among suppliers, manufacturers, and distributors. Traditionally reliant on fossil-fuel-powered vehicles, the sector's transition

to electromobility is vital for decarbonisation. The imperative to decarbonise business logistics is intensified by global climate commitments aiming to reduce greenhouse gas (GHG) emissions, with the machinery and equipment industry being a significant contributor through its complex supply chains and energy consumption patterns. Electromobility, the adoption and integration of electric vehicles (EV) and electric-powered machinery emerges as a critical technology facilitating the transition to low-carbon logistics in this sector.

Recent developments in EV technology, including battery management, charging infrastructure, and powertrain efficiency, have enabled wider application of electric trucks and forklifts in industrial logistics. Innovative optimisation algorithms that incorporate dynamic load factors, integrated slow and fast charging, and vehicle-to-grid interaction significantly improve operational efficiency while minimising costs and battery degradation, factors crucial for industrial adoption in machinery transport and warehousing contexts (Wu and Tian, 2024). Complementing these advances, contemporary reviews of the Green Vehicle Routing Problem position emission minimisation alongside cost and service objectives, demonstrating how modern metaheuristics reduce CO₂ through consolidation, speed smoothing, and stop sequencing (Garside et al., 2024), while freight eco-routing studies show that algorithmic route choice can cut fuel use and emissions, with realised benefits contingent on congestion, time-window constraints, and driver adherence (Pahwa et al., 2024). These advancements allow logistics operators to schedule charging during low electricity price periods and balance energy storage with operational demands, incentivising EV deployment at scale.

Electromobility forms a core component of Green Supply Chain Management (GSCM) initiatives in manufacturing industries. Green supply chains benefit from lowering GHGs. From the extraction of raw materials to the ultimate delivery to the end users, a supply chain includes the activities related to the movement and transformation of items as well as the information flows that go along with them (Pacura et al., 2024). GHGs in supply chains can be reduced by streamlining these processes and making use of new technologies. For example, logistics operations can make use of greener vehicles, such as e-bikes, electric trucks, and hydrogen-powered vehicles. Spatial modulation (SM) and index modulation (IM) are two examples of green supply technologies that can be useful. These cutting-edge communication technologies can help monitor vehicle conditions, optimise routes, and increase the efficiency of information transmission (Li et al., 2023; Wen et al., 2019). The machinery and equipment industry benefits from Industry 4.0 technologies, such as IoT, Big Data, and blockchain, to enable data-driven decision-making for fleet management, energy usage, and sustainability reporting (Labaran and Masood, 2023). At the data layer, IoT telemetry enables near-real-time monitoring of logistics-related emissions, shifting reporting from periodic estimation to continuous measurement and creating rapid feedback loops for operational abatement (Yin et al., 2024; Sepanosian et al., 2024). In parallel, digital-twin models of logistics assets and flows provide a “simulate-before-deploy” environment in which charging layouts, fleet schedules, and consolidation policies can be stress-tested against energy and emissions KPIs, de-risking investments in electrified operations (Liu et al., 2024; Rigó et al., 2024). For credible disclosure and incentive alignment, blockchain-based measurement-reporting-verification frameworks secure emissions data and automate crediting,

strengthening trust in decarbonisation claims across multi-actor transport chains (Merlo et al., 2025). Taken together, these elements: optimisation, IoT sensing, digital twins, and blockchain MRV - constitute a complementary Industry 4.0 stack that operationalises low-carbon logistics by coupling data-driven decision support with verifiable outcomes (Fernando et al., 2021).

Policy instruments that support infrastructure rollout, especially high-capacity and standardised charging stations are fundamental for upscaling electromobility (Kraemer et al., 2023). Coupling these efforts with rational electricity pricing aligned with social marginal costs, as well as with cleaner electricity generation, enhances the environmental benefits of using EVs in logistics (Rapson and Muehlegger, 2023). The ultimate goal of every enterprise for long-term survival is sustainability in all its aspects: economic, environmental, and social (Fidlerová et al., 2022). Sustainability issues are therefore closely linked to the future development of the enterprise.

1. Methods of Research

This paper employed a mixed-method approach combining a structured literature review with primary empirical research to comprehensively examine the role of electromobility in reducing carbon emissions within business logistics in the machinery and equipment industry. The literature review was conducted following systematic search and screening procedures to identify relevant peer-reviewed journal papers. The aim was to evaluate the current state of knowledge, emerging trends, and technological developments in electromobility, as well as its potential applications in logistics processes. The insights from the literature review provided the theoretical and conceptual framework for designing the empirical research component.

The primary data collection was based on a structured questionnaire survey targeting enterprises operating in the machinery and equipment industry in Slovakia. A total of 62 enterprises participated, representing a range of geographical regions and organisational sizes. The survey results were analysed using descriptive statistical methods to determine percentage distributions and differences between medium-sized and large enterprises.

2. Results of the Research

The research sample consisted of 62 enterprises operating in the machinery and equipment industry in Slovakia. In terms of company size, no small enterprises (0.00%) participated, while 12 medium-sized enterprises (19.35%) and 50 large enterprises (80.65%) were represented. The geographical distribution of respondents covered all Slovak regions, with the largest share from the Bratislava Region (24.19%), followed by the Žilina Region (19.35%) and the Trenčín Region (16.13%). Smaller proportions were recorded in the Trnava Region (14.52%), the Košice Region (9.68%), and the Nitra and Prešov Regions (6.45%). The Banská Bystrica Region accounted for the lowest representation (3.23%).

Regarding the primary business focus, the overwhelming majority of respondents were engaged in manufacturing machinery and equipment (82.26%), while smaller shares were active in repair and maintenance of machinery (12.90%) and in logistics and transport services for machinery (4.84%). No respondents fell into the “other” category. In terms of sustainability orientation, more than half of the enterprises reported having a strong sustainability strategy with defined targets (56.45%), while 37.10% enterprises had undertaken some initiatives without a formal strategy. Only 6.45% enterprises indicated that they were meeting only the minimum regulatory requirements, and none reported having no sustainability measures in place.

The results presented in Table 1 indicate that the primary motivation for adopting electromobility in business logistics varies slightly between medium-sized and large enterprises in the machinery and equipment industry in Slovakia. For medium-sized enterprises, environmental sustainability and CO₂ reduction constitute the most frequently cited driver (41.67%), followed by long-term cost savings (33.33%). In contrast, large enterprises place greater emphasis on the economic dimension, with 40.00% identifying cost savings as their strongest incentive, while environmental considerations rank second at 34.00%. Compliance with legislation and regulations emerges as a moderate influence for both groups, accounting for 16.67% of medium-sized and 20.00% of large enterprises. Company reputation and branding are mentioned least often, reported by just 8.33% of medium-sized and 6.00% of large enterprises.

Tab. 1: Strongest driver for electromobility adoption

Option	Medium-sized	Large
Environmental sustainability and CO ₂ reduction	41.67 %	34.00 %
Compliance with legislation and regulations	16.67 %	20.00 %
Long-term cost savings	33.33 %	40.00 %
Company reputation and branding	8.33 %	6.00 %
Total	100.00 %	100.00 %

Source: own elaboration

The data in Table 2 reveal that electromobility integration in business logistics is still in an emerging phase for both medium-sized and large enterprises in the machinery and equipment industry in Slovakia. Partial implementation dominates in both groups, reported by half of medium-sized enterprises (50.00%) and 44.00% of large ones, indicating that many enterprises are in the process of gradual adoption. A considerable share is still at the planning stage, accounting for 33.33% of medium-sized and 36.00% of large enterprises, suggesting a strong pipeline of future initiatives. Fully implemented systems remain relatively uncommon, observed in only 8.33% of medium-sized and 12.00% of large enterprises, reflecting the technological, financial, and infrastructural challenges of complete integration. Notably, the proportion of enterprises with no electromobility adoption is minimal and nearly identical between the two groups (8.33% and 8.00%)

Tab. 2: Current level of electromobility implementation

Option	Medium-sized	Large
Fully implemented	8.33 %	12.00 %
Partially implemented	50.00 %	44.00 %
Planning to implement	33.33 %	36.00 %
No implementation yet	8.33 %	8.00 %
Total	100.00 %	100.00 %

Source: own elaboration

As shown in Table 3, both medium-sized and large enterprises in the machinery and equipment industry in Slovakia identify local and short-haul transport as the most suitable area for electromobility deployment, with 41.67% and 44.00% respectively selecting this option. Intra-company material handling is the second most frequently mentioned area, cited by 33.33% of medium-sized enterprises and 30.00% of large enterprises, reflecting the practicality of introducing electric solutions in controlled, shorter-range environments. Long-distance transport is considered the least appropriate for electrification at this stage, with only 8.33% of medium-sized and 10.00% of large enterprises identifying it as the primary target, likely due to limitations in range and charging infrastructure. Service and support vehicles hold a similar position in both categories, reported by 16.67% of medium-sized and 16.00% of large enterprises, suggesting a moderate but consistent opportunity for electrification in supplementary operational roles.

Tab. 3: Most suitable logistics area

Option	Medium-sized	Large
Intra-company material handling	33,33 %	30,00 %
Local/short-haul transport	41,67 %	44,00 %
Long-distance transport	8,33 %	10,00 %
Service and support vehicles	16,67 %	16,00 %
Total	100.00 %	100.00 %

Source: own elaboration

Table 4 indicates that insufficient battery charging infrastructure is perceived as the most significant technical barrier to electromobility adoption in logistics, reported by 41.67% of medium-sized enterprises and 36.00% of large enterprises in the machinery and equipment industry in Slovakia. Limited vehicle range emerges as the second most pressing concern, reported by 25.00% of medium-sized and 28.00% of large enterprises, reflecting the ongoing limitations of current battery technologies for longer or more demanding routes. Payload and performance constraints are more frequently mentioned by large enterprises (24.00%) than medium-sized ones (16.67%), likely due to the heavier transport requirements typical in larger-scale operations. Finally, a lack of technical knowledge is recognised as a challenge by 16.67% of medium-sized and 12.00%

of large enterprises, suggesting that while skills gaps exist, they are considered less critical than infrastructure and technology performance issues.

Tab. 4: Main technical challenge

Option	Medium-sized	Large
Limited vehicle range	25.00 %	28.00 %
Battery charging infrastructure	41.67 %	36.00 %
Payload and performance limitations	16.67 %	24.00 %
Lack of technical knowledge	16.67 %	12.00 %
Total	100.00 %	100.00 %

Source: own elaboration

Table 5 shows that both medium-sized and large enterprises in the machinery and equipment industry in Slovakia generally perceive the economic viability of electromobility for decarbonising logistics as positive but not without reservations. The largest share in both groups rates it as moderately cost-effective, with 41.67% of medium-sized and 40.00% of large enterprises holding this view, suggesting cautious optimism about financial returns. A substantial proportion remains uncertain or expects only break-even outcomes, 33.33% among medium-sized and 36.00% among large enterprises, indicating that many companies are still awaiting clearer evidence of long-term profitability. A smaller share considers electromobility to be very cost-effective (16.67% of medium-sized, 12.00% of large enterprises), while an equally small segment sees it as not cost-effective at all (8.33% of medium-sized, 12.00% of large enterprises).

Tab. 5: Economic viability assessment

Option	Medium-sized	Large
Very cost-effective	16.67 %	12.00 %
Moderately cost-effective	41.67 %	40.00 %
Uncertain or break-even	33.33 %	36.00 %
Not cost-effective	8.33 %	12.00 %
Total	100.00 %	100.00 %

Source: own elaboration

Table 6 illustrates that both medium-sized and large enterprises in the machinery and equipment industry in Slovakia view government and regulators as the most influential stakeholders in accelerating electromobility adoption in logistics, with 41.67% of medium-sized and 44.00% of large enterprises identifying them as key drivers. This highlights the expectation that public policy, regulatory frameworks, and financial incentives will play a decisive role in shaping the pace and scope of implementation. Manufacturers and technology providers are the second most frequently mentioned group, cited by 25.00% of medium-sized and 24.00% of large enterprises, reflecting the importance of technological readiness and product availability. Customers and clients (16.67% of medium-sized, 18.00% of large enterprises) and industry associations

(16.67% of medium-sized, 14.00% of large enterprises) are seen as having a supportive but less dominant role.

Tab. 6: Stakeholder with the biggest role

Option	Medium-sized	Large
Manufacturers and technology providers	25.00 %	24.00 %
Government and regulators	41.67 %	44.00 %
Customers and clients	16.67 %	18.00 %
Industry associations	16.67 %	14.00 %
Total	100.00 %	100.00 %

Source: own elaboration

Table 7 shows that high purchase and investment costs are perceived as the dominant barrier to electromobility implementation in logistics in the machinery and equipment industry in Slovakia, reported by half of medium-sized enterprises (50.00%) and nearly the same proportion of large enterprises (48.00%). Insufficient charging infrastructure ranks as the second most significant challenge, identified by 25.00% of medium-sized and 24.00% of large enterprises, underscoring the continuing limitations of support facilities. Technical constraints related to vehicle range and load capacity are mentioned by 16.67% of medium-sized and 18.00% of large enterprises, reflecting the performance demands of logistics operations. The least frequently cited barrier is the lack of qualified personnel, reported by only 8.33% of medium-sized and 10.00% of large enterprises, suggesting that workforce capabilities are not currently considered a major obstacle compared to financial and infrastructural issues.

Tab. 7: Biggest overall challenge to implementation

Option	Medium-sized	Large
High purchase and investment costs	50.00 %	48.00 %
Insufficient charging infrastructure	25.00 %	24.00 %
Technical limitations (range, load capacity)	16.67 %	18.00 %
Lack of qualified personnel	8.33 %	10.00 %
Total	100.00 %	100.00 %

Source: own elaboration

Table 8 indicates that both medium-sized and large enterprises in the machinery and equipment industry in Slovakia view environmental and economic outcomes as the primary benefits of electromobility in logistics. Reduced emissions and environmental impact are most frequently cited by medium-sized enterprises (41.67%) and remain a leading factor for large enterprises (36.00%), reflecting the sector's recognition of electromobility's role in achieving sustainability targets. Lower operating costs are the second most important benefit, reported by 33.33% of medium-sized and 34.00% of large enterprises, suggesting that financial efficiency is an equally compelling incentive. Meeting customer or market expectations is mentioned by a smaller proportion of

respondents (16.67% and 18.00%), indicating that while market pressure plays a role, it is secondary to direct operational and environmental gains. Compliance with regulations is the least frequently cited benefit, noted by 8.33% of medium-sized and 12.00% of large enterprises, which suggests that current adoption is driven more by strategic and economic considerations than by regulatory obligations.

