



Ekonomická
fakulta
Faculty
of Economics

Jihočeská univerzita
v Českých Budějovicích
University of South Bohemia
in České Budějovice

INPROFORUM 2025

Proceedings of the 19th International Scientific Conference
INPROFORUM. Economy Under Pressure.





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Foreword

The INPROFORUM conference is a long-standing academic event organized by the Faculty of Economics of the University of South Bohemia in České Budějovice since 2007. Over the years, it has provided a platform for academics, students, and practitioners to present the results of their work, share experience, and discuss current issues in the fields of economics, management, and public administration.

The INPROFORUM 2025 conference was held under the subtitle “Economy Under Pressure.” This theme reflects today’s environment, in which the economy, political decision-making, and public institutions increasingly face a combination of major challenges—from growing public debt and slowing economic growth to demographic shifts and rising pressure on health-care financing. These developments underline the need to seek solutions that are not only effective, but also sustainable in the long term.

This year’s plenary programme focused on two main topics. The first addressed the myths of public finance consolidation, which frequently appear in both professional and public debate on how budgets can be stabilized. The second topic concerned intermediation in health insurance markets, an area that can significantly influence how the health-care system functions, its cost structure, and the accessibility of health care.

The following keynote speakers contributed to the plenary session:

Assoc. Prof. Ing. Robin Maialeh, Ph.D., LL.M. (Research Institute for Labour and Social Affairs, Czech Republic)

Plenary lecture: “Myths of Public Finance Consolidation”

Anthony T. Lo Sasso, Ph.D. (DePaul University, Chicago, USA)

Plenary lecture: “Intermediation in Health Insurance Markets”

INPROFORUM 2025 connected broader public finance issues with the specific context of how health insurance operates, creating space for expert discussion on how to respond to economic pressure in practice.

Our participants submitted 51 papers, and 42 of them were presented in the following discussion forums on the topics listed below:

Recent and future trends and challenges in retail, international trade, marketing and tourism

Management of change and innovation

Resilient regions: Sustainability Under Pressure of Global Challenges and Uncertainty

Finance, accounting and taxes

Economics of agriculture: new challenges and opportunities

Economy resilience: macroeconomic and microeconomic perspective

Mathematical-Statistical Modelling and Optimization in Practice

The INPROFORUM 2025 conference was organized under the auspices of doc. RNDr. Zuzana Dvořáková Líšková, Ph.D., Dean of the Faculty of Economics at the University of South Bohemia in České Budějovice.

Finally, I would like to express my sincere thanks to all conference participants, speakers, members of the organizing committee, and reviewers who contributed to the academic quality of the programme and helped foster a constructive and inspiring discussion.

On behalf of the organizing committee

doc. Ing. Ladislav Rolínek, Ph.D.
Vice-dean for Science and Research

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Session:
Resilient Regions: Sustainability under Pressure of Global
Challenges and Uncertainty

Enterprise Environmental Transparency and ESG Implementation

Roman Buchtele¹, Lukáš Klarner², Petra Matoušková³

Abstract: The aim of this article is to describe the transparency of enterprises regarding their environmental impacts in the context of ESG implementation. The research was conducted through a quantitative questionnaire survey at the enterprise level. In total, 78 valid responses were collected across various sectors, providing a diverse empirical basis. The study is structured around three research questions: (1) How do enterprises approach transparent monitoring of their environmental impacts? (2) What is the effect of having a clearly defined strategy for reducing the environmental impacts of enterprises' activities on transparent monitoring of environmental impacts? (3) What is the effect of the perceived barriers to ESG implementation on transparent monitoring of environmental impacts? The findings contribute to a better understanding of the relationship between the level of transparency in monitoring and communicating environmental impacts and selected variables such as enterprise size, environmental impact reduction strategies, and perceptions of barriers to ESG implementation.

Keywords: environmental impact, environmental transparency, enterprises, ESG, sustainability

JEL Classification: Q01, Q56

1 Introduction

On its path to achieving sustainable development (WCED, 1987), the European Union and EU law require enterprises to disclose information on social and environmental issues in a transparent manner. The rules were applied for the first time by enterprises in the 2024 financial year for reports published in 2025. This information is intended primarily for investors, consumers, and other stakeholders to assess enterprises in terms of sustainability, as required by the European Green Deal (European Commission, n. d.). The abbreviation ESG stands for environmental, social and governance factors (Gaia Soana, 2024), with these factors being systematically taken into account in corporate governance and investment analysis (Henriquez-Salman, 2025). Kaźmierczak (2022) further adds that these factors are essential for measuring sustainability, but also the impact of an enterprise. These factors are a set of non-financial indicators that lead to enterprise responsibility and can be used by investors to evaluate enterprises. Enterprises therefore focus on ESG in order to remain competitive in an ever-changing environment (Yadav & Prashar, 2022).

In today's world, enterprises need to be managed in innovative and sustainable ways. That is why emphasis is placed not only on implementing ESG principles, but also on reporting on them (Kaźmierczak, 2022). In recent years, non-financial reporting has been growing steadily, especially in developed economies, where enterprises are under increasing pressure not only from investors (Behl et al., 2021). ESG reporting often focuses on quantitative data, which is described in a very concise manner (Gole et al., 2021). Arvidsson & Dumay (2021) also argue that if enterprises do not openly disclose information and respond to questions about sustainability, they expose themselves to the risk of mistrust from the market, but also to higher capital costs. However, Searcy & Buslovich (2014) suggest that ESG reporting sometimes provides ambiguous and incomparable information, which may cause problems for the enterprise.

This is closely linked to environmental impact reporting. This can be characterised as the process of collecting and analysing data from various areas of the environment. These include, for example, air quality, water, soil and weather conditions. Its purpose is to assess environmental policies and their impacts (Shalu & Singh, 2023). The most important factor in monitoring environmental impact is transparency. In recent years, the demand for transparency has increased,

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leading to the expansion of business activities focused on monitoring services. For this purpose, enterprises may employ smart technologies, artificial intelligence, or various audits (Searcy et al., 2022).

Communication is fundamental to ensuring transparency in environmental monitoring. According to Erbaugt et al. (2024), communication shapes both the form and the boundaries of monitoring through specific communicative activities. These activities subsequently contribute to the regulation of human behaviour and generate outcomes related to the environment. Newig et al. (2023) further add that whoever communicates has decision-making power. This applies to the shaping of citizens, enterprises, and the interactions between them.

2 Methods

The aim of this article is to describe the transparency of enterprises regarding their environmental impacts in the context of ESG implementation.