Tab. 8: Most important expected benefits

Option	Medium-sized	Large
Reduced emissions and environmental impact	41.67 %	36.00 %
Lower operating costs	33.33 %	34.00 %
Meeting customer/market expectations	16.67 %	18.00 %
Compliance with regulations	8.33 %	12.00 %
Total	100.00 %	100.00 %

Source: own elaboration

3. Discussion and Conclusion

The findings of this paper reveal that the adoption of electromobility in the machinery and equipment industry in Slovakia is shaped by a complex interplay of environmental aspirations, economic considerations, and policy influences. Medium-sized enterprises demonstrate a stronger inclination towards environmental sustainability and CO₂ reduction as their primary adoption driver, while large enterprises place slightly more emphasis on long-term cost savings, though still recognising the importance of environmental benefits. This divergence may reflect differences in operational scale, investment capacity, and strategic priorities, with larger enterprises potentially better positioned to capitalise on cost efficiencies over time. Implementation levels show that electromobility integration remains in a formative stage, with partial deployment as the prevailing condition. A significant share of enterprises is in the planning phase, suggesting considerable latent growth potential in the near term. The most suitable applications are identified in local and short-haul transport, complemented by intra-company material handling, reflecting a focus on operational environments that align well with current battery range capabilities. However, several constraints persist. Insufficient charging infrastructure is the most frequently cited technical challenge, followed by limited vehicle range. Economic viability is generally viewed with cautious optimism, though one-third of enterprises remain uncertain about profitability. Financial barriers are prominent, with high investment costs being the leading obstacle, underscoring the need for targeted support mechanisms. The expectation that government and regulators will play the most significant role in driving adoption highlights the importance of policy stability, incentive schemes, and infrastructural investment.

The dynamics of electromobility development are also visible in European Union countries. Finland has legally bound carbon neutrality for 2035 and a Fossil-Free Transport roadmap targeting ≥50% cuts in domestic transport GHGs by 2030 (vs. 2005) and a fossil-free transport sector by 2045, signalling strong policy certainty for

electromobility investment (International Energy Agency, 2023). Austria's long-term climate strategy to 2050 likewise prioritises electrification in transport as part of its neutrality target, reinforcing the role of national roadmaps (Federal Ministry for Sustainability and Tourism, 2020). France has modelled the infrastructure scale-up needed to sustain the transition: ~350,000 public chargers by 2030 (and 5.7–6.0 million total chargers when home/workplace are included), with fast-highway chargers rising to ~4,400 by 2030—a planning baseline that links EV uptake to concrete network growth (International Council on Clean Transportation, 2021). The Netherlands is piloting battery-electric drayage at the Port of Rotterdam to establish business cases and charging logistics for short-haul operations (Smart Freight Centre, 2024). Germany is attacking the principal barrier-en-route charging-via a national programme to install ~350 HDV fast-charging sites covering ~95% of federal highways, aligned with a goal for one-third of heavy road haulage to be electric or run on renewable fuels by 2030 (Alkousaa, 2024). Sweden's system analyses quantify cost-optimal decarbonisation pathways for heavy-duty road transport, finding that BEV-dominant or BEV+FCV mixes can meet long-haul needs under differing infrastructure timings and cost assumptions (Parviziomran and Bergqvist, 2025; de Oliveira Laurin et al., 2025). Spain's grid-facing studies show that achieving ~4 million EVs (~20.7% fleet) will require distribution-network upgrades and enabling regulation, complementing the NECP's target of 5 million EVs by 2030 (Martínez-Lao et al., 2025). The Alternative Fuels Infrastructure Regulation (AFIR) mandates HDV charging hubs at least every 60 km on the TEN-T core and every 100 km on the wider network by 2030, while technical briefs estimate that ~1,000 MCS-equipped stations could enable ~91% of long-haul trucking flows-providing a continental backbone for zero-emission logistics (T&E, 2024; Fraunhofer Institute for Systems and Innovation Research ISI, 2024). Poland's comparative life-cycle assessments show EVs already outperform ICEVs on GHGs under the current grid mix, with further gains expected as the power sector decarbonises (Burchart-Korol et al., 2018). The Czech Republic's recent assessment confirms EV adoption reduces the carbon footprint and urban noise, underscoring environmental co-benefits that complement decarbonisation goals (Turek et al., 2024).

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Short- and Mid-Term View on the Purchasing Power of Employees Working in the Public and Private Sectors, Considering the Existence of a Minimum Wage and the Influence of Inflation

Abstract

The paper addresses the issue of employees' purchasing power, examining the minimum wage and taking the inflation rate into account. It considers an approach that uses a variable basis to evaluate employees' labor. The current situation is characterised by a lack of regular wage increases, resulting in a decline in real purchasing power due to inflation. The paper aims to determine how current practices can adapt to current influences and trends while increasing employee motivation and maintaining their real purchasing power. It also addresses how to achieve fairness and reduce uncertainty in the context of differing employee conditions. A wage indexation-based model has been created to solve this problem. This model solves the problem of decreasing purchasing power, thereby helping to achieve fairness and reduce uncertainty.

Key Words: Inflation Rate, Minimum Wage, Purchasing Power Of Employees, Wage Indexation

JEL Classification: E02, E24, E31

Introduction

This paper examines an approach that applies a variable basis for employee compensation under the conditions present in Czechia in 2025. For each job, employees are entitled to a mutually agreed form of remuneration — typically in the form of a wage or salary. However, in the absence of regular wage indexation, the real purchasing power of this compensation declines due to inflation. Growth in the basic salary — the fixed component that excludes variable elements — is influenced by various factors, such as an

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employee's improved performance, length of service (loyalty), completion of education, a greater scope of responsibilities, or increased accountability for assigned tasks, team leadership, or project management. Externally, wage growth can be driven by trade unions through collective bargaining mechanisms or by government interventions, which can influence overall wage levels — particularly for low-income workers subject to the minimum wage.

This paper aims to discuss ways to adapt current practices in the system to contemporary influences and trends, thus achieving not only higher employee motivation by maintaining their real purchasing power, but also achieving fairness and reducing uncertainty in the context of different conditions among employees and their certainty.

The concept of fairness, according to Brzezinski et al. (2024), Hornby et al. (2015), can be defined as a state in which equal outcomes have been achieved under equal conditions. Fairness according to (Baier and Katoen, 2008) can be viewed as an assumption that is related to a selected system, process or variable. The classical view of fairness is associated with the number of (usually infinite) occurrences of an event in an infinite sequence of events that can occur in a given system. In the context of this paper, fairness is seen as achieving a level playing field among workers. This uncertainty is defined as the lack of relevant information necessary for unambiguous and correct inference, and thus for forming a correct evaluation or judgement (Provazník and Kozumplík, 1999; Zappia, 2025). Reducing uncertainty in the model improves the predictability of the real state.

1. Purchasing Power Issues

The prologue of the most translated book in the world, the Bible, begins with the phrase: "In the beginning was the Word." That imagined beginning is, mathematically speaking, the left-bounded quantity it is call time. Rather than being purely mathematical, time is primarily associated with physics and other physical sciences. Thus, the concept of time as it is commonly understood is a quantity that is unbounded on the right. However, the concept of time is not exclusively used in the exact sciences. Economics also takes its position on this, from whose point of view time is perceived as a limited quantity, which is in direct contradiction to what has been stated so far. Each individual has only a limited, previously unknown, amount of time to realize his needs. Time can thus be seen as a resource, in this case a limited and therefore scarce resource.

In general, the rarer an asset is, the higher its price and the lower its availability. However, there are exceptions; drinking water, for example, is scarce in nature but affordable for most of the developed world. The situation with human labour must be analysed more thoroughly. From a global perspective, human labour is a very readily available commodity. Its price is further reduced by the fact that it is a renewable resource. The ever-increasing number of inhabitants, especially those of working age, on Earth does not compensate for its depletion. In this case, the price of the work should therefore be very low. Indeed, there are countries where labour is much cheaper than in Czechia.

When considering an open market economy—the focus of this paper—the scale is much smaller, with a population of less than 11 million out of the global 8 billion. Taking into account that this population includes people of retirement age (over 65) and a large number of individuals under the age of 15, the theoretical working—age population is approximately 7 million. (CZSO, 2025a). From this subset can also be subtracted sole proprietors, business owners, the long-term unemployed, and other groups who are not one hundred to enter the workforce. The figure therefore shrinks further to a range of around 4 million inhabitants (CZSO, 2025; MoIaT, 2025). The scarcity of human resources, as opposed to the scarcity of goods of common consumption, can be determined, in addition to the availability in place and time, also by abilities (physical, mental, etc.), education, the level of technological progress in society, to a large extent also the willingness to work and, of course, the price. Getting a quality employee in a certain location, at a certain time, with the optimal prerequisites and skills, and at a certain price, is becoming more and more difficult and this activity is often outsourced for many reasons, which will not be elaborated further here.

It is possible to look at the recruitment process from both sides and trace the intersections. While on the employer's side, the demand side is dominated by the desire to allocate the best possible resources available and, taking into account the allocated budget, tends to look more at the physical and mental equipment of the job seeker. From the (potential) employee's point of view, the situation is more oriented towards the remuneration or commuting time than, for example, the reputation of the company. When supply and demand meet, the key issue is often the level of remuneration.

2. Wage Indexation

To further understand the content, it is important to recall at this point that wage demands have been an unusually sensitive issue for a long time. The reasons for this include labour shortages (Czechia has one of the lowest unemployment rates in the EU — European Central Bank, 2025), dynamic growth in living standards, but also the way in which governments have determined the minimum wage. Following seven years without an increase to the minimum wage, it was raised for the first time in 2013, by CZK 500. With almost annual regularity, the minimum wage was then further increased to the current CZK 20 800 (MoLSA, 2024). A theoretical low-income employee (e.g. Mr. X) who started working on 1 January 2013 for CZK 8,000 gross per month could thus improve his salary by 52.5% by 2018, by 100% by 2022 and currently by 160%! However, the increase in the minimum wage also has a legitimate impact on other employees who were, for example, paid CZK 9,000 gross per month on 1 January 2013. As a model, Mr. Y can be considered, who is more experienced than Mr. X. There was a wage difference of CZK 1,000 between Mr X and Mr Y on 1 January 2013, which in other words means that Mr Y is paid 12.5% more. However, if Mr X received an increase of CZK 500 due to a change in legislation on 1 August 2013, the ratio between the more experienced Mr Y and the newcomer Mr X was then only CZK 500.

Mr Y's experience was therefore only 5.9% more valuable at that point, which undermined the fairness originally established between the subjects. In order not to lose motivation and to maintain the aforementioned fairness between employees, external circumstances forced Mr Y to start negotiating for higher remuneration. However, his salary certainly did not increase by 6.25% in nominal terms as in the case of Mr X, but less. Nominal wages also increased more slowly for employees who had been better compensated at the beginning of the observed period. This is confirmed by the trend in average wages, which provides a more reliable indicator. Comparing the average wage in Czechia in the first quarter of 2013 with the most recent data from the first quarter of 2025 shows that the increase is not 160%, but only about 85% (CZSO, 2025b). Among other things, this phenomenon can be interpreted as a narrowing of the gap between the value of work in lower-skilled occupations and work with higher value added. This fact can be interpreted using Mr. X (see above) and Mr. Z as models, with Mr. Z's abilities nominally valued at, for example, CZK 40,000 gross per month as of January 1 2013. At that time, Mr. Z's work is valued 5 times better than Mr. X's work. As noted above, by 2025 Mr Z's pay could have increased by 85%. As of 1 January 2025, a nominal wage of CZK 74,000 can be considered, which is only 3.56 times higher than that of Mr X. As a result, the employee Mr Z may perceive his valuation as inadequate compared to others in the labour market and the economy as a whole, which in turn may lead to a higher turnover of such workers.

As illustrated above, it is quite likely that in some occupations wage costs may have increased by more than 100% or even 160%, but in other occupations this may not have been the case, and may even have increased selectively (e.g. in blue-collar occupations at the expense of Technical and Economic Officer) or only minimally. Nominal wage stagnation, i.e. wage rigidity, ultimately creates room for a reduction in real purchasing power in some occupations due to the constant impact of inflation. This threat is also real for workers who are employed as freelancers. There is often no trade union to put pressure on wage increases. Union activity is regularly under scrutiny, usually in the autumn and spring when collective agreements are concluded. Often these negotiations are publicised in an attempt to increase pressure on employers and achieve the required wage increases. Strong unions are often able to negotiate increases above inflation, but this is not always successful. In addition, unions also advocate, among other things, improving the working environment or introducing benefits.

Nowadays, benefits (usually non-monetary) are a popular recruitment tool. Classic examples of benefits include a meal allowance, an extra week of holiday, a pension contribution, sick days (3-5 days), discount/coupon vouchers, discounted mobile operator tariffs, home office, mobile phone or car for private purposes (Kubíčková and Patáková, 2018; Kocourková et al., 2023). These benefits have become mainstream in various forms and degrees in terms of originality. In this respect, the work of unions is already rather minority and more attention is focused on pay increases. Moreover, none of these benefits address real wage levels. The manifestations of wage inequality described above can be applied both within the private sector, on which the figures and reasoning are based, and within the public sector, which will be the subject of the following paragraphs.

3. Model for Wage Indexation

A glance at Government Regulation No. 466/2024 Coll., on salary ratios of employees in public services and administration, as amended (Czechia, 2024), in Annex 1, illustrates a simple structure of employee remuneration (see Tab. 1). The matrix is constructed both by the number of years of experience and by the grade for which a predefined education or qualification and professional competence are assumed. Tab. 1 makes it clear at a glance what remuneration an employee will receive today, in one, two or 10 years' time, with the average rate of salary annual increment at 30 years' service being around (at unchanged grade) 1.03% p.a. (see in Table 2). Authors consider that the increment is a manifestation of the additional remuneration of the staff member for the expertise acquired over the years, but not that it is a salary increase due to inflation. If this were indeed the case, its real purchasing power would remain unchanged and its superior expertise would remain unappreciated. It is clear that inflation is therefore not taken into account and that the maintenance of the employee's real purchasing power is not guaranteed. The situation is similar in the remaining pay grades.

Tab. 1: Pay scales by grade and step - Annex 1 to Government Regulation No 466/2024 Coll. (in CZK per month)

Pay Step	Years of Recognized Experience	Pay Grade							
		1	2	...	8	9	...	15	16
1	up to 1 year	13,540	14,440	...	21,530	23,110	...	35,740	38,530
2	up to 2 years	13,910	14,860	...	22,250	23,840	...	36,970	39,860
3	up to 4 years	14,320	15,320	...	22,980	24,650	...	38,250	41,240
4	up to 6 years	14,740	15,760	...	23,730	25,460	...	39,590	42,680
5	up to 9 years	15,210	16,250	...	24,520	26,310	...	40,960	44,160
6	up to 12 years	15,680	16,750	...	25,350	27,180	...	42,380	45,700
...	...	...	...	...	...	...	...	...	...
12	over 32 years	18,840	20,180	...	30,920	33,220	...	52,170	56,320

Source: Czechia (2024)

The solution to this problem may be the introduction of a remuneration model that reflects the current rate of inflation, which is described later in this paper. The basic idea can be simplified to simply stating that wages should be indexed to the rate of inflation on a monthly basis. And rightly so. Each employee's wages would be indexed in each subsequent paycheck. Let's give an example: Mr P commenced employment on 1 January 2025 and his salary was, by mutual agreement, CZK 40,000 gross per month. The net salary was paid on 10 February 2025 by bank transfer to Mr P's bank account.

On 10 February, the Czech Statistical Office (CZSO) announced the monthly inflation rate for January 2025 (i.e. for the period between 1 January and 31 January 2025), which was 2.5% (CZSO, 2025c). The inflation rate announced by the CZSO in March for February

2025 was 2.5% (CZSO, 2025c) and Mr P's salary increased to CZK 42,025 gross and it could go on like this. This approach does not currently exist and is thus an unconventional solution that will hopefully open up many questions, modifications and different perspectives on this issue. The authors are aware of the possible pros and cons of this model. The disadvantages include: dealing with a situation in which negative inflation, i.e. deflation, occurs, fear of administrative complexity, voluntary entry into the system, possible threat or limitation of the influence of trade unions, regional disparities in inflation rates. However, all of these concerns have solutions. In the following paragraphs, let us focus on some of the above-mentioned attributes.

Tab. 2: Summary of salary evaluation of an employee (classified in pay salary 1) - by Annex 1 to Government Regulation No 466/2024 Coll.

Creditable Experience	Increase	Description	Average Valuation
up to 1 year	-	basic salary	-
up to 2 years	2,73%	appreciation for an additional 1 year	2,73% p.a.
up to 4 years	2,95%	appreciation for an additional 2 years	1,46 % p.a.
up to 6 years	2,93%	appreciation for an additional 2 years	1,45 % p.a.
up to 9 years	3,19%	appreciation for an additional 3 years	1,06 % p.a.
up to 12 years	3,09%	appreciation for an additional 3 years	1,00 % p.a.
up to 15 years	2,93%	appreciation for an additional 3 years	0,95 % p.a.
up to 19 years	3,10%	appreciation for an additional 4 years	0,76 % p.a.
up to 23 years	3,06%	appreciation for an additional 4 years	0,77 % p.a.
up to 27 years	3,32%	appreciation for an additional 4 years	0,81 % p.a.
up to 32 years	2,99%	appreciation for an additional 5 years	0,58% p.a.

Source: own construction by Czechia (2024)

In 2025 we already have an experience and knowledge about voluntary entry - how many inhabitants joined to the voluntary based so called 2nd pillar of social insurance (CT, 2015). From today's point of view we can declare, that from the Government side this financial instrument has not been communicated properly and did not allowed to the participants to change their decision after they have entered into the system (FA, 2023). Furthermore some of the participants forget to withdraw their money after Government cancelled this project. The age factor will not be described here as it is not relevant for the purposes of this article.

Emphatic authors feels, how easy could be to communicated such a complex thing to the educated audience of economists, but on the other side the Gaussian distribution shows also other employees, those should not fully understand this topic at all, and furthermore its consequences those arise from their decision later. In these days we can say the so called Gen Z is better prepared for the dynamic of the world, but the whole society is created by mix of Gen Y/Gen X and the others and by different type of people who are more sceptic to the changes and namely in case of someone's salary. Here the authors feels the importance of Unios and concrete local HR departments to communicated individually

the impact of the employees decision if needed. The combination of two above mentioned attributes are based on the author's opinions, the most difficult keys for success of the smooth application of the model. In the area of administrative barriers, the authors state that the above-described change is not a parametric change in the percentage point of health or social insurance. The calculation basis mechanism is practically still the same (only a change was made in 2020), if we abstract the individual tax discount for the payer, or the amount of the discount for a student or an unemployed partner, e.g. a spouse.

The is mechanism assumes the two-way calculation of salaries in the same software for all employees in one company. The mechanism and difference in salary has to be described in the Collective agreements and exclude the right to pay the same salary for the same work and same experienced worker, because in this model there will be two same qualified persons, whereas both join into the company in the same moment and one of them will voluntary join to the above-mentioned inflation adjusted model and the other not. The first one will have most probably higher salary next month then the worker who did not join. Current wording of most of Collective agreements does not expect this and therefore a collective negotiation is periodically scheduled on yearly basis between the Unions and the Employer/representants of Company. Salary will have to be paid only in second half of the upcoming month. Some of the companies, mainly with a foreign based capital pay the salaries before the 10th calendar day in the month. If we will use as an unquestionable and a reliable source CZSO, the data are available around the mid of the month. Only after publication of official data, the financial closure of the month in the plant can be done.

The other solution is to include the model with one month delay. But with this approach we'll open a new chapter of polemics, how to pay the "fair inflation adjusted" salary in case the employee will terminate his/her contract. In the event of a situation where deflation occurs in the first month or months after employment, several solutions can easily be found. In such a case, the employer can certainly agree with the employee on a certain pay cap set at 100% of the agreed remuneration or perhaps also at 90% of the agreed pay. Both parties bear the risk in this respect. Another solution may be to freeze wages during deflation and hold the wage freeze during subsequent inflation for the same period of time. A short brainstorming could find many approaches to solve this disadvantage. Another disadvantage is undoubtedly its administrative complexity. Each payroll (accounting) system is different and it is therefore necessary to update the software, which can easily be achieved through planned annual patches. After the experience with the introduction of the 2nd pillar of supplementary pension insurance in Czechia, the voluntary nature of this system is also a disadvantage.

It is assumed that the idea underlying the principle of such remuneration may not be immediately clear to the majority of the population, and therefore participation in this method of remuneration would initially be on a voluntary basis. People, whether they are public or private sector employees, want to be in control of their money and easily check the correct calculation of their pay. It is worth remembering that recent years have been marked by several adjustments to the parameters that play a role in the calculation of wages. This means that the employee (and the employer) loses certainty about how the

calculation will work in future periods. As far as trade unions are concerned, the authors see potential for unions to be given more space to negotiate other benefits, which have historically included, for example, shorter working hours, which have become a highly debated issue not only in Czechia (Zrůtký, 2016; CT, 2018), but also abroad (Tatje, 2018). The question of an individual approach to an employee's pay would thus remain in the hands of the employee's individual bargaining power and the employer's budgetary possibilities. As for inflationary wage increases, it can certainly be argued that inflation is not the same in all regions. It is therefore up to the agreement between the employee and the employer as to what approach for indexation both parties agree on. That is to say, whether they use a figure that represents the national average inflation or whether they go for the inflation in the region.

Tab. 3: Fictive inflation path 2026-2033

Year	2026	2027	2028	2029	2030	2031	2032	2033
Inflation	2,1%	2,60%	2,00 %	2,80 %	3,90%	2,00 %	1,30%	2,60%

Source: own construction

A certain degree of certainty in the public sector is provided by the aforementioned government regulation. Here the authors see several shortcomings, as already mentioned. The main one is the absence of inflationary pay indexation. Thus, the government must periodically discuss the amount of salaries and possibly increase the values in the table by hundreds of crowns. In order to reduce the bureaucratic burden, a solution is proposed whereby this table will be created for the last time for the base year (e.g. 2025) and in 2026 the government regulation relating to this standard will only state the percentage by which the base value in the relevant grade will be increased (always in January).

For employees who join during the year, then only a pro rata share. For comparison, see Tab. 4 - Model for Wage Indexation, which considers a possible inflation rate in the years 2026-2032 (fictitious data presented in Tab. 3) and applies the procedure described above (where n is number of years by which the salary will be adjusted for a given number of years of experience; π is annual inflation in % and $p.a.$ is per annum). The resulting value of the 2026-2032 wage bill for public sector employees can be seen in Tab. 5 (results of selected pay grades).

The data on inflation (Tab. 3) are fictitious, but they show that if the salaries of employees are adjusted each year for inflation and then the salary is also adjusted by an amount (or percentage) reflecting professional growth, then the salary growth will be closer to real values and it will not be necessary, ceteris paribus, to validate the values specified in the government decree each year. It goes without saying that if there are unexpected shocks to the economy, salary validation, be it freezes or restructuring, will be inevitable.

Tab. 4: Model for Wage Indexation

Pay Step	Years of Recognized Experience	Pay Grade				
		1	...	8	...	16
1	up to 1 year	13,540	...	21,530	...	38,530
2	up to 2 years	$\% \pi + 2,73\%$	...	$\% \pi + 3,69\%$	...	$\% \pi + 3,45\%$
3	up to 4 years	$n (\% \pi + 1,72\%)$ p.a.	...	$n (\% \pi + 1,98\%)$ p.a.	...	$n (\% \pi + 1,86\%)$ p.a.
4	up to 6 years	$n (\% \pi + 1,71\%)$ p.a.	...	$n (\% \pi + 1,91\%)$ p.a.	...	$n (\% \pi + 1,87\%)$ p.a.
5	up to 9 years	$n (\% \pi + 1,47\%)$ p.a.	...	$n (\% \pi + 1,57\%)$ p.a.	...	$n (\% \pi + 1,51\%)$ p.a.
6	up to 12 years	$n (\% \pi + 1,46\%)$ p.a.	...	$n (\% \pi + 1,56\%)$ p.a.	...	$n (\% \pi + 1,52\%)$ p.a.
7	up to 15 years	$n (\% \pi + 1,43\%)$ p.a.	...	$n (\% \pi + 1,55\%)$ p.a.	...	$n (\% \pi + 1,52\%)$ p.a.
8	up to 19 years	$n (\% \pi + 1,33\%)$ p.a.	...	$n (\% \pi + 1,39\%)$ p.a.	...	$n (\% \pi + 1,37\%)$ p.a.
9	up to 23 years	$n (\% \pi + 1,32\%)$ p.a.	...	$n (\% \pi + 1,4\%)$ p.a.	...	$n (\% \pi + 1,37\%)$ p.a.
10	up to 27 years	$n (\% \pi + 1,35\%)$ p.a.	...	$n (\% \pi + 1,4\%)$ p.a.	...	$n (\% \pi + 1,37\%)$ p.a.
11	up to 32 years	$n (\% \pi + 1,24\%)$ p.a.	...	$n (\% \pi + 1,3\%)$ p.a.	...	$n (\% \pi + 1,29\%)$ p.a.
12	over 32 years	$\% \pi$	...	$\% \pi$	...	$\% \pi$

Source: own construction by Czechia (2024)

Tab. 5: Results of Model for Wage Indexation (in CZK per month)

Year	Pay Grade									
	1	2	...	7	8	9	10	...	15	16
2025	13,540	14,440	...	20,080	21,530	23,110	24,790	...	35,740	38,530
2026	13,879	15,112	...	21,144	22,671	24,334	26,103	...	36,634	40,571
2027	14,377	15,654	...	21,903	23,485	25,208	27,041	...	37,403	42,028
2028	14,966	16,296	...	22,801	24,447	26,241	28,149	...	38,375	43,750
2029	15,487	16,863	...	23,594	25,298	27,154	29,128	...	39,143	45,273
2030	16,151	17,586	...	24,606	26,383	28,319	30,378	...	40,239	47,215
2031	16,959	18,466	...	25,837	27,703	29,736	31,897	...	41,808	49,576
2032	17,481	19,035	...	26,633	28,556	30,652	32,880	...	42,644	51,104
2033	17,896	19,487	...	27,265	29,234	31,379	33,661	...	43,199	52,317

Source: own construction

Conclusion

The paper critically examined the price of human labour in Czechia and the resulting inequalities, which are caused, among other things, by government intervention in the minimum wage. The minimum wage undoubtedly interferes with the market environment of both private and public entities, predetermining the development of wage costs for a given entity. However, periodic increases in the minimum wage, i.e. the remuneration for unskilled work, do not always correspond with wage increases for skilled workers. Therefore, it is necessary to find alternative solutions that replace the current conventional approach with a more effective mechanism. This should ensure that pay equity is achieved in future and avoid the erosion of purchasing power. This will contribute to the social well-being of employees and, by extension, society as a whole.

Although the private and public sectors have different characteristics, the authors view remuneration as a process with similar features. Wage indexation is easier within the private sector, mainly due to its specific features, such as collective bargaining and greater flexibility in decision-making. However, collective bargaining can eliminate individual merit and ability, thus suppressing fairness. In the public sector, wage indexation is based more on political than economic principles. A common feature of both sectors is the frequent disregard for inflation as a macroeconomic phenomenon with a direct impact on purchasing power. In our view, if indexation occurs only once a year, this is insufficient. In such a case, the regular monthly indexation described in the paper would be an easy solution. It is not possible to conduct a thorough analysis of the entire model in relation to the given issue today. The main reason for this is that the model has not yet been implemented, and it is unclear whether or when this will happen, or to what extent. However, if the model is implemented, the authors believe there is greater potential for elaborating on macroeconomic aspects, since the inflation rate, interest rates, investment and GDP will be subject to phenomena not described here.

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The Power of Image: the Impact of Visuals on Online Consumer Decision Making

Abstract

The visual presentation of products is a key factor influencing customer decision-making in an online environment where consumers are unable to physically interact with the goods. This paper examines how different visual formats - thumbnail photographs, dynamic visuals, videos and 3D presentations - influence customers' mental imagery, attitudes and purchase intentions. An analysis of expert studies found that dynamic formats and videos, especially those demonstrating product use, have a significantly positive effect on customer engagement and purchase decisions. It was also found that the effectiveness of visual elements varies by product type, with the ability to compensate for the lack of physical contact with visuals designed to suggest tactile qualities or text descriptions being crucial for experiential products (e.g. food, clothing). The study also highlights the importance of congruence between visual imagery and accompanying text and draws attention to the automatic, uncontrollable effects of visual stimuli on customer attitudes, which operate independently of the user's motivation and cognitive resources. The results provide online retailers with practical guidelines for optimizing visual strategies to increase purchase intentions and reduce consumers' cognitive uncertainty.