Three research questions were identified based on a literature review.

- 1) How do enterprises approach transparent monitoring of their environmental impacts?
- 2) What is the effect of having a clearly defined strategy for reducing the environmental impacts of enterprises' activities on transparent monitoring of environmental impacts?
- 3) What is the effect of the perceived barriers to ESG implementation on transparent monitoring of environmental impacts?

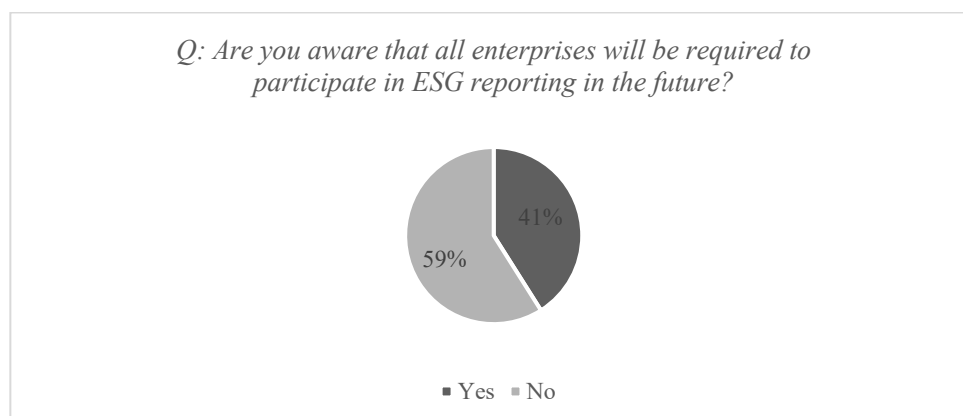
The data collection took place in the first quarter of 2025, specifically during February and March. Data for this study were collected through quantitative research using a questionnaire consisting of 23 questions. The instrument was structured into three main parts: (i) questions characterising the respondent (5 items), (ii) questions concerning the enterprise in which the respondent is employed, and (iii) research-related questions. In total, 78 completed questionnaires were obtained. Among these, 23 responses came from micro-enterprises, 30 from small enterprises, 18 from medium-sized enterprises, and 7 from large enterprises. Regarding sectoral representation, the most of responses originated from manufacturing (15), followed by construction (13), retail (11), transport and logistics (7), IT (4), health and pharmaceuticals (3), financial services and banking (2), and energy (2). An additional 21 responses were classified in the "other" category, which included enterprises engaged in agriculture, tax services, consultancy, or property management.

Contingency tables within the crosstabs procedure in IBM SPSS were used for statistical verification of the dependence between the variables under investigation. To test the statistical significance of the categorical variables, the Chi-square test of independence was employed (IBM, 2025). In data analysis, the abbreviation AR stands for adjusted residual.

3 Research results

The first important variable for interpreting the results is whether the enterprises surveyed are aware that in the future, enterprises will be required to participate in ESG reporting. A total of 41% of respondents indicated that they were aware of this fact (Figure 1).

Figure 1 Awareness of Enterprises' Obligation to Participate in ESG Reporting

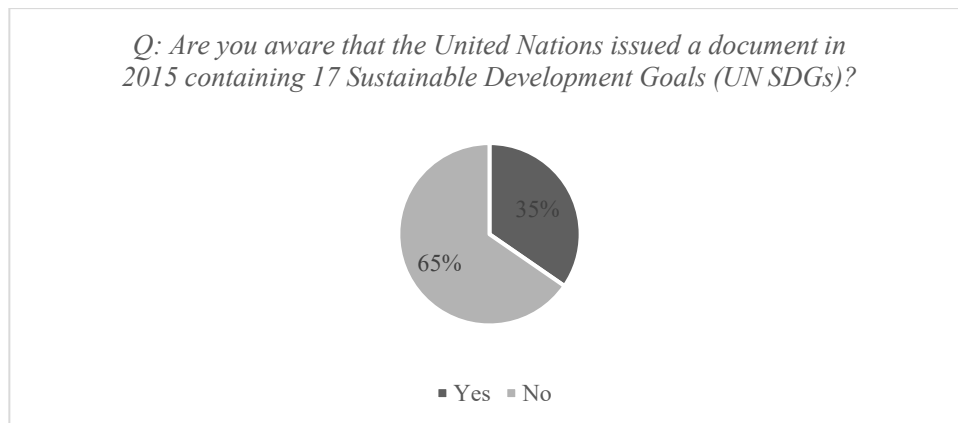


Source: Own processing; n = 78

Moving to a more general level, to the sphere of global commitments to sustainability, the SDGs are considered to be the current commitment of signatories to sustainability. Another change being monitored is whether business leaders are

aware of the fact that their individual activities contribute to this global commitment at the UN level. Only 35% of respondents stated that they were aware of this fact (Figure 2).

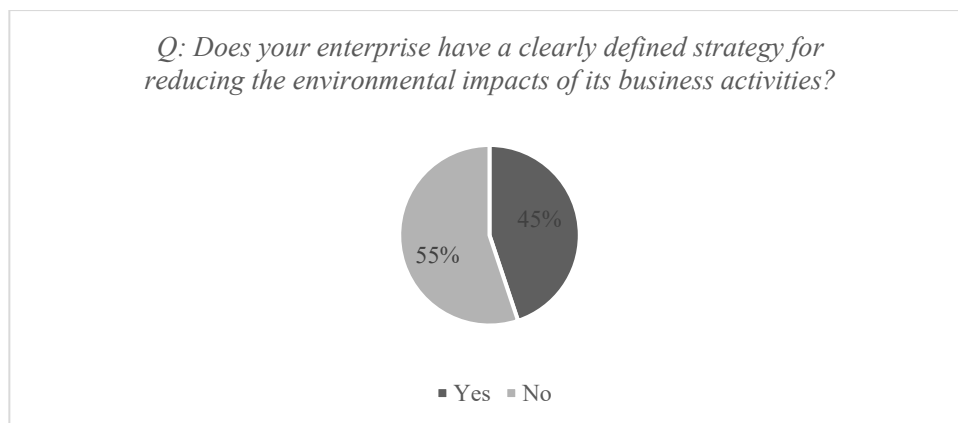
Figure 2 Awareness of the United Nations' 2015 SDG Document



Source: Own processing; n = 78

An integral characteristic of the companies surveyed is whether they have developed a strategy to reduce the environmental impact of their business activities. In our sample, a total of 45% of enterprises have incorporated such a strategy into their strategic management (Figure 3).