Key Words: Visual Product Presentation, Consumer Decision-Making, Purchase Intention, Mental Imagery, C-Commerce Marketing

JEL Classification: M31, M37

Introduction

In today's online environment, the visual presentation of products plays a vital role in the customer decision-making process (Cheng & Zhang, 2022). Since consumers do not have the opportunity to physically interact with the goods, they rely primarily on visual information to judge the quality of products and make subsequent purchasing decisions. This includes a wide range of visual formats such as preview photos, dynamic visuals, videos and 3D presentations (Jiang et al., 2024), (Wang et al., 2024).

This systematic review seeks to address the research question: What impact do preview photographs and other visual forms of product presentation in online environment have on consumer decision-making and purchasing behaviour? The analysis focuses on identifying key visual elements and mechanisms that can help online retailers and marketers to optimize their visual strategy and increase the effectiveness of online presentations. Despite the growing body of literature examining the influence of visual elements on consumer behavior in the context of online commerce, existing studies tend to focus on narrowly defined aspects. For instance, Vazquez et al. (2023) focus on specific aspects of image quality and text review types in social commerce and their impact on purchase intentions through mental imagery and social presence. Similarly, Kim and Lennon (2008) compare the influence of visual and verbal information on attitudes and purchase intentions in a more general online shopping context, with an emphasis on compensating for the absence of physical contact. Up to date, there is a lack of a comprehensive systematic review that synthesises findings on the influence of a wider range of visual formats - from thumbnail photographs and dynamic visuals to videos and 3D presentations - on mental imagery, attitudes and purchase intentions in the online environment (Vazquez et al. , 2023), (Kim & Lennon, 2008).

1. Methods of Research

The aim of this study was to explain how thumbnail photos and other visual elements influence customer decision-making in the online environment. To do so, a systematic literature search was conducted, with relevant studies being searched in the Web of Science database. The decision to limit the search to Web of Science was based on its comprehensive coverage of high-quality, peer-reviewed journals and advanced filtering tools that support systematic reviews. Although databases such as Scopus or Google Scholar could potentially provide broader coverage, they also include a higher proportion of non-peer-reviewed or duplicate records, which may reduce the methodological rigour of the review. Future research could extend the search to these databases to capture additional relevant studies.

The search strategy was designed with an emphasis on two thematic areas: visual aspects of product representations and customer decision-making processes. The query used combined keywords from both areas, namely:

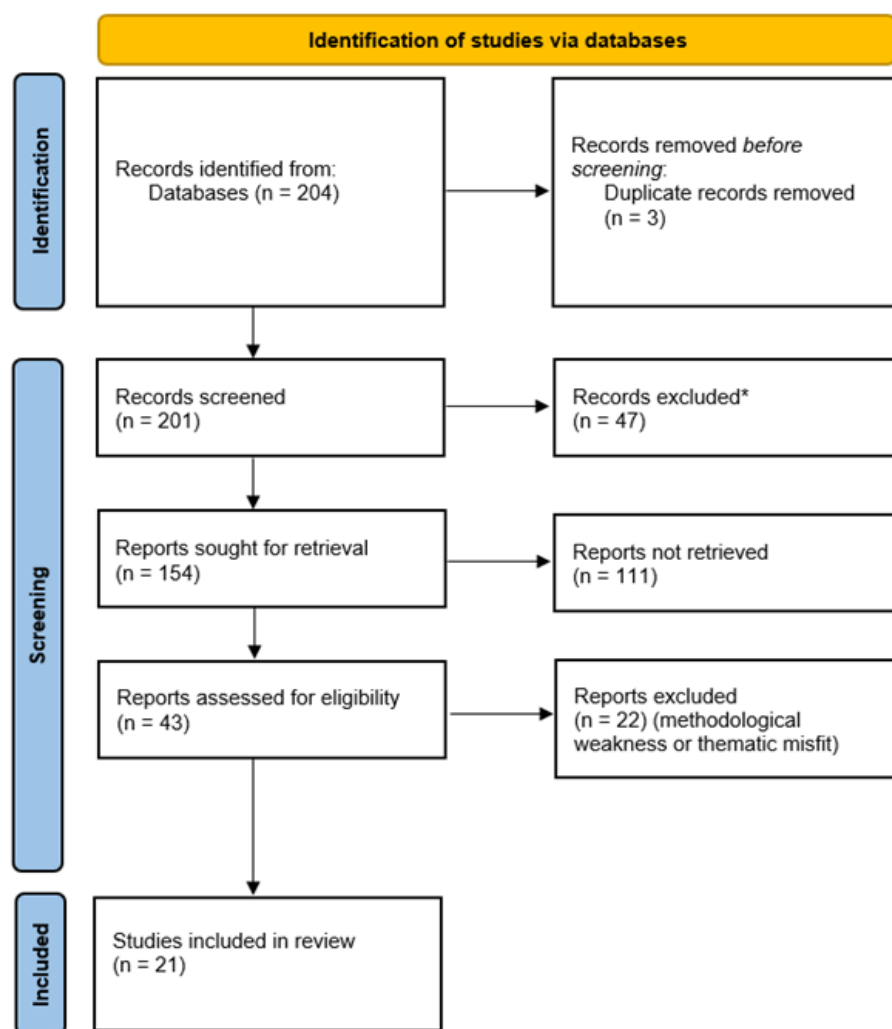
("thumbnail image" OR "preview image" OR "product photo" OR "product image" OR "visual representation" OR "image quality" OR "imagery") AND ("consumer decision-making" OR "customer choice" OR "purchase intention" OR "click behavior" OR "choice behavior" OR "user decision")

The last search was conducted on 30 June 2025, identifying a total of 204 results. A series of selection criteria were subsequently applied. First, three duplicate records were removed, after which filtering by publication year (2015 to 2025) was continued, reducing the number to 169 studies. Next, only articles written in English (166) were retained, followed by only "article" type documents, resulting in a set of 154 records.

This file was then subjected to a first screening based on title and abstract. At this stage, 12 articles that did not answer the research question were excluded. The resulting file after the first screening therefore comprises 142 articles.

Of the 142 records, 43 articles were traced and full text was retrieved. These studies were then subjected to a second round of screening, in which 22 studies were excluded on the basis of content and methodological relevance. The resulting set of 21 articles forms the basis for the systematic analysis conducted in this search. The process of study selection, including the stages of identification, screening and inclusion in the final analysis, is clearly illustrated in the following PRISMA diagram (Fig. 1). The diagram documents the numbers of records at each stage of the selection process and the reasons for their eventual exclusion.

Fig. 1: Diagram of study selection



Source: own processing based on PRISMA template (Prisma, 2021)

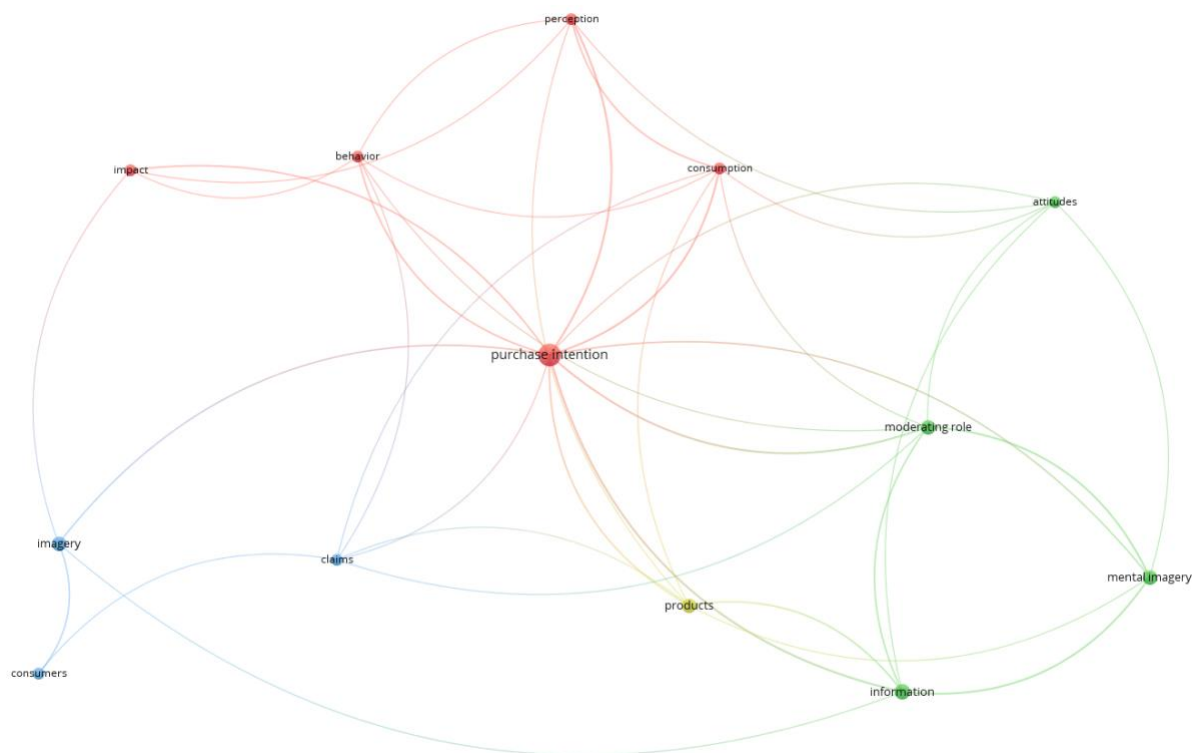
*Excluded based on publication year (outside 2015–2025), document type (non-article), or language (non-English).

2. Results of the Research

In order to support the structure of the systematic search results, keyword analysis was also performed using the VOSviewer software tool. This approach allowed the identification of the main thematic areas based on the frequency and association between terms that occurred together in the analysed articles. The resulting network of key terms shows that the most frequent and central term is purchase intention, which is linked to a number of other key terms reflecting different mechanisms of influence of visual elements.

Based on this visualization, the results of the systematic search could be divided into four main categories: (1) influence on attitude and purchase intention, (2) product perception and mental representation, (3) specific visual elements and their impact, and (4) the role of product type. These areas correspond to thematic clusters in the visualization network.

Fig. 2: Visualisation of thematic clusters based on keyword analysis



Source: own processing with VOSviewer sw

2.1 Influence on attitudes and purchase intention

In the online environment, visual representations of products, such as preview photographs or other digital formats, are among the important sources of information by which consumers judge product quality and subsequently make purchase decisions. Different types of visual presentation, including still images, videos or 3D models,

significantly influence consumers' perceptions, their emotions and also their final purchase intentions (Zhang, 2023).

Research has shown that "mindful ads", which contain carefully chosen visual elements, can create a stronger sense of immersion in the product presentation, leading to higher purchase intention compared to conventional ads (Errmann, 2025). Similarly, dynamic visuals, including videos, significantly enhance purchase intention compared to static images, especially for products where visual information helps to bridge information asymmetry. Dynamic presentation also reduces the emergence of cognitive conflict and promotes positive emotional responses from customers (Wang et al., 2021).

The style of preview images and the type of packaging are also of specific importance. For example, studies have shown that natural versus artificial packaging imagery has a significant impact on purchase intention for products that may evoke feelings of embarrassment in customers. (Ye et al., 2022). In addition, it has been confirmed that a rich visual presentation ("rich product presentation") helps customers understand both the practical and emotional value of a product more comprehensively, which again supports their purchase decision (Zhang, 2023).

2.2 Product perception and mental representation

Images effectively stimulate the mental imagination of consumers. The visual appeal of packaging design, including product illustration, significantly influences purchase intention (Zhao et al., 2024). In online environments where tactile experience is lacking, visual information can compensate for tactile deficiencies (Jiang et al., 2024). Tactile suggestive visuals ("haptic cues in metaphorical visual language" - MVL) can enhance the perception of tactile product features and influence purchase intentions. Specifically, handheld tactile cues can enhance mental simulation for products where touch is important (e.g., blankets), thereby increasing perceptions of softness and warmth, leading to more positive product evaluations and purchase intention (Cheng & Zhang, 2022).

The vividness of mental imagery determines how strongly visual stimuli in advertising work. When an image conveys specific and meaningful information about product consumption, the consumer mentally connects to it and the imagination is activated. Conversely, if the image contains little relevant information, attention shifts to the visual surface - the colors, quantity, or style (Zhang et al., 2025). In the digital environment, then, the match between the visual and the description also plays a role: if they match, imagination vividness, understanding, and positive attitudes toward the product increase (Cheng & Zhang, 2022).

2.3 Specific visual elements and their impact

Different types of visual elements have different effects on customer decision-making. For example, dynamic product displays significantly reinforce purchase intent over static visuals, especially in the context of online seafood sales. This is because dynamic visuals

promote customer immersion and stimulate their mental imagination more vividly (Wang et al., 2021). Similarly, the repeated display of the same ingredient on product packaging can reinforce the perception of taste, promote sensory-specific satiety and positively influence purchase intention (Thomas et al., 2023).

Significant differences in the effectiveness of visual formats are shown in a study focusing on staggered product views. This is because these views, when specifically described, promote vividness of mental imagery, which facilitates better product understanding, creates more positive customer attitudes, and increases their willingness to purchase. Conversely, in the case of abstract descriptions, conventional views are more effective because they facilitate imagination and understanding of the product (Cheng & Zhang, 2022).

An increasingly common strategy for online retailers is to use videos to showcase products. Videos are richer and more vivid than photos or text and significantly increase the perceived ease of imagining a product. At the same time, they offer the closest experience to physically viewing the goods in a store. The effectiveness of this approach has been confirmed by studies that show how to use a product more effectively than videos that focus only on its appearance. This is true for both products that customers primarily search for ("search" products) and those whose features are best judged by direct experience ("experience" products) (Cheng et al., 2022; Zhang, 2023).

2.4 The role of product type

The impact of visual elements varies by product type. For products such as food or clothing, mental imagery plays a major role due to the absence of direct tactile contact (Jiang et al., 2024), (Jeganathan & Szymkowiak, 2023). At the same time, however, it has been shown that, for example, for common clothing items - such as a sweatshirt - tactile descriptions in text form can be more effective than pictorial visualization when it comes to triggering tactile imagery and influencing purchase decisions (Silva et al., 2021).