Figure 3 Defined Strategies for Reducing Environmental Impacts of Business Activities



Source: Own processing; n = 78

Another variable for contingency tables is the perceived barriers to ESG implementation at the enterprise level. The outputs of previous research, which focused primarily on barriers and support for overcoming them (Buchtele et al., 2025), were used. Table 1 shows the ranking of these barriers according to the importance assigned to them by the respondents. The average value was calculated by converting the responses into numerical values (Definitely a barrier = 1, Rather a barrier = 2, Rather not a barrier = 3, Definitely not a barrier = 4). The biggest obstacle for enterprises is perceived to be unclear return on investment in ESG measures. This is followed by a lack of ESG specialists and the complexity of ESG regulations.

Table 1 Ranking of Barriers to the Implementation of ESG Principles

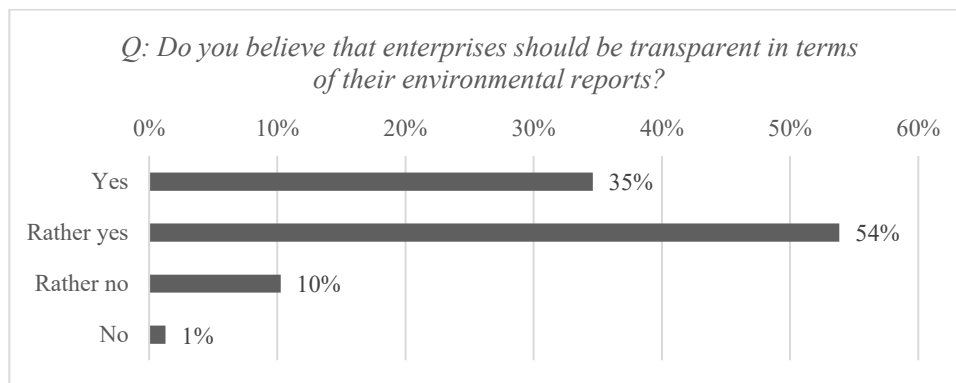
<i>Please rank the following barriers to the implementation of ESG principles in order of their importance</i>	Mean	Rank
Lack of financial resources	2.12	4
Insufficient knowledge of ESG	2.03	3
Complexity of ESG regulations	1.94	2
Lack of ESG specialists	1.94	2
Weak pressure from customers	2.78	6
Weak pressure from business partners	2.79	7
Limited access to validated data	2.47	5
Unclear return on investment in ESG measures	1.86	1

Source: Buchtele et al., 2025; n = 78

The key question posed to representatives of the selected enterprises, and subsequently subjected to the main statistical analysis, is whether they believe that enterprises should be transparent in terms of their environmental reports. Figure 4 shows that the majority of respondents express agreement. A total of 35% of respondents choose the affirmative answer "yes" and 54% choose the more moderate agreement "rather yes."

A statistically significant relationship was also found between the question under consideration and whether the enterprise has a clearly defined strategy for reducing the environmental impact of its business activities ($\chi^2 = 11.448$; $df = 3$; $p = 0.010$). If the enterprise has such a strategy, it agrees excessively more with the question under consideration and chooses the answer yes ($ar = 3.3$). If the enterprise does not have such a strategy, it is significantly more likely to choose the moderate answer "rather yes" ($ar = 2.2$).

Another statistically significant relationship was found between the question surveyed and the perception of barriers to ESG implementation—unclear return on investment in ESG measures ($\chi^2 = 29.005$; $df = 9$; $p = 0.001$). If the respondent selects "yes" for the question surveyed, it is significantly more likely to state that the unclear return on investment in ESG measures is more of an obstacle ($ar = 2.6$). If respondent selects the more moderate affirmative answer "rather yes" to the monitored question, respondent states that the unclear return on investment in ESG measures is definitely an obstacle ($ar = 2.6$).

Figure 4 Enterprises and Transparency in Environmental Reports

Source: Own processing; n = 78

Figure 5 illustrates the share of surveyed enterprises that monitor the environmental impact of their activities. A total of 40% of enterprises indicated "yes," while a further 23% selected the more moderate option "rather yes." These results demonstrate that the majority of surveyed enterprises monitor the environmental consequences of their activities.

A statistically significant relationship was found between the question surveyed and the size of the enterprise ($\chi^2 = 21.599$; $df = 12$; $p = 0.042$). Enterprises with 1-9 employees are more likely to select the answer "no" ($ar = 3.0$). Conversely, the enterprises with 50-249 employees are disproportionately more likely to select the answer "yes" ($ar = 2.1$).

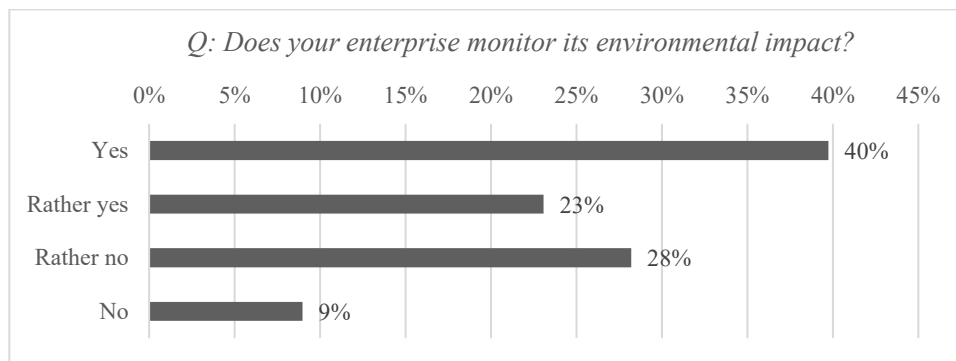
Another statistically significant relationship was found between the question under review and awareness of enterprises' involvement in ESG reporting ($\chi^2 = 9.633$; $df = 3$; $p = 0.022$). Enterprises that are aware of this fact are significantly more

likely to answer "yes" to the question under review ($ar = 2.0$). Conversely, enterprises that are unaware of this fact more often select the answer "no" to the monitored question ($ar = 2.3$).

The existence of the aforementioned strategy ($\chi^2 = 28.223$; $df = 3$; $p = 0.000$) also influences the question under study. Enterprises that have such a strategy are significantly more likely to answer "yes" ($ar = 5.2$). Conversely, those that do not have such a strategy are more likely to answer "no" ($ar = 2.5$) and "no" ($ar = 2.5$).

The last statistically significant relationship was found between the observed question and the perception of weak pressure from business partners as an obstacle to ESG implementation ($\chi^2 = 18.300$; $df = 9$; $p = 0.032$). Enterprises that report that this is not an obstacle for them are disproportionately more likely to answer "yes" to the observed question ($ar = 3.4$).