Visual presentation works well for a smaller selection of products and can be particularly effective when it comes to slightly innovative goods - for example, through staggered views that encourage understanding and imagination. However, for larger ranges or highly innovative products, it may be more appropriate to opt for more detailed verbal descriptions to better support informed decision-making. Thus, the choice of presentation form should take into account both the number of choices and the degree of innovativeness of the product (Wang et al., 2024), (Cheng & Zhang, 2022).

3. Discussion

This systematic review focused on the research question of the impact of preview photographs and other forms of visual product presentation on consumer decision-making and purchasing behaviour in the online environment. The results of the analysis of available studies showed that visual elements play a key role in shaping consumers'

mental imagery, reinforcing positive attitudes towards the presented products and increasing their purchase intentions. The following discussion further develops these findings in the broader context of existing scholarship, highlighting their theoretical relevance and practical implications for marketing communication and strategic decision-making in the online retail environment.

3.1 Theoretical Implications

The results of the research extend the existing knowledge on the influence of visual presentation in the online environment. Studies have confirmed that visual elements significantly promote mental imagery, leading to more positive attitudes and higher purchase intention. Dynamic elements, such as videos, reduce customer uncertainty and evoke positive emotions more effectively than static images (Wang et al., 2021). Mindful ads with strong visual elements have also been shown to draw customers more strongly into the presentation and encourage purchase intent (Li et al., 2023).

It is also important to match the type of visuals and accompanying text. For example, detailed ("exploded") views are more appropriate when combined with concrete descriptions, while general views are better complemented by abstract texts (Cheng & Zhang, 2022). Moreover, in the online environment, the possibility to physically touch the product is missing, which can be partially compensated by suggestive tactile descriptions. These descriptions are often more effective than visual stimuli alone, especially for products such as clothing (Cheng & Zhang, 2022). Conversely, for products such as pajamas or dumbbells, tactile cues in the form of visuals help simulate direct experience and support purchase decisions (Leng et al., 2022).

Recent research has shown that some visual cues affect customers automatically, regardless of their motivation or cognitive capacity. This suggests that preview photos may operate outside of consumers' conscious control, with important implications for their persuasive power (Hütter & Sweldens, 2018).

3.2 Practical Implications

The results of the research also provide several practical recommendations that online retailers and marketers can use to effectively optimize the visual presentation of products. First of all, it is worth investing in dynamic visuals, such as videos or dynamic visuals, especially for products where the image serves as the primary source of information (Wang et al., 2021). Specifically, videos that show the product in use are more effective than videos that focus only on the product's appearance. This is true both for products whose features customers primarily search for ('search' products) and for products whose qualities can be appreciated more through direct experience ('experience' products) (Cheng et al., 2022).

For food products, it is then recommended to use repetition of images of the same ingredients on the packaging or preview photo. This is because this approach helps to

highlight the mental image of taste, which positively influences consumers' purchase intention (Thomas et al., 2023). In the case of products where tactile sensation plays a significant role (e.g., clothing), it is advisable to compensate for the absence of physical touch with vivid, tactilely suggestive descriptions directly on the website to help customers better visualize the texture and feel of the product (Silva et al., 2021).

3.3 Research limitations

Although the systematic search provided valuable insights, it is important to note its limitations, some of which are based on the limitations of the individual studies analysed. The demographic limitations of the samples are a crucial aspect, as many studies included samples composed predominantly of university students or specific groups of participants, limiting the ability to generalise the findings to a wider population. This reliance on relatively homogeneous samples, particularly university students, may limit the ecological validity of the findings. Younger, more digitally literate participants may respond differently to visual presentation formats than older or less tech-savvy consumers, potentially overstating the effectiveness of certain visual strategies in the broader population.

Another limitation is the experimental setting - most studies took place in simulated online scenarios or in laboratory conditions, which may reduce the applicability of results in real-world settings. In addition, some studies purposely limited participants to desktop or laptop users, which raises the question of whether the observed visual effects would have the same effect when using smaller mobile devices.

Specific limitations also relate directly to this systematic review: the search was conducted only through the Web of Science database, included studies published in the last 10 years, and was conducted in English only. These limitations may mean that relevant findings published in other databases, over a longer timeframe or in other languages may not have been captured.

Given the global scope of the reviewed studies, it is important to consider potential cultural moderators of visual effects. For instance, cultural differences in aesthetic preferences, colour symbolism, or communication styles may influence how consumers interpret and respond to product visuals. Future research could investigate whether visual strategies found effective in one cultural context yield similar results elsewhere.

Conclusion

This systematic research confirmed that the visual presentation of products has a major impact on customer behaviour in the online environment. The findings show that preview photographs and dynamic visual elements such as videos significantly promote positive attitudes, reinforce mental imagery and lead to increased purchase intentions. On a theoretical level, it was found that appropriately chosen visual formats not only improve product perception, but also reduce cognitive uncertainty and automatically influence customer attitudes without users' conscious control.

In marketing practice, these findings offer concrete recommendations for optimizing the visual strategy of online retailers. In particular, it is recommended to use dynamic visuals and videos that show the product in the context of its use, thereby increasing customer engagement and purchase intent. At the same time, it is recommended to use repeated displays of key product elements (e.g. **ingredients in food products**), which reinforces customers' sensory perceptions. This systematic review thus provides both a theoretical framework for further academic research and concrete guidance for effective marketing practice.

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Risk Aversion, Age, and Gender as Predictors of New Media Adoption: Evidence from LinkedIn, Twitter, Skype, and Viber

Abstract

This study investigates how risk aversion, age, and gender influence the adoption and use of new media platforms, specifically LinkedIn, Twitter, Skype, and Viber. Drawing on data from a web-based survey conducted via 1ka.si, we analyzed responses from 529 university students (289 men and 240 women), the vast majority of whom were 24 years old or younger. The questionnaire measured frequency of platform use, demographic characteristics, and self-assessed risk aversion levels. Our findings reveal significant associations between individual risk profiles and platform usage, with more risk-averse individuals showing lower engagement on socially and professionally open networks such as LinkedIn and Twitter. Age and gender were also found to be important moderating factors, shaping both the likelihood of adoption and patterns of usage across platforms. These results offer valuable insights into the psychological and demographic determinants of digital behavior and highlight the importance of tailoring digital communication strategies to diverse user profiles..

Key Words: New Media Adoption, Risk Aversion, Age and Gender, Social Networking, Digital Behavior

JEL Classification: L86, D81

Introduction

In recent years, the rapid proliferation of new media platforms such as LinkedIn, Twitter, Skype, and Viber has transformed how individuals communicate, network, and access information. However, user adoption of these technologies is far from uniform. Emerging evidence suggests that individual characteristics—such as risk aversion, age, and

gender—play a significant role in shaping attitudes toward and engagement with new media. Risk-averse individuals may hesitate to embrace platforms perceived as exposing personal data or requiring social openness. Age-related differences influence both technological literacy and communication preferences, while gender dynamics intersect with social norms and professional use cases.

This paper explores how these three factors—risk aversion, age, and gender—jointly and independently affect the adoption and usage patterns of selected new media platforms. By analyzing user behavior across LinkedIn, Twitter, Skype, and Viber, this study seeks to identify underlying psychological and demographic mechanisms that influence media engagement. Understanding these dynamics is essential for platform developers, policymakers, and educators aiming to bridge digital divides and promote inclusive digital participation.

1. Literature research

Understanding the determinants of information and communication technology adoption is crucial, given the pervasive integration of digital platforms into daily life and their implications for social interaction, information access, and economic activity (Gil-Clavel & Zagheni, 2019). Previous studies have explored technology acceptance broadly, with some focusing on specific technologies such as smartphones or social media; however, less is known about the underlying reasons influencing consumers' actual online behavior across the diverse range of available technologies (Çera et al., 2020). While a significant body of literature addresses the adoption of social networking sites, much of it focuses on broad demographic trends, such as the general propensity of younger individuals to adopt SNSs and the higher continued usage rates among females (Lin et al., 2011). However, detailed empirical investigations into how specific psychological constructs like risk aversion, alongside established demographic variables, differentially predict the adoption of distinct new media platforms remain underexplored. This study aims to bridge this gap by providing empirical evidence on the predictive power of risk aversion, age, and gender on the adoption of specific social networking applications, offering a more nuanced understanding of user engagement. The present study addresses this research lacuna by examining these factors within the context of LinkedIn, Twitter, Skype, and Viber, thereby contributing to the literature on technology adoption and providing practical insights for platform developers and marketers. This approach allows for a granular analysis of user behavior beyond generalized patterns, identifying specific drivers for engagement with different digital tools (Kircaburun et al., 2018). The study utilizes a quantitative approach to analyze user data and identify significant correlations between the predictor variables and platform adoption. This will contribute to a more comprehensive understanding of user behavior in the digital realm and inform strategies for optimizing platform design and targeted marketing efforts.

The research also seeks to address shortcomings identified in previous literature by expanding the theoretical framework of technology acceptance models to incorporate the influence of individual psychological traits, such as risk aversion (Apau & Lallie, 2022).

This expanded framework allows for a more holistic understanding of user engagement with new media, moving beyond purely demographic analyses to consider the deeper psychological underpinnings of technology adoption. It builds upon established models like the Technology Acceptance Model, which has been extensively validated across various information systems and communication technologies (Rauniar et al., 2014). This study broadly classifies sub-constructs within three dimensions—adoption, behavior, and technological—to explore the relationships between these attributes, proposing that digital behavior and demographic characteristics moderate the main relationships (Singh et al., 2020). The study's methodology involved a robust data collection process and rigorous statistical analysis to ensure the validity and reliability of its findings. Additionally, some research has focused on the influence of cultural dimensions, such as masculinity/femininity and uncertainty avoidance, on social networking site adoption rates and usage patterns across different countries, further underscoring the multifaceted nature of technology assimilation (Stump & Gong, 2017).

This study applies a new model combining three different theories with other constructs to provide a comprehensive insight into the current state of knowledge regarding technology adoption at the individual level (Granić, 2023) (Octavius & Antonio, 2021). This multi-method evaluation builds upon existing technology acceptance literature by incorporating relevant technological and behavioral attributes, investigating the moderating effect of digital behavior and demographic characteristics, and ultimately contributing to a deeper understanding of user beliefs and perceptions concerning FinTech Services. This comprehensive approach allows for a nuanced understanding of how varying user characteristics influence their engagement with diverse digital platforms, moving beyond generalized adoption models to provide platform-specific insights (Singh et al., 2020).

Furthermore, within the broader context of technology adoption, empirical research has investigated how gender and personality traits, such as those defined by the Big Five Inventory framework, influence the frequency of use of specialized digital platforms like deal sites, revealing that while gender often plays a role, personality traits like neuroticism and openness to experience can also be significant predictors depending on the user's awareness and engagement level with the technology (Sudzina, 2016).

This approach acknowledges that while generalized models like the Technology Acceptance Model have been widely validated across various information systems and communication technologies, they may benefit from the integration of finer-grained psychological and demographic variables to explain nuances in technology adoption (Aiolfi et al., 2021).

2. Methods of Research

A questionnaire was developed to gather data on the use of social networking sites, demographic attributes, and levels of risk aversion. The data collection was carried out through an online survey hosted on 1ka.si. The final sample included 529 participants, comprising 289 men and 240 women. A convenience sampling method was employed,

with all respondents being university students. No financial or other incentives were offered for participation. Around 95% of the participants were aged 24 or younger.

For the purpose of this research, following social networking sites were included in the questionnaire: Twitter, LinkedIn, Skype, and Viber. The reason for including Skype and Viber is, that they represent non-typical social networks, as opposed to Twitter and LinkedIn, which are leaders in their respective fields. Also, they are not so widely studied in the existing literature. These were measured on an ordinal scale where 1 meant online connected, 2 meant 1x daily, 3 meant 1x weekly, 4 meant 1x monthly, 5 meant "I have an account, but I do not use it", and 6 meant "I do not have an account". These were used as dependent variables. The independent variable was risk-aversion. It was measured on a 1-10 Likert scale where 1 meant risk-loving, and 10 meant risk-aversion. Control variables were gender, and age. Ordinal regression function of IBM SPSS 27 will be used to test how risk-aversion, gender, and age influence use of social networking sites. A variance inflation factor (VIF) will be used to evaluate the extent of multicollinearity.

3. Results of the Research

The ordinal regression model of the impact of risk aversion, age, and gender on use of LinkedIn is provided in Tab. 1.

Tab. 1: Ordinal regression model for LinkedIn

	Estimate	Std. Error	Wald	Df	Sig.
use = 1	-8.321	0.844	97.153	1	0.000
use = 2	-7.399	0.808	83.902	1	0.000
use = 3	-6.455	0.783	67.959	1	0.000
use = 4	-5.918	0.773	58.668	1	0.000
use = 5	-5.169	0.762	46.067	1	0.000
Age	-0.256	0.035	53.280	1	0.000
Risk aversion	0.171	0.045	14.684	1	0.000
Gender = male	-0.402	0.191	4.455	1	0.035
Gender = female	0 ^a	.	.	0	.

Legend: a. This parameter is set to zero because it is redundant
 Source: authors' calculations in IBM SPSS 27

The use of LinkedIn is influenced by risk aversion, gender, and age, with higher usage observed among risk-averse individuals, men, and older users.

With regards to the explanatory power, Cox and Snell pseudo-R² is 0.145, Nagelkerke pseudo-R² is 0.157, McFadden pseudo-R² is 0.065, and the significance of the model fit is below 0.001.

The ordinal regression model of the impact of risk aversion, age, and gender on use of Twitter is provided in Tab. 2.

Tab. 2: Ordinal regression model for Twitter

	Estimate	Std. Error	Wald	df	Sig.
use = 1	-2.164	0.650	11.069	1	0.001
use = 2	-1.577	0.647	5.943	1	0.015
use = 3	-1.167	0.645	3.271	1	0.071
use = 4	-0.960	0.645	2.218	1	0.136
use = 5	-0.093	0.643	0.021	1	0.885
Age	-0.003	0.029	0.012	1	0.914
Risk aversion	-0.016	0.038	0.166	1	0.683
Gender = male	-0.691	0.165	17.565	1	0.000
Gender = female	0 ^a	.	.	0	.

Legend: a. This parameter is set to zero because it is redundant
 Source: authors' calculations in IBM SPSS 27

Gender is the sole factor influencing Twitter usage, with men exhibiting higher usage rates. With regards to the explanatory power, Cox and Snell pseudo-R² is 0.034, Nagelkerke pseudo-R² is 0.035, McFadden pseudo-R² is 0.011, and the significance of the model fit is below 0.001.

The ordinal regression model of the impact of risk aversion, age, and gender on use of Skype is provided in Tab. 3.

Tab. 3: Ordinal regression model for Skype

	Estimate	Std. Error	Wald	df	Sig.
use = 1	-3.940	0.797	24.456	1	0.000
use = 2	-3.231	0.756	18.246	1	0.000
use = 3	-2.473	0.735	11.319	1	0.001
use = 4	-1.728	0.725	5.680	1	0.017
use = 5	1.452	0.722	4.037	1	0.045
Age	0.028	0.033	0.728	1	0.393
Risk aversion	-0.048	0.043	1.214	1	0.270
Gender = male	-0.117	0.184	0.407	1	0.523
Gender = female	0 ^a	.	.	0	.

Legend: a. This parameter is set to zero because it is redundant
 Source: authors' calculations in IBM SPSS 27

None of the considered variables impact use of Skype. With regards to the explanatory power, Cox and Snell pseudo-R² is 0.004, Nagelkerke pseudo-R² is 0.004, McFadden pseudo-R² is 0.002, and the significance of the model fit is 0.585.

The ordinal regression model of the impact of risk aversion, age, and gender on use of Viber is provided in Tab. 4.

Tab. 4: Ordinal regression model for Viber

	Estimate	Std. Error	Wald	Df	Sig.
use = 1	-1.362	0.880	2.398	1	0.122
use = 2	-0.675	0.862	0.613	1	0.434
use = 3	-0.225	0.856	0.069	1	0.792
use = 4	0.194	0.852	0.052	1	0.820
use = 5	1.691	0.852	3.939	1	0.047
Age	0.075	0.040	3.556	1	0.059
Risk aversion	0.101	0.043	5.518	1	0.019
Gender = male	0.180	0.182	0.975	1	0.323
Gender = female	0 ^a	.	.	0	.

Legend: a. This parameter is set to zero because it is redundant

Source: authors' calculations in IBM SPSS 27

Risk aversion influences Viber usage, with higher adoption observed among risk-averse individuals. With regards to the explanatory power, Cox and Snell pseudo- R^2 is 0.019, Nagelkerke pseudo- R^2 is 0.022, McFadden pseudo- R^2 is 0.009, and the significance of the model fit is 0.016.

4. Discussion

This study provides novel insights into how risk aversion, age, and gender influence the adoption and usage patterns of four distinct new media platforms: LinkedIn, Twitter, Skype, and Viber. The results underscore that these psychological and demographic factors do not uniformly affect all platforms, highlighting the importance of platform-specific analyses when investigating digital behavior.

Firstly, the finding that risk-averse individuals are more likely to use LinkedIn and Viber more frequently suggests that these platforms may be perceived as safer or more controlled environments compared to more open social networks. LinkedIn's professional networking focus might appeal to risk-averse users seeking to maintain a curated online presence with clear professional boundaries. Similarly, Viber, primarily a messaging app, may be viewed as a private communication tool, aligning with risk-averse preferences for controlled social interactions. This contrasts with Twitter, where risk aversion did not significantly predict usage, possibly due to its open and often unpredictable social environment, which may deter risk-averse users.

Secondly, gender differences emerged as significant predictors for LinkedIn and Twitter usage, with men using these platforms more than women. This aligns with previous literature suggesting gendered patterns in social media adoption and usage, potentially

reflecting differences in professional networking behaviors and social communication styles. The lack of gender impact on Skype and the exclusive influence of risk aversion on Viber usage further emphasize that gender effects are platform-dependent.

Thirdly, age was a significant predictor only for LinkedIn usage, with older users more engaged on this platform. This may reflect the professional orientation of LinkedIn, which is more relevant to users at later stages of their academic or career trajectories. The predominantly young sample (mostly under 24) may explain the limited age effects on other platforms, which are generally popular among younger demographics.

Interestingly, none of the studied variables significantly influenced Skype usage, suggesting that this platform's adoption may be driven by factors beyond risk aversion, age, and gender, such as situational needs for video communication or institutional requirements. The explanatory power of the models, while statistically significant for LinkedIn and Twitter, was modest, indicating that other psychological, social, or contextual factors likely contribute to new media adoption and use. Future research could incorporate additional variables such as personality traits, cultural influences, or technological literacy to deepen understanding. While the study was conducted with a student sample, evidence from similar research indicates a strong likelihood that the findings would generalize to the broader population.

Overall, these findings highlight the complex interplay between individual psychological traits and demographic characteristics in shaping digital behavior. They suggest that platform developers and marketers should tailor their strategies to accommodate diverse user profiles, considering how risk perceptions and demographic factors influence engagement. E.g., enhancing privacy controls and professional features may attract risk-averse users, while gender-sensitive communication strategies could improve inclusivity.

Conclusion

This study embarked on an empirical investigation into the intricate relationship between risk aversion, age, and gender and the adoption and usage patterns of four prominent new media platforms: LinkedIn, Twitter, Skype, and Viber. Our findings reveal that these individual characteristics significantly influence digital behavior, though their impact is notably platform-specific rather than universal. Specifically, we found that risk-averse individuals were more inclined to use LinkedIn and Viber, suggesting a preference for platforms perceived as more structured, private, or professionally oriented. This contrasts with more open social networks where risk aversion might lead to lower engagement. The study also highlighted significant gender differences, with men exhibiting higher usage of LinkedIn and Twitter. This underscores the need to consider differing social and professional networking tendencies between genders. Furthermore, age emerged as a predictor solely for LinkedIn usage, with older students showing greater engagement, likely reflecting the platform's career-oriented nature. Importantly, the variables under consideration did not significantly impact Skype usage, indicating that its adoption may be driven by distinct contextual factors.

These results offer crucial insights for understanding user behavior in the evolving digital landscape. For platform developers and marketers, the implication is clear: a one-size-fits-all approach to user engagement is insufficient. Strategies should account for varying risk perceptions and demographic profiles. For instance, enhancing privacy settings and professional functionalities might attract risk-averse users, while gender-aware design could foster more equitable participation across platforms. Our findings also contribute to the broader academic discourse on technology adoption, reinforcing the idea that integrating psychological constructs like risk aversion alongside traditional demographics provides a more nuanced understanding than either factor alone.

Although generalized models such as the Technology Acceptance Model have been extensively validated across diverse information systems and communication technologies, their explanatory power could be enhanced by incorporating more fine-grained psychological and demographic variables to capture nuances in technology adoption (Aiolfi et al., 2021). While this study provides valuable empirical evidence, its limitations—such as the reliance on a university student sample and self-reported data—suggest avenues for future research. Expanding the sample to include a more diverse age range and professional backgrounds, utilizing objective usage data, and exploring additional psychological traits or cultural factors would further enrich our comprehension of new media adoption.

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The Significance of Social Entrepreneurship for Sustainable Municipal Development

Abstract

Social entrepreneurship offers significant potential for sustainable municipal development by integrating social, economic, and environmental values. This study examines the attitudes of mayors and representatives of municipalities in the administrative district with extended competence Liberec towards social enterprises. Results reveal a narrow perception focused mainly on employing disadvantaged groups, with limited awareness of broader environmental and economic aspects. Although social entrepreneurship is generally viewed favourably, municipalities lack strategic integration and support mechanisms. The study recommends targeted awareness-raising, institutional cooperation, and proactive municipal planning to fully realise the potential of social enterprises as a tool for inclusive, resilient, and sustainable community development.

Key Words: Social Entrepreneurship, Sustainable Development, Local Government, Disadvantaged Groups, Community Development

JEL Classification: L31, Q01

Introduction

In the context of current social, economic and environmental challenges, social entrepreneurship is gaining importance as an effective tool for promoting sustainable development at the municipal level. Social entrepreneurship combines economic goals with innovative solutions to social and environmental problems. It offers considerable potential for enhancing the quality of life in municipalities. Despite growing recognition of the benefits of social entrepreneurship at the national level, municipalities often face challenges in incorporating social entrepreneurship principles into their strategic plans. These obstacles are typically associated with a lack of expertise and practical experience. Social enterprises focus primarily on integrating disadvantaged groups into the labour market. That is why they are bringing economic benefits compared to registration at the

employment office and contributing to the reduction of social exclusion. At the same time, they are characterised by a strong relationship with the local environment, which is reflected in their emphasis on environmental protection and community development. In this respect, they represent an alternative to the prevailing trends of economisation, modernisation and materialisation of society (Malík Holasová, 2014). They make it with an emphasis on local community development, responsible human resource development and long-term sustainability.

This article aims to analyse the attitudes of mayors and municipal representatives in the administrative district of the municipality with extended competence Liberec towards social entrepreneurship in the context of sustainable development. A secondary aim is to assess the level of awareness of social entrepreneurship and its potential for addressing local social and environmental challenges. Social enterprises can play a key role in the development of municipalities. This means not only by supporting employment and social inclusion but also as partners of public administration in achieving sustainable development goals (Lindgreen et al., 2009).

The importance of social entrepreneurship is also reflected in the macroeconomic context, where its development contributes to the stability and resilience of local economies (DTI, 2002). This contribution is supported by legislative measures at the national level, such as the Act on Integrative Social Enterprise, and development tools at the regional level, including business incubators, advisory centres, and thematic catalogues of social enterprises. The article's structure is as follows: the introductory section is followed by a literature review, which provides a theoretical framework for the issue under investigation. Subsequently, the research methodology will be presented, the results obtained will be analysed. And finally, the key conclusions will be discussed, along with proposals for measures to support the development of social entrepreneurship within the local community.

There is no single, universally accepted definition of social entrepreneurship in the professional literature. In general, social entrepreneurship is understood as a market-oriented strategy aimed at achieving a social goal (Kerlin, 2009). In a narrower sense, the emphasis is primarily on employing socially excluded people, which brings both economic and social benefits (Austin et al., 2006). A broader concept of social entrepreneurship includes not only social enterprises but also socio-environmental and integration enterprises. In this concept, the harmonisation of business, moral, and social identity is necessary. It is, therefore, not primarily about the commercialisation of nonprofit organisations but rather about finding a balance between economic sustainability and social benefits.

From a broader perspective, social entrepreneurship is understood as an alternative mechanism arising from the inability of the market and the public sector to respond effectively to social problems. In this context, social enterprises are perceived as entities that seek to combine a social mission with economic self-sufficiency. They are characterised by specific values and goals (Dey, 2014). These enterprises utilise market mechanisms that are based on the principles of sustainability and social responsibility while generating profits (Dey, 2014). Social enterprises can be considered as an indicator

of the level of social responsibility, i.e., the extent to which their activities are consistent with the goals and principles of sustainable development (Hertel et al., 2022). Social entrepreneurship at the community level represents an innovative approach to solving local problems and also a key tool for promoting sustainable development. The importance of supporting social enterprises is also evident in the context of macroeconomic stability (DTI, 2002), where they can contribute to strengthening social cohesion and economic resilience.

The primary goal of social entrepreneurship is to carry out activities that benefit the public, which are explicitly enshrined in the founding documents and are fulfilled through economic activity. Social enterprises often focus on employing people at risk of social exclusion and also integrate an environmental approach. On the other hand their activities are frequently closely linked to environmental protection. A key aspect of developing social enterprises is the implementation of sustainable development principles, which encompass ecological responsibility, responsible human resource management and active support of community development (Lindgreen et al., 2009). Social entrepreneurship is an integral part of the broader social economy framework, guided by principles of social contribution, responsibility, transparency, and democratic decision-making regarding profit.

One of the key aspects of social entrepreneurship is its ability to respond flexibly to the specific needs of local communities. On one hand, nonprofit organisations and associations are involved in these activities. On the other hand, it is the municipalities themselves that often initiate projects aimed at employing disadvantaged groups or addressing environmental issues. A participatory approach to local community development makes a significant contribution to strengthening social capital, fostering trust, and cultivating positive relationships between social enterprises and public institutions. This type of cooperation promotes long-term sustainability and increases the effectiveness of local development strategies. The community can play an active and crucial role in the development of a given municipal area. A well-chosen approach to this potential can lead to the creation of business opportunities within the local community. It is characteristic of social entrepreneurship that it predominantly operates in local and regional markets, fulfilling its mission at the local level by addressing social problems and promoting environmental sustainability (Barraket et al., 2010).

Community entrepreneurship can be developed through social enterprises, also including those owned by municipalities (Sriyono et al., 2021). A specific example is the so-called village enterprises in Indonesia (Kania et al., 2021) or NGOs involved in microenterprise development to alleviate poverty in a local community (Luke and Chu, 2013). Village-owned enterprises can contribute the prosperity of local communities and can be managed in collaboration with residents (Kushartono et al., 2023). For the effective development of these enterprises, it is essential to properly select the target community and identify its specific characteristics that can facilitate the socialisation of disadvantaged groups (Battilana and Dorado, 2010). One of the indicator of territorial development and a fundamental feature of sustainability, is the positive relationship of the inhabitants with the area. The link between the public sector and the local community can be realised through voluntary and community sector organisations. These

organisations play a crucial role in fostering social cohesion. In some cases social enterprises can represent the interests of the community in opposition to public institutions. Social entrepreneurs who are primarily motivated by social purpose can be perceived by the local community as trustworthy providers of public services at the local level (Muftugil-Yalcin and Mooijman, 2024).

Social enterprises, by their very nature, are based on principles of social responsibility. So it is natural to expect close and positive cooperation with local governments. Municipalities can contribute significantly to the development of social enterprises through the provision of land, professional facilities, the use of municipal facilities or in the form of financial support. The attitude of mayors and other municipal leaders towards social entrepreneurship and sustainable development plays a crucial role in shaping a modern business and social environment. In this time there are growing efforts to integrate sustainability principles into local development policies, which are essential not only for economic growth but also for ensuring social and environmental well-being. Mayors, as key actors in local governments, can significantly influence the promotion and support of social entrepreneurship aimed at addressing social challenges and improving the quality of life of residents (Svatošová and Novotná, 2012). The importance of mayors' involvement lies in their ability to strategically manage the development of municipalities and effectively utilise available instruments (such as for example European Structural Funds). These funds represent a crucial source of funding for projects aimed at enhancing economic and social cohesion, which are contributing the reduction of regional disparities (Svatošová and Novotná, 2012) and improving the living conditions of residents. Mayors thus become not only advocates of local interests, but also facilitators of social innovation and entrepreneurial initiatives that can enrich the life of the local community (Knapová, 2011).