Figure 5 Monitoring of Environmental Impact by Enterprises



Source: Own processing; $n = 78$

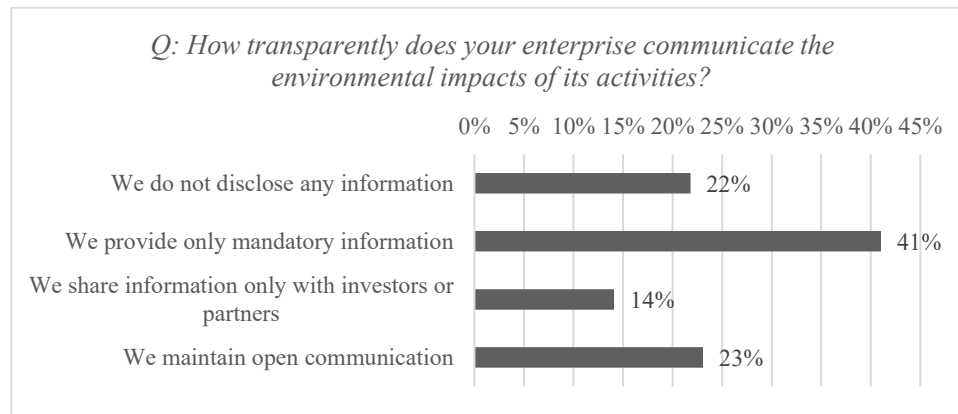
Enterprises were also asked to evaluate how transparently they communicate the environmental impact of their activities. A total of 41% reported that they provide only mandatory information, while 23% indicated that they practice open communication. Furthermore, 14% of enterprises stated that they share such information exclusively with investors and business partners, and 22% reported that they do not provide any information at all (Figure 6).

A statistically significant relationship was observed between enterprise size and the variable under investigation, which was, however, anticipated ($\chi^2 = 26.036$; $df = 12$; $p = 0.011$). Enterprises with 1–9 employees were disproportionately more likely to report that they do not disclose any information ($ar = 3.7$).

A statistically significant relationship was also found in the case of the above-mentioned strategy for reducing environmental impact and the question under study ($\chi^2 = 17.251$; $df = 3$; $p = 0.001$). Enterprises that have such a strategy maintain open communication to an excessive degree ($ar = 3.7$). Conversely, enterprises that do not have such a strategy do not disclose any information ($ar = 2.6$).

The last statistically significant relationships were between the observed variable and the perception of barriers to ESG implementation. In the case of the barrier of insufficient knowledge about ESG ($\chi^2 = 17.432$; $df = 9$; $p = 0.042$), enterprises that report this as a barrier are disproportionately more likely to report that they only provide mandatory information ($ar = 2.0$). Enterprises that perceive the absence of ESG specialists as only a minor obstacle tend to engage in open communication to a greater extent ($\chi^2 = 20.793$; $df = 9$; $p = 0.014$; $ar = 2.7$). The same pattern is observed regarding the perception of barriers related to unclear ESG investments ($\chi^2 = 18.493$; $df = 9$; $p = 0.030$). Enterprises that consider this factor to be only a minor barrier tend to engage in open communication to a greater extent ($ar = 2.9$).

Figure 6 Transparency of Enterprises' Communication on Environmental Impacts



Source: Own processing; n = 78

4 Discussion and Conclusions

Our study shows that most companies (54%) tend to agree with the transparency of environmental reports of enterprises, while 35% express absolute agreement. However, as was found, 40% of companies monitor their own environmental impacts, another 23% tend to monitor them, and 28% tend not to monitor them. The highest proportion of companies (41%) provide only mandatory information in terms of communicating their environmental impact, 23% maintain open communication, and 22% provide no information. Another 14% provide information only to stakeholders.

Sharing information about the environmental impact of activities is a contentious issue, with the transparency of this communication and companies' efforts to prevent the dissemination of negative information being well-documented (Caputo et al., 2021). Furthermore, it has been proven that several factors positively influence environmental performance and transparency of communication, such as gender diversity in enterprise management or its age structure (Van Hoang et al., 2021). Furthermore, the literature shows that there are still significant gaps in the transparency, completeness, and methodological accuracy of impact communication, and not all companies communicate their impacts transparently (Traub et al. 2025).

At the same time, the research focused on the impact of a clearly defined strategy for reducing the environmental impact of business activities on transparent monitoring of environmental impacts. As the analysis showed, all three issues monitored are affected, i.e., areas related to the belief that companies should be transparent in their reports, whether they monitor environmental impacts themselves, and how transparent the communication of these impacts is.

The literature in this area also provides a number of insights and strategies related to the transparent monitoring of environmental impacts in terms of their communication and strategy. In general, a positive relationship is observed between pressure for environmental legitimacy and impression management when disclosing information. At the same time, companies facing pressure for environmental legitimacy tend to engage in selective disclosure of information and have a stronger motivation to manage impressions (Luo et al., 2022). It has also been found that when companies adhere to the Global Reporting Initiative rules in preparing ESG reports, they have more proactive strategies in the areas of environmental investment, carbon emission reduction, and stakeholder engagement (Luo & Tang, 2022). However, it should be noted that creating an optimal strategy for corporate impact reporting and sustainability reporting requires financial investment, which does not necessarily lead to greater transparency (Tang & Higgins, 2022).

The research also focused on determining the impact of perceived barriers to ESG implementation on transparent monitoring of environmental impacts. In terms of whether organizations should be transparent in their environmental reporting, three barriers were identified as having an impact: insufficient knowledge, a lack of ESG specialists, and unclear return on investment. A similar effect was observed for the barrier of weak pressure from business partners to monitor the environmental impact of enterprises. The attitude towards the transparency of enterprises in relation to their environmental reports is influenced by the unclear return on investment in ESG.

Unclear return on investment is an obstacle mentioned in connection with the modernization of equipment or production processes to meet ESG targets, which is closely related to the communication of the environmental impact of enterprises (Liou et al., 2023). The study by Bezerra et al. (2024) identifies other challenges related to the implementation of ESG and its subsequent reporting, such as a lack of indicators and regulatory guidelines, organizational resistance, or insufficient transparency of indicators. The perceived obstacles can be of various kinds. In addition, some studies show that the

exchange of information on environmental impacts negatively moderates the relationship between enterprise stakeholders and sustainable practices within the enterprise's supply chain, pointing to the fact that stakeholders do indeed influence the transparency of an enterprise's environmental impacts (Agyabeng-Mensah et al., 2024).