Foreign experience, for example, from the Netherlands (Backer, 2019), shows that although cooperation between social enterprises and municipalities is considered important, entrepreneurs often lean more towards a model of autonomous diversity. This approach suggests a desire for independence. On the other hand, they would welcome a more supportive institutional environment. Barriers to cooperation may be due to a lack of political will (Backer, 2019) or a vague idea of the possibilities of interconnection. Institutional barriers stemming from different goals and values can hinder the effective engagement of social enterprises in municipal structures, which often favour commercial interests and do not adequately reflect social impact in the subsidies (Muftugil-Yalcin and Mooijman, 2024). At the same time, social enterprises often actively contribute to solving public problems, such as poverty or limited access to resources crucial for human well-being, for example drinking water (Westley et al., 2011). It is, therefore, essential that municipal representatives recognise the importance of these enterprises, identify their potential and seek systematic collaboration.

Empirical evidence from the US (Korosec and Berman, 2006) shows, that in 2003 more than half of city leaders reported that their cities had high levels of social entrepreneurship, with collaboration taking place directly or through grant programmes. An inspiring example from the European context is the Amsterdam Impact initiative, which aims to make Amsterdam an internationally recognised centre for social

entrepreneurship (Amsterdam Municipality, 2019). This paper will focus on assessing the attitudes of mayors and representatives of municipalities in the administrative district with extended competence Liberec, which has extended competence towards social entrepreneurship in the context of sustainable development. As well as their awareness of the social entrepreneurship issue and its potential for sustainable municipal development. **The research is based on answering the following research questions:**

1. What attitudes do mayors and representatives of municipalities in the administrative district of the municipality with extended competence, Liberec, have towards social entrepreneurship?
2. What is their awareness of the concept of social entrepreneurship and its dimensions (social, environmental, economic)?
3. How do they perceive the potential of social entrepreneurship to support the sustainable development of their municipalities?
4. What are their views on the possibilities of municipal support for social entrepreneurship?

1. Methods of Research

The research was conducted between April and June 2024 through a questionnaire survey to assess the attitudes of mayors and representatives of municipalities within the administrative district of the municipality with extended competence, Liberec, towards social entrepreneurship in the context of sustainable development. The choice of this administrative unit was based on the principle of subsidiarity, as the authorities of individual municipalities serve an important link between regional and local levels of public administration. The research focused on individual municipalities within the administrative district with extended competence Liberec.

The survey aimed to obtain the views of municipal representatives on social entrepreneurship, their awareness of its principles and their perception of its potential for municipal development. Based on the information received, recommendations were formulated to raise awareness of social entrepreneurship. The questionnaire was designed by the research team from the Faculty of Economics at the Technical University of Liberec based on previous experience with family entrepreneurship research and an extensive literature search. It contained both closed- and open-ended questions, focusing on the definition of social enterprise, its importance for community development, forms of support, and identification of development needs. For example: Which activities in your municipality are supported by social enterprises? (Select any number of answers, or add others)

The distribution of the questionnaires was carried out through personal visits to the mayors of the municipalities by the team from the Municipality of Liberec's Department of Territorial Analytical Documentation and Geographical Information System. All 28 municipalities in the administrative district of the municipality with extended competence Liberec, were contacted. The return rate was 15 completed questionnaires. A combination of quantitative methods (mainly percentage of responses) and qualitative

approaches (analysis of open-ended responses) was used for data analysis. The low return rate may have been influenced by respondents' concerns about their lack of knowledge of the topic or misinterpretation of the topic. The timing of the survey, which took place before the regional elections, may also have played a role.

2. Results of the Research

The analysis of the questionnaire survey results shows, that the prevailing perception of social entrepreneurship among representatives of municipalities in the administrative district of the municipality with extended competence Liberec, is closely related to the employment of people disadvantaged in the labour market. Up to 93% of respondents associate the term "social enterprise" with this characteristic. In comparison, almost 80% perceive it primarily as a workplace for people with disabilities, whose main objective is to support these individuals regardless of economic performance or production quality. This approach is consistent with a narrower definition of social enterprise that emphasises the integration function of people at risk of social exclusion (Austin et al., 2006).

Conversely, perceptions of the broader concept of social entrepreneurship, which involves linking social purpose with economic self-sufficiency and environmental responsibility (Dey, 2014), are only marginally represented among respondents. Only a third of respondents believe that social enterprises play a significant role in achieving the Sustainable Development Goals. The environmental dimension, economic sustainability, and broader impact on the local community are not perceived by respondents as important aspects of social enterprise. This gap between the theoretical framework and practical perceptions may be probably due to a lack of awareness and focus on the social aspects of entrepreneurship by municipal representatives. A limited understanding of the complex nature of social entrepreneurship may be one reason why municipalities fail to fully leverage their potential in their development strategies. The lack of knowledge and experience in this area is a significant barrier to the effective implementation of the social entrepreneurship concept in practice.

The research results also point to specific benefits that social enterprises can offer to municipalities. The most frequently mentioned benefit is their role in social development - 57% of respondents perceive their potential in reducing unemployment and straightening labour market conditions. Half of the respondents also state, that social enterprises, through the employment of disadvantaged individuals, contribute to improving their living conditions, strengthening their sense of security and enhancing the overall quality of life in the municipality. The economic self-sufficiency of social enterprises is also perceived positively - half of the respondents believe, that social enterprises can generate profit and are not entirely dependent on public support, which supports their long-term sustainability. Environmental benefits are perceived less strongly - only a fifth of respondents perceive social enterprises as actors with a positive relationship to ecological protection. However, 29% of respondents consider it important, that these enterprises can contribute to environmental objectives, for example, by reducing CO₂ emissions or energy intensity.

An interesting finding is, that although only a fifth of respondents know the specific social enterprises operating in their community (for example Texman was mentioned in Liberec), 43% of respondents assume they are linked to the local community, and 36% perceive their contribution to regional development. These results may indicate a general, superficial awareness of the community character of social enterprises. The key areas of community development are considered by 60% of respondents to be addressing the situation of disadvantaged residents, improving the quality of public space and expanding the range of community activities. It means, these are areas that social enterprises can effectively fulfil not only through supporting the employment of people with specific needs but also through environmental projects or initiatives aimed at developing local communities. Although respondents are often unaware of this potential, the results suggest, that social enterprise can be an important tool for addressing specific regional challenges.

The research findings are not consistent with the high level of awareness and engagement with social enterprises reported for example in the US context in Korosec and Berman's (2006) study. A narrow and simplistic perception of social entrepreneurship persists in the administrative district of the municipality with extended competence Liberec, which is reduced to the inclusion of disadvantaged groups in the labour market. The majority of respondents (71%) are unaware of the specific involvement of social enterprises in the municipality's life. Only a minority understand their broader role in sustainable development. The results show that:

- a) perceptions of social enterprise among municipal representatives are narrow, focused mainly on the employment of disadvantaged people;
- b) environmental and economic aspects are perceived less strongly;
- c) low knowledge of specific social enterprises in municipalities limits their use;
- d) there is potential for development, but a lack of systematic support and awareness-raising exists.

The results of the study indicate the need for systematic awareness-raising and support for social entrepreneurship at the municipal level. The study provides empirical insight into the perception of social entrepreneurship in a specific regional context and contributes to expanding knowledge about its potential for sustainable development. It also highlights the need to bridge the gap between theoretical concepts and practical understanding of the phenomenon of social entrepreneurship at the local government level.

3. Discussion

The research aimed to analyse the attitudes of mayors and representatives of municipalities in the administrative district of the municipality with extended competence Liberec, with extended competence in social entrepreneurship within the context of sustainable development and to assess their awareness of this concept. The results show, that although respondents intuitively realise the potential of social

entrepreneurship for the development of local communities, their understanding is mainly reduced to the employment of people disadvantaged in the labour market. Such narrowly defined perceptions represent a significant barrier to the full use of social entrepreneurship as a tool for sustainable community development.

The research was burdened by several limitations that may affect its generalizability. One of the main limitations was the low return rate of the questionnaires - only 15 of the 28 municipalities participated in the survey. This fact reduces the representativeness of the results. The low participation may have been due to respondents' concerns about their limited knowledge of the topics of social entrepreneurship and sustainable development. The timing of the survey in the run-up to the regional elections may also have negatively affected respondents' willingness to participate. Another limitation is the regional focus of the survey, which does not allow direct application of the findings to other regions with different socio-economic conditions. The prevailing narrow perception of social entrepreneurship among respondents may also have influenced their answers to questions about the broader benefits of the concept. The fact that 71% of respondents were unaware of any specific social enterprise operating in their community, may have further limited the depth of their responses.

However, from a theoretical perspective, it is clear that social enterprise has a much broader scope, including environmental responsibility, economic self-sufficiency and active engagement in community life. To effectively integrate this concept into municipal strategic planning, it is essential to overcome the current knowledge and awareness deficit, not only among municipal representatives but also within the broader community. Public administrations should take a proactive approach to promoting social entrepreneurship in the future. It includes systematic awareness-raising, education and facilitating dialogue between municipalities and social enterprises. Such an approach can lead to the creation of workable partnerships and contribute to building more sustainable and prosperous communities. Such as for example in America (Korosec and Berman's, 2006).

Based on the findings of the research, the following recommendations for public administration can be formulated. This can contribute to the effective increase of social entrepreneurship as a tool for sustainable development:

1. Promoting employment and levelling labour market conditions.

- a) Introduction of interest-free or low-interest loans for social enterprises aimed at employing disadvantaged groups as an instrument of active employment policy.
- b) Prioritising local suppliers and social enterprises in public procurement as a form of support for the local economy and an inclusive labour market.
- c) Establishment of municipal social enterprises as a direct tool to tackle unemployment of disadvantaged groups and promote social integration at the local level.

2. Strengthening social cohesion and quality of life in the municipality.

- a) Provision of municipal premises under favourable conditions for social enterprise activities that contribute to the integration of disadvantaged people into community life and the strengthening of social cohesion.
- b) Implementation of awareness-raising campaigns to disseminate information on the benefits of social entrepreneurship and its impact on local communities.

3. Promoting the economic sustainability of social enterprises.

- a) Providing expert advice on the development of socially-oriented business plans.
- b) Developing business incubators to support start-up social enterprises and to ensure their economic viability and long-term sustainability.

4. Promoting the environmental dimension of social entrepreneurship.

- a) Prioritising social enterprises in public procurement with an environmental focus.
- b) Including environmentally oriented activities in the evaluation criteria of competitions (such as the Village of the Year) and awarding environmentally oriented social enterprises to increase their visibility and prestige.

Future research should focus on a deeper analysis of the barriers to implementing social entrepreneurship at the municipal level and on a comparative study of the relationship between municipalities and social enterprises in different regions or countries, including examples of best practices.

Conclusion

Social entrepreneurship is a crucial tool for promoting sustainable municipal development, particularly in areas such as employment for disadvantaged groups, fostering community cohesion and promoting environmental responsibility. However, research conducted in the administrative district of the municipality with extended competence Liberec, has shown, that awareness of the concept among municipal representatives is limited and often reduced to its social dimension. To effectively integrate social entrepreneurship into municipal development strategies, it is necessary to strengthen awareness, promote cooperation between public administration and social enterprises and create a favourable institutional environment. Only under these conditions can the full potential of social entrepreneurship as a tool for building inclusive, economically stable and environmentally responsible communities be realised.

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Human Resource Management in Biotech and DeepTech Startups - the Pilot Study

Abstract

Startups are important drivers of innovation and economic transformation. Biotech and DeepTech sectors are particularly significant, requiring deep scientific insight, advanced education, and robust support systems to translate high-tech breakthroughs into market-ready applications. Unlike established corporations, startups operate under conditions of high uncertainty, limited resources, and rapid development. Their success depends not only on technological advancement and access to capital but also on effective human resource (HR) management tailored to early-stage dynamics. This paper presents a structured review of academic literature, reports, and case studies from the past fifteen years (2010–2025), complemented by a pilot consultation reflecting the Czech and broader Central and Eastern European (CEE) context. It analyses key dimensions of HR management in Biotech and DeepTech startups, including leadership, talent acquisition and retention, interim management, and the role of support infrastructures such as incubators and accelerators. Particular attention is given to the challenges of attracting specialized talent, building interdisciplinary teams, and bridging cultural differences between science and business. The findings highlight the importance of visionary and adaptable leadership capable of navigating complex regulatory and organizational environments, as well as the contribution of interim managers, business angels, and early-stage investors who help fill strategic HR gaps and provide mentoring. Additionally, the study aligns with European policy frameworks promoting gender equality and HR capacity-building. Supported by literature-based evidence and region-specific insights, the paper offers recommendations for founders, investors, and policymakers, concluding that strategic HR management is a critical factor for long-term competitiveness of innovation-driven ventures.

Key Words: Startups, Deeptech, Human Resource, Leadership, Interim Management

JEL Classification: M12, M13, O32

Introduction

Startups belong to key drivers of technology transfer and innovation, significantly influencing economic growth and technological advancement (Cohen, 2014; Dealroom,

2023). Unlike traditional established corporations, startups operate in environment with significant uncertainty, rapid growth, and highly limited resources. The success of startups is highly influenced by effectiveness of a human resource management (HRM) and its impact on team dynamics, leadership, and talent retention (Mahadevia, 2014; Van Scheijndel, 2020). Operating at the intersection of science, technology, and business, DeepTech and Biotech startups aim to develop disruptive solutions that challenge existing markets or create entirely new ones. According to the European Commission (Dealroom, 2023), startups typically exhibit high growth potential, a global outlook, and a strong emphasis on technological and digital innovation.

Unlike traditional businesses, startups are defined by their ability to quickly adapt strategies and processes, while building scalable business models. As Ries (2011) notes, a startup is a temporary organization designed to search for a repeatable and scalable business model through iterative experimentation and feedback-driven learning. Particularly within the fields of Biotech and DeepTech, startups face unique challenges and opportunities that stem from long development cycles, high research and development costs, and a strong reliance on academic-industry collaboration and technology transfer (Van Rooij, 2023; MIT REAP, 2022).