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The Use of RHDI and SHDI for Measuring Sustainability in EU Regions

Antonín Hořčica¹

Abstract: This article builds on the previous contributions presented at the INPROFORUM conferences, which focused on the application of functional time series analysis to assess sustainability through selected indicators. The aim of the present study is to compare two human development indicators applicable to the assessment of sustainability at the regional level: the Regional Human Development Index (RHDI), developed for the European Commission, and the Subnational Human Development Index (SHDI), based on the UNDP methodology and compiled by the Global Data Lab. The analysis covers EU regions at the NUTS 0, NUTS 1, and NUTS 2 levels over the period 2000–2020, corresponding to three programming periods of EU cohesion policy. Descriptive statistics and functional time series analysis were used. Although the two indices differ in their construction, they exhibit similar trends. The RHDI provides a more detailed regional perspective, whereas the SHDI allows for broader international comparability. This study is among the first to systematically compare these indicators in the context of European regions and highlights their potential for evaluating the impacts of European policies, as well as their practical application within the framework of cohesion policy.

Keywords: sustainability, human development, RHDI, SHDI, EU regions, functional time series analysis, cohesion policy

JEL Classification: C14, Q01, R11, R58

1 Introduction

The European Union (EU) has adopted the concept of sustainable development as one of the key principles of its long-term strategies. This framework, originally defined in the report *Our Common Future* (WCED, 1987) and further developed in the 2030 Agenda for Sustainable Development (United Nations, 2015), forms the foundation for the transformative strategic documents of the EU (European Commission, 2001), including the European Green Deal (European Commission, 2019). Thus, sustainability in the EU context is conceived as balanced economic, social, and environmental development. This integrated approach is embedded in cohesion policies, which represent the EU's primary instrument for reducing regional disparities and implementing sustainability objectives in practice.

Effective planning, implementation and evaluation of these policies require reliable and comparable indicators capable of capturing the complex state and dynamics of development at the regional level. Regions, as defined within the standardized Nomenclature of Territorial Units for Statistics (NUTS) classification, represent the crucial level for analyzing the impacts of European interventions. Analysis at the NUTS 0 (countries), NUTS 1, and NUTS 2 (major and minor regions) levels allow not only the identification of specific development challenges but also facilitate evidence-based policy design and more targeted allocation of European funds. Measurement beyond traditional economic metrics such as GDP is essential to understand genuine quality of life and sustainability.

To measure the multifaceted nature of regional development, human development indices have gained prominence. Among the most significant is the Regional Human Development Index (RHDI), developed at the request of the European Commission (Hardeman & Dijkstra, 2014) specifically for monitoring purposes within the EU using harmonized Eurostat data. The second is the Subnational Human Development Index (SHDI), produced by the Global Data Lab based on the globally recognized United Nations Development Program (UNDP) methodology that ensures high international comparability. Although both indices track the same three dimensions, health, education, and standard of living, they differ in their subindicators, data sources, and computational methodologies.

The research gap lies in the absence of a comparative study employing advanced statistical methods capable of capturing and comparing complete developmental trajectories in the time series of both indices. This article aims to fill this gap and extend the author's previous work (Hořčica, 2023, 2024) using functional data analysis (FDA) methods.

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2 Goals

The primary objective of this study is to systematically compare the Regional Human Development Index (RHDI) and the Subnational Human Development Index (SHDI) as tools to assess sustainability at the regional level of the EU (NUTS 0, 1, and 2). The analysis covers the period 2000-2020, encompassing three complete programming periods.

Specific objectives include analyzing and comparing methodological differences in the construction of both indices, including their components and normalization procedures. Additionally, the study aims to compare both indices using descriptive statistics and functional data analysis. Finally, the research seeks to assess the practical suitability and potential of both indices for monitoring and evaluating the impacts of European cohesion policies.

These objectives lead to the following research questions: (1) Are the temporal and spatial trends of the RHDI and SHDI indices consistent across EU regions? (2) What are the specific advantages and limitations of each index for assessing regional sustainability, and which is more appropriate for evaluating EU cohesion policy objectives?

To address these questions, three working hypotheses have been formulated: H1: The RHDI and SHDI indices exhibit a high mutual statistical correlation across EU regions, confirming their general consistency as tools for measuring human development. H2: RHDI better captures specific regional disparities within EU member states than SHDI due to its use of indicators directly linked to European policy objectives and Eurostat data. H3: Although the temporal trajectories of both indices during 2000-2020 show overall convergence tendencies, functional analysis will reveal significant differences in the dynamics and volatility of EU development that traditional methods would not detect.

3 Methods

3.1 Geographical aspects of sustainability and regional division of the EU

For the purposes of regional sustainability analysis in the European Union, a unified statistical classification of territorial units has been developed, known as the Nomenclature of Territorial Units for Statistics (NUTS). This hierarchical structure, established by Eurostat, divides the territory of member states into three main levels (NUTS 1, 2, and 3). It is designed to enable comparability of statistical data across EU countries and over time. In the context of European strategies, cohesion policies most frequently utilizes the NUTS 2 level, which represents the key administrative unit for allocating financial resources from EU funds and for assessing territorial disparities.

Given the different geographic coverage of the indices examined, data harmonization was necessary for this study. While RHDI is based primarily on data at the NUTS 2 level with the possibility of aggregation to higher NUTS 1 and NUTS 0 levels, SHDI operates with a combination of NUTS 1 and NUTS 2 levels depending on the size of individual states and the availability of underlying data. Therefore, only those regions for which values of both indicators were available for the entire 2000-2020 observation period were included in the final analysis. A more detailed analysis of data availability and comparability will be presented in the results section of this article.

3.2 Comparison of the construction of the SHDI and RHDI indices

Both regional indices examined in this study are based on the theoretical foundation of the Human Development Index (HDI), which has been developed by the United Nations Development Program since 1990 (UNDP, 2019). HDI combines three fundamental dimensions, health, education, and standard of living, which are aggregated using the geometric mean after normalization.

The SHDI, managed by the Global Data Lab, represents a direct extension of this global methodology to the subnational level (Smits & Permanyer, 2019). It maintains an identical structure to the HDI, which ensures its primary advantage: global comparability (Global Data Lab, n.d.). For normalization, it uses the fixed goalposts method.

For the health dimension, life expectancy at birth has a minimum value of 20 years and a maximum of 85 years. For the education dimension, expected years of schooling and mean years of schooling have minimum values of 0 and maximum values of 18 and 15 years, respectively. For the standard of living dimension, measured as GNI per capita, the minimum is set at \$100 and the maximum at \$75,000 in purchasing power parity (PPP) terms.

Table 1 Comparison of the calculation of the SHDI and RHDl Indices

Calculation Ph.	Criterion	SHDI	RHDI
1. Normalization	Establishing min-max values	Fixed, global boundaries (established by UNDP)	Dynamic, relative boundaries (from EU regional data) and five-year projection
	Basic formula	$actual\ value - min / max - min$	
	Application of basic formula	Natural logarithm is applied to the income dimension	Formula is inverted for indicators with negative trends
2. Averaging	Type of mean	Arithmetic mean	
	Application of mean	Only for education dimension (average of two indicators)	For all three dimensions, always averaging two indicators.
3. Final Calculation	Aggregation method	Geometric mean (of dimension indices): $SHDI\ nebo\ RHDI = \sqrt[3]{D_{health} \cdot D_{education} \cdot D_{income}}$	

Source: Author's elaboration based on UNDP (2019), Global Data Lab (n.d.), Hardeman & Dijkstra (2014).

In contrast to the global approach of SHDI, the RHDI was developed specifically for the European Union to better reflect its policy priorities and data availability (Hardeman & Dijkstra, 2014). The methodology, further elaborated by the Joint Research Centre (JRC), differs in two key aspects.

First, it employs six sub-indicators: for health, these are life expectancy at birth and infant mortality rate; for education, the NEET rate (Not in Education, Employment, or Training) and the proportion of the population with tertiary education; and for income, net adjusted household disposable income and employment rate. Second, rather than using fixed global values for normalization, it employs a dynamic min-max method where boundaries are determined directly from the European regional dataset, extended with a five-year linear projection. The methodology also distinguishes between indicators with positive and negative trends. An overview of the computational differences is presented in Table 1.

3.3 Data Sources, time frame, and regional classification

Data for this study were obtained from two primary sources: the SHDI database version 7.0, managed by the Global Data Lab, and RHDI, for which calculations utilized data from the Eurostat database. This dataset builds on the author's previous work, in which data gaps were identified and addressed (Hořčica, 2024). The analysis covers the period 2000-2020 and the EU regions at NUTS levels 0, 1, and 2.

A critical methodological step involved the processing and harmonization of both datasets to create a final analytical dataset where each unit has valid values for both indices at the same NUTS level. The process included addressing data gaps, where missing values in the RHDI time series were imputed using multiple imputation methods (Amelia algorithm) following Hořčica (2024). In rare cases where data for a particular unit were completely missing, they were supplemented from alternative official sources (e.g., UNDP, CEIC).

During the harmonization of the SHDI database, when the NUTS 2 level was not used, a targeted regional selection was necessary. Additionally, the historical evolution of the NUTS nomenclature was taken into account. Regions that could not be reliably harmonized across both datasets were excluded from the final analysis.

3.4 Statistical analysis methods and R software

All statistical processing and data visualization were performed in the R programming environment (R Core Team, 2023), using tidyverse packages for data processing (Wickham et al., 2019). The analysis was carried out in two phases.

The first phase comprised descriptive statistical analysis (calculation of means and standard deviations) and correlation analysis (Pearson and Spearman coefficients) for the basic assessment of the properties of the data throughout the programming periods and verification of hypothesis H1 regarding the mutual consistency of the indices.

The core of the analytical approach is functional data analysis (FDA), which, unlike classical methods, treats the entire temporal evolution of a region as a single functional unit, a curve, enabling a more robust comparison of trends and dynamics (Hořčica, 2023). For FDA implementation, the GET package (Global Envelope Tests) in R was employed (Mrkvička, 2020). Two key techniques were used: functional boxplots (fBoxplot()) to visualize central trends, variability, and outlying trajectories, and the global envelope test for formal statistical verification of the hypothesis regarding differences between RHDI and SHDI trajectories (Myllymäki et al., 2017). These methods enabled visual and statistical comparison of the two indices.

4 Research results

4.1 Data availability and harmonization

The first analytical step involved creating a harmonized dataset for the SHDI and RHDI indices, ensuring that each analyzed territorial unit had valid values for both indices at the same NUTS level, primarily NUTS 2.

Table 2 Regional inclusion in analysis according to the SHDI and RHDI data harmonization

NUTS Level	Countries	SHDI and RHDI Harmonization
NUTS 2	Belgium, Bulgaria, Czech Republic, Denmark, Italy, Netherlands, Portugal, Austria, Romania, Greece, Slovakia, Spain, Sweden	Fully harmonized and complete NUTS 2 regions
Incomplete NUTS 2	Finland, France, Croatia, Lithuania	For Croatia, older NUTS 2 nomenclature used; for RHDI, regions FI20 and FRY5 excluded; for Lithuania, only 1 NUTS 2 region used
NUTS 0 = NUTS 2	Estonia, Cyprus, Luxembourg, Latvia, Malta	Countries without regional structure; NUTS 0 data used; SHDI and RHDI data supplemented from external sources
NUTS 2 + NUTS 1	Poland, Hungary	In SHDI one region corresponds to NUTS 1 level
NUTS 1	Germany	NUTS 1 level used for both indices
Excluded	Ireland, Slovenia	SHDI available only at incompatible NUTS 3 level

Source: Author's elaboration

Analysis of the source data revealed specific issues that required adjustments, as summarized in Table 2. Therefore, the resulting analytical dataset contains 206 comparable NUTS 1 and NUTS 2 regions. This comprises 18 NUTS 1 regions (16 German, 1 Hungarian and 1 Polish), 5 national regions that correspond to NUTS 2, and 183 NUTS 2 regions. This structure forms the basis for all subsequent statistical tests and visualizations. The complete dataset containing the RHDI and SHDI data is available upon request.

4.2 Comparison of indices using descriptive statistics

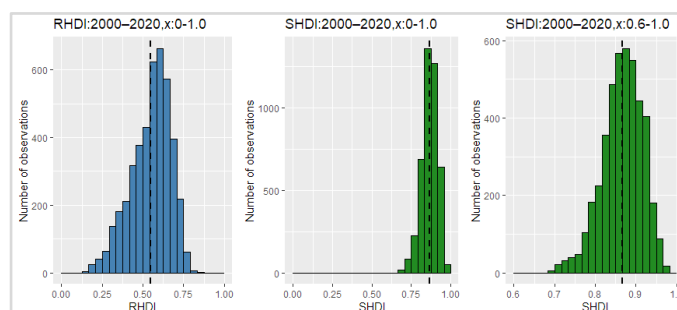
Descriptive analysis was first conducted to assess the fundamental properties of both indices and their mutual relationship. Basic summary statistics are presented in Table 3. The two indices operate on different scales. SHDI achieves a mean value of 0.867 with a low standard deviation of 0.047, indicating that values are clustered in the upper portion of the global spectrum. In contrast, RHDI has a mean value of 0.551 but more than doubles the standard deviation of 0.114, as illustrated in the histograms in Figure 1.