European policy frameworks, such as Horizon Europe and the European Innovation Council (EIC), increasingly emphasize gender equality and HR capacity as drivers of innovation. Measures such as the mandatory Gender Equality Plan (GEP) for Horizon Europe applicants and targeted initiatives like Women TechEU, which supports women-led deep-tech startups, underline that HR strategies also intersect with compliance and funding eligibility (European Commission, 2023; EIC, 2024).

Against this background, this study investigates HRM strategies that enable Biotech and DeepTech startups to address organizational and ecosystem-level challenges. It focuses on leadership dynamics, talent acquisition and retention, interim management, and the role of support infrastructures such as incubators and accelerators. While the literature review adopts an international perspective, preliminary findings were validated through a pilot consultation reflecting the Czech and broader Central and Eastern European (CEE) context. This combined approach offers both a conceptual framework and region-specific insights, aiming to inform best practices for founders and investors as well as policy recommendations to strengthen innovation ecosystems.

1. Methods of Research

This study consists of a literature review analysing academic papers, industry reports, and case studies related to human resource management (HRM) in Biotech and DeepTech startups. The literature was systematically searched using academic databases including Scopus, Web of Science, and Google Scholar, focusing primarily on contributions published between 2010 and 2025, with particular emphasis on recent research from the last five years.

To complement the literature review, preliminary insights were validated through a pilot consultation with three seasoned professionals offering diverse ecosystem perspectives: a general partner of a DeepTech/ Biotech fund (**VC fund perspective**), an institutional LP representative (**banking and financial sector**), and a Biotech startup CEO (**individual startup perspective**). Semi-structured interviews (**45–60 minutes**) explored HR challenges, talent dynamics, and interim leadership needs. This pilot captured strategic viewpoints and provided qualitative validation of the literature findings. Their insights reflect the perspective of the Czech innovation ecosystem and, to some extent, broader CEE region. A broader stakeholder survey is planned in the next research phase to enhance generalizability.

The key areas of focus include:

1. Challenges for DeepTech and Biotech Startups
2. The role of leadership and HR management in startup success.
3. Talent acquisition and retention strategies in highly specialized sectors.
4. The impact of interim management in bridging managerial gaps.
5. The effectiveness of external support: incubators, accelerators, and venture capital in HR strategies.

A qualitative analysis was conducted to synthesize insights and identify patterns that contribute to the scalability and sustainability of Biotech and DeepTech startups.

2. Results of the Research

2.1 Challenges for DeepTech and Biotech Startups

Management of startups includes a wide range of challenges critically shaping their trajectory, moreover, additional complexity is observed in high-tech fields like Biotech and DeepTech. Financial uncertainty is among the most pressing issues, as early-stage ventures often require significant investment in product development while revenue or profit is usually not generated before exit. These startups are typically dependent on external funding provided by investors or non-dilutive public support, which demands credible business models and clear paths to return on investment (**Ries, 2011; Van Rooij, 2023**). Regulatory demands on newly developed products, especially in sectors like pharmaceuticals and medical technologies dramatically increase needed resources and timelines for innovative products marketing. To obtain approvals from bodies such as the FDA, EMA or MDR notified bodies can be time-consuming and expensive (**Franco, 2025; Martjan, 2025**). In addition, attracting and retaining relevant highly experienced staff and top-tier talent is increasingly difficult due to intense competition with established firms and the limited financial resources of young startups (**Scheijndel, 2023**).

Beyond regulatory challenges, many startups introduced in less mature ecosystems such as Central and Eastern Europe usually struggle due to limited access to experienced founders, serial entrepreneurs, and professional management. A lack of practical know-

how in areas like fundraising, international expansion, and product development can limit growth potential (Xiao, 2024; Chahine et al., 2020).

Another critical challenge lies in human resource management, which in startup settings differs significantly from established companies. DeepTech and Biotech startups typically operate in high-uncertainty environments with limited resources and fast-changing team structures. Unlike corporates with formalized HR systems, these startups must build effective teams quickly, often by combining diverse skill sets from scientific, technical, and commercial domains (Watson, 2025). This requires not only targeted talent acquisition, but also strategic decisions about team structure, leadership roles, and culture-building from the earliest stages. HR in these startups must balance flexibility with long-term planning, especially as they transition from small, informal teams to structured organizations. Managing this evolution effectively (including the onboarding of experienced external leadership, handling interdisciplinary collaboration, and fostering retention) is essential for sustained innovation and growth (NeSmith, 2024; Mahadevia, 2014).

These constraints underline a key insight: startup success depends not only on breakthrough ideas or technological innovations, but also on the ability to navigate complex financial, regulatory, and human capital hurdles. This is particularly true for Biotech and DeepTech ventures, where risk, timelines, and resource requirements are inherently greater.

2.2 Leadership in Startups

Leadership plays one of the most crucial roles in startup success, especially in complex and high-tech fields such as Biotech and DeepTech. Unlike in traditional corporates, startup leadership demands rapid decision-making, adaptability, and the ability to inspire teams under high uncertainty and limited resources (Ries, 2011). Successful startup leaders show visionary thinking, resilience, and a hands-on approach to deliver expected outcomes (McKinsey & Company, 2024). In science-driven ventures, leaders should be able to bridge the cultural and communication gap between research-oriented teams, investors and business stakeholders. These challenges require strong interpersonal skills, adaptability in strategic decision-making, and the capacity to operate effectively even when information is incomplete or evolving (Van Scheijndel, 2020; Gloor, 2011; Reynolds, 2024).

A common dilemma is whether startups should remain founder-led or transition to professional management as they grow. Founders often bring passion and deep technology insight but may lack experience in business development and scale-up activities, managing operations, or navigating relationships (Chahine et al., 2020). Interim management could be one of interesting solutions, allowing startups to temporarily onboard experienced executives for critical phases like fundraising, international expansion, or restructuring before upcoming financing round (Mochnacz, 2023; Van Rooij, 2023) as well as overpass lack of regulatory expertise (Martjan, 2025). This approach offers startups strategic expertise, agility, and knowledge transfer without long-

term cost commitments (Mulder, 2020). In Biotech and DeepTech startups, leadership must also contend with long R&D cycles, strict regulatory pathways, and interdisciplinary teams, which require exceptional coordination skills and communication capabilities (MIT REAP, 2022; Xiao, 2024).

In addition, leadership diversity is getting to be recognized as a performance driver including diversity by gender, background, or cultural perspective. Diverse teams are associated with more robust decision-making and innovation (Hughes, 2024). Inclusive organizational cultures belong to supportive aspects especially in science-based ventures, where both scientific excellence and commercial impact should be valued. Ultimately, strong leadership in startups is not only about vision but also about navigating complex ecosystems, integrating different mindsets, and continuously aligning purpose, people, and performance (McKinsey & Company, 2024; Fabian, 2024). These leadership qualities become even more critical given the reliance on external stakeholders for funding and strategic alignment in Biotech and DeepTech ventures.

2.3 Interim Management and Support Infrastructure

With respect to the importance of leadership outlined above, many startups (especially those in Biotech and DeepTech) face significant limitations in leadership capacity and operational expertise, particularly during critical stages of growth and transformation. One of the valuable solutions could be an interim management allowing companies to temporarily engage experienced professionals to bridge gaps in leadership, regulatory knowledge, or business development. Hired interim leaders could provide strategic input, oversee key transitions such as scaling or restructuring, and could be crucial to improve trust of investors. Furthermore, these positive effects do not require long-term commitments and financial liability before companies are able to hire experienced staff (Mochnacz, 2022; Mulder, 2020). As noted by Mochnacz (2023), interim managers are particularly effective in helping early-stage startups navigate uncertainty and align teams with evolving business needs.

In parallel, the broader startup support ecosystems and infrastructure plays a complementary role in addressing capability gaps and facilitating startup growth (Cohen, 2014). It could consist of venture -building incubators, supportive accelerators, and early-stage investors or business angles, who are able to support companies with a hands-on approach. These individuals and platforms usually offer structured programs focused on business planning, legal and regulatory support, mentorship, and access to networks and associated investors. The importance of such support is magnified in highly technical sectors, where specialized resources such as laboratories, compliance expertise, and academic-industry partnerships are often essential for progress (Van Rooij, 2023). Business angels, as highlighted by Lange et al. (2024), contribute not only early-stage capital but also strategic guidance and operational know-how. Angles often act as interim managers themselves, serving as a board members, or chairs, supporting strategic targeting and leadership or supporting significant hiring decisions. In this perspective, supportive infrastructure including angel investors can significantly strengthen HR strategies and act as a de-risking mechanism.

Taken together, interim executives, startup infrastructure, and engaged investors form a synergistic ecosystem that reinforces leadership capacity and organizational resilience. For

Biotech and DeepTech startups, this combination helps mitigate key risks associated with talent shortages, knowledge gaps, and regulatory complexity—challenges that are often more pronounced than in other sectors. As such, effective use of interim management and support mechanisms can significantly improve the odds of sustainable scaling and long-term success.

3. Discussion

The findings presented in this study highlight several key dimensions of effective human resource management (HRM) in Biotech and DeepTech startups. These include the importance of visionary leadership, strategic use of interim management, and the enabling role of supportive infrastructure and engaged early-stage investors. In summary, these elements form a synergistic framework that helps startups navigate common constraints, including limited resources, regulatory complexity, and talent shortages, which are particularly pronounced in high-tech sectors. To make these findings more accessible for both academic and practitioner audiences, the key HR success factors identified in this study are summarized in Table 1. These factors synthesize literature-based insights and practical perspectives into an actionable framework for Biotech and DeepTech startups.

The table illustrates how leadership, interim management, talent strategies, and ecosystem support collectively contribute to startup resilience and scalability. These dimensions are not isolated but interdependent, reinforcing the need for integrated HR strategies that combine internal capabilities with external resources.

To preliminarily validate the relevance of these factors within a Czech and CEE context, a pilot stakeholder consultation was conducted with three seasoned professionals representing diverse ecosystem perspectives:

- a general partner of a DeepTech/Biotech fund (venture capital perspective),
- a representative of an institutional limited partner (banking and financial sector),
- and a CEO of a Biotech startup in the CEE market.

Despite the small sample size and exploratory nature of the consultation, the feedback broadly supported the study's key conclusions:

1. HR related challenges are among the most critical barriers to scaling DeepTech and Biotech startups.
2. Interim management could be seen as a practical and cost-effective way to bridge leadership and execution gaps in key stages of growth.
3. Supportive infrastructure, mentorship and early-stage investor support could (in perspective of responders) increases the likelihood of a long-term success of startups.

Tab. 1: HR Success Factors for Biotech and DeepTech Startups

HR Success Factor	Why It Matters	Implications for Startups
Visionary & Adaptive Leadership	Startups require leaders who can align science, business, and investor expectations under uncertainty.	Essential for navigating long R&D cycles, regulatory hurdles, and interdisciplinary teams.
Strategic Use of Interim Management	Bridges critical capability gaps during growth, funding rounds, or regulatory preparation.	Offers cost-effective expertise and boosts investor confidence without long-term commitment.
Effective Talent Acquisition & Retention	Attracting specialized talent is difficult due to competition and limited resources.	Requires creative incentives (equity), mission-driven culture, and strong onboarding practices.
Breaking Down Silos	Cultural gaps between scientists, business teams, and investors slow decision-making.	HR policies should foster cross-functional collaboration and communication early on.
Leveraging Support Infrastructure	Incubators, accelerators, and innovation hubs provide expertise, labs, and mentorship.	Reduces cost of scaling and improves access to compliance/regulatory knowledge.
Investor & Business Angel Engagement	Early-stage investors often add strategic HR guidance beyond capital.	Use investors as mentors, board members, or even interim managers during scaling phases.
Diversity in Leadership & Teams	Diversity drives creativity, resilience, and innovation capacity.	Encourage inclusion in gender, cultural background, and skills to strengthen team adaptability.
Culture & Organizational Development	Early HR systems influence long-term scalability and stability.	Founders should prioritize building values, trust, and feedback culture from the outset.

Source: authors

These findings also align with European innovation policies, which increasingly embed HR capacity-building and diversity into their funding frameworks. For example, Horizon Europe requires applicants to implement a Gender Equality Plan (**GEP**) as an eligibility criterion, while the European Innovation Council (**EIC**) promotes diversity by targeting at least 40% participation of women-led startups in pitch interviews and ensuring gender balance in evaluation panels. Initiatives such as Women TechEU further provide financial and mentoring support to women-led deep-tech ventures (**European Commission, 2023; EIC, 2024**). Incorporating these dimensions into HR strategies may enhance both organizational competitiveness and access to EU funding.

These pilot insights suggested that the core assumptions of this study are aligned with practitioner realities in the Czech startup environment. However, further and more comprehensive research is needed to understand regional specificities in HRM practices, ecosystem maturity, and institutional support. A broader survey or comparative case study approach across multiple CEE regions could provide more robust evidence base and

help tailor policy tools and support programs more effectively. This discussion sets the stage for translating insights into actionable strategies, both for startup practitioners and policymakers.

Conclusion

Biotech and DeepTech startups face a unique set of human resource challenges that significantly affect their long-term viability and competitive positioning. This study identified several strategic approaches that can help overcome these challenges and strengthen startup performance in the face of uncertainty and complexity. Leadership and management development: Scientifically oriented founders often lack experience in people management, business development, and organizational growth. Training programs provided by universities, incubators, and innovation hubs should focus on upskilling founders in leadership, strategic thinking, and cross-functional collaboration.

Interim management as a flexible solution: Engaging experienced interim managers enables startups to address specific organizational bottlenecks during critical growth phases. These professionals also facilitate knowledge transfer, team alignment, and investor confidence—without requiring long-term contracts.

Leveraging support infrastructure: Technology parks, incubators, and accelerators offer essential resources for early-stage startups. Their ability to provide legal, regulatory, financial, and strategic support is crucial for helping startups transition from early development to scalable operations. Strategic involvement of early-stage investors: Beyond providing capital, investors often contribute to HR strategy, governance, and mentoring, improving startup resilience and growth potential.

Promoting diversity in leadership and teams: Startups that embrace gender, cultural, and disciplinary diversity benefit from broader perspectives, stronger team dynamics, and improved innovation capacity. Diversity should be seen as both a social priority and a strategic advantage. This study provides an initial framework for understanding the strategic value of HRM in DeepTech and Biotech startup ecosystems. Future research should focus on validating these findings in broader regional contexts, exploring longitudinal effects of leadership transitions, and identifying high-impact interventions that enhance team resilience and talent retention across the startup lifecycle.

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