Table 3 Basic statistical characteristics of RHDI and SHDI (2000-2020)

Index	Minimum	Mean	Std. Deviation	Maximum
RHDI	0.215	0.551	0.114	0.778
SHDI	0.721	0.867	0.047	0.951

Source: Author's elaboration

Figure 1 Distribution histograms of the RHDI and SHDI values for the period 2000-2020



Source: Author's elaboration

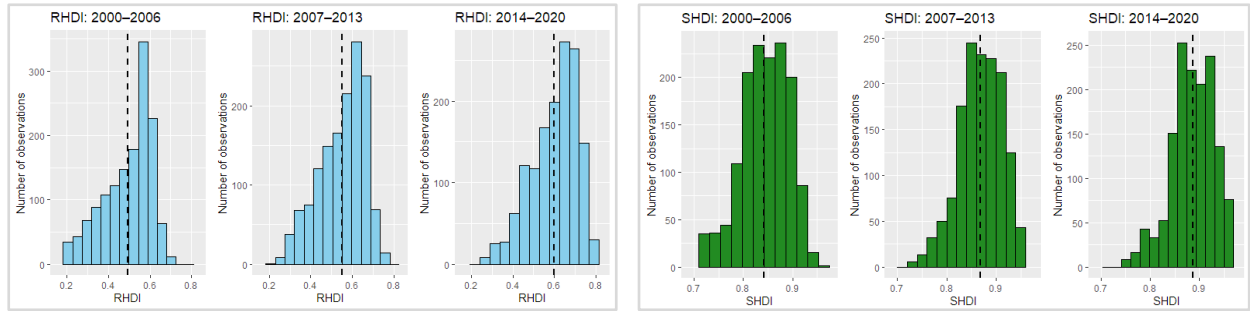
From a temporal perspective, analysis of data divided according to three seven-year programming periods revealed two key trends. First, the mean values of both indicators systematically increase over time, demonstrating improvement in human development levels across the EU. Second, both indices exhibit a continuous decrease in standard deviation over time (see Table 4). This phenomenon, known as sigma-convergence, confirms that inequalities in human development levels among EU member states are diminishing.

Table 4 Evolution of RHDl and SHDI across programming periods

Index	Period	Mean	Standard Deviation
RHDI	2000–2006	0.486	0.113
	2007–2013	0.553	0.098
	2014–2020	0.615	0.090
SHDI	2000–2006	0.839	0.049
	2007–2013	0.871	0.038
	2014–2020	0.892	0.037

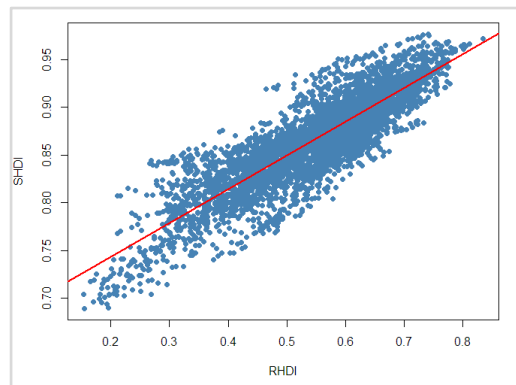
Source: Author's elaboration

Histograms for individual periods (see Figure 2) confirm the first trend, but the convergence is not visually conclusive.

Figure 2 Evolution of RHDl and SHDI distributions across programming periods

Source: Author's elaboration

To examine the relationship between both indices, a linear regression model was constructed with SHDI as the dependent variable and RHDl as the independent variable. The results confirmed a very strong and statistically highly significant positive linear relationship, further supporting the findings of the correlation analysis. The visual representation of this relationship is evident in Figure 3.

Figure 3 Linear regression model of the relationship between RHDl and SHDI

Source: Author's elaboration

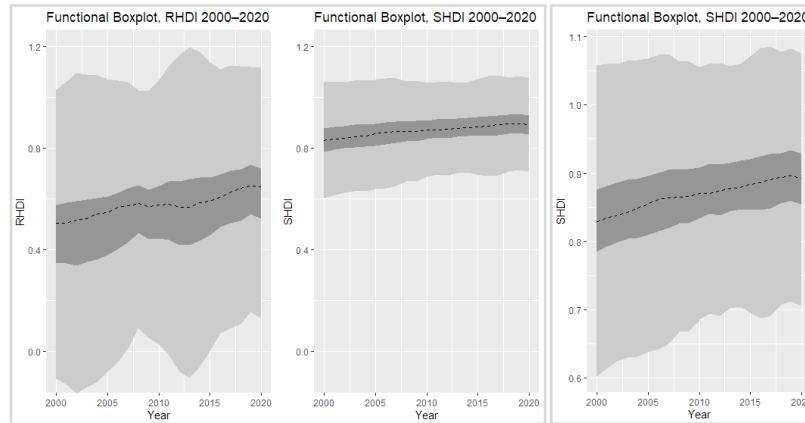
A key finding is the Multiple R-squared value, which reached 0.7554. This indicates that changes in RHDl values can explain approximately 75.5% of the variance in SHDI values, confirming their mutual dependence.

Analysis of the model coefficients yielded the following equation: $SHDI = 0.672 + 0.354 * RHDl$. The general validity of the model is also highly significant, as confirmed by the F-test value ($1.335e+04$) and the virtually zero p-value ($p < 2.2e-16$). These findings quantitatively demonstrate that despite methodological differences, both indices are strongly interconnected and capture very similar underlying dynamics of regional human development.

4.3 Analysis using functional data analysis

Figure 4 presents functional boxplots for RHDl and SHDI at the regional level for the period 2000–2020, displayed without outlier regions for clarity of the main trends. The dashed line indicates the median trend, the dark gray band represents 50% of the most common trajectories (analogous to the interquartile range), and the light gray band shows the total range.

Figure 4 Functional boxplots of RHDI and SHDI at the regional level (2000-2020)



Source: Author's elaboration

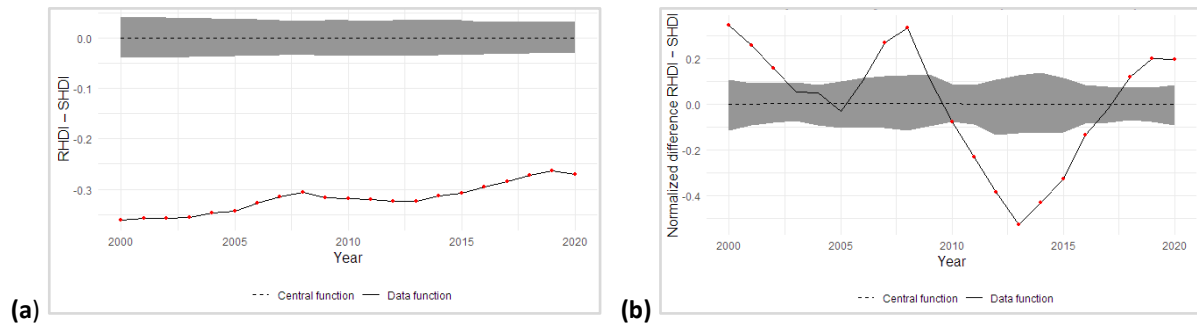
Visual comparison yields consistent conclusions confirming the descriptive statistics: the rising median indicates improvement, and the narrowing bands suggest convergence. The graphs simultaneously reveal different sensitivity and scale: The RHDI covers a broad range and better illustrates internal differences, while the standard SHDI (center) has values compressed in the upper part of the global scale. The added SHDI box

plot with an adjusted scale (right) allows for a better visual comparison of the curve shapes, showing that, despite differing levels, the dynamics and trends of both indices are very similar. However, for a detailed measurement of disparities within the EU, RHDI remains the more suitable tool due to its construction and scale.

To formally statistically verify the differences between the indices, two global envelope tests from the GET package were performed. The first test (Figure 5a) compared the difference in the mean values of RHDI and SHDI, while the second (Figure 5b) compared the similarity of their trajectory shapes after data normalization (removing differences in level and scale).

The first test confirmed that the difference between the mean RHDI and SHDI values is highly statistically significant ($p\text{-value} = 0.002$). As shown in Figure 5a, the actual difference curve lies entirely outside the gray "envelope of randomness." This formally proves that both indices produce demonstrably different results, which is a logical consequence of their different construction and purpose: SHDI for global comparison, RHDI for detailed analysis within the EU. Notable is the slightly convergent trend of the difference curve, attributable to a "ceiling effect" in SHDI for the most developed countries.

Figure 5 Global envelope test of differences (a) and similarity of curve shapes (b)



Source: Author's elaboration

The second test, which focuses on the similarity of curve shapes after normalization, did not reveal a statistically significant difference in overall shape ($p\text{-value} = 0.14$). However, as evident from Figure 5b, although the difference curve on average moves within the "envelope of randomness," it locally deviates outside it during several periods (e.g., around 2004, 2009-2015, and after 2018).

This indicates that while the overall developmental dynamics are statistically indistinguishable, these local deviations suggest that the sensitivity of both indices to specific events or year-on-year changes may differ. Therefore, the indices may respond differently to economic shocks or policy impacts in specific years. This result confirms overall trend agreement (supporting H1) while simultaneously highlighting the differences in dynamics that reflect the different construction and sensitivity of both indicators.

4.4 Evaluation of working hypotheses and answers to research questions

Based on the analysis conducted, all three established hypotheses were confirmed:

Hypothesis H1 was confirmed. The values of the RHDI and SHDI index exhibit very strong statistical correlation, as demonstrated by the analysis of the average trends and the linear regression model (4.2). Additionally, the curve similarity test confirmed that their developmental trajectories are statistically indistinguishable shapes (4.3). This demonstrates that, despite different constructions, both indices measure very similar fundamental concepts and capture the same human development dynamics.

Hypothesis H2 was confirmed. Descriptive statistics (4.2) and visualizations using histograms and functional boxplots (Section 4.3) showed that RHDI has significantly higher value dispersion than SHDI. This confirms that RHDI is a more sensitive tool for capturing and measuring regional disparities within the European Union.

Hypothesis H3 was confirmed. Time series analysis of both indices (4.2) revealed a continuous decrease in standard deviation, providing direct evidence of an ongoing convergence process (sigma-convergence) among EU regions.

These findings directly address the research questions posed in the introduction. The analysis revealed that RHDI and SHDI indices are highly consistent in terms of temporal trends and dynamics, yet differ in their scale, sensitivity, and spatial differentiation. While SHDI, through its global methodology, provides valuable context for international comparison, its ability to distinguish differences among highly developed EU regions is limited. Conversely, RHDI proved to be a more suitable tool for assessing regional sustainability in the European context, primarily due to its higher sensitivity and use of sub-indicators directly aligned with European policy objectives.

5 Conclusion

The objective of this study was to systematically compare the Regional Human Development Index (RHDI) and the Subnational Human Development Index (SHDI) as tools for measuring sustainability at the regional level within the European Union. The analysis, based on descriptive statistics and functional data analysis methods, confirmed that despite methodological differences, both indices capture similar macro-level trends, yet they differ in their sensitivity and intended purpose.

The findings suggest that the two indices are not mutually exclusive, but rather complementary. For policymakers, it is recommended to employ the RHDI as a tool for detailed monitoring and evaluation of the impacts of cohesion policy programs, while the SHDI can serve as a supplementary indicator for global benchmarking of the EU's performance.

Several avenues for future research are proposed. It would be beneficial to apply comparative functional analysis at a more granular regional level (NUTS 2 and NUTS 3) once data availability permits. Furthermore, investigating the causes of local variations in the dynamics of both indices, identified through the shape similarity test and linking them to specific economic shocks or policy interventions would provide valuable insights. A key step towards a more comprehensive measurement of sustainability would also involve extending the analysis to include the environmental dimension, which is currently absent from both human development indices.

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The Sustainability-Adoption Paradox: Why High Adopting MSMEs Report More Barriers - Evidence from Zimbabwe

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Abstract: The integration of Micro, Small, and Medium Enterprises (MSMEs) into the sustainability agenda is crucial for sustainable development, yet remains poorly understood in resource-constrained contexts. This study explores the complex interplay between sustainable practice adoption and perceived barriers among MSMEs in Zimbabwe. Through a cross-sectional survey of 312 enterprises, we identified a distinct hierarchy in the adoption of sustainable development practices: solar energy leads significantly (62.18%), substantially outdoing waste recycling (41.67%), water conservation (42.31%), and sustainable packaging (40.06%). While financial constraints (high costs: 50.3%; limited financing: 48.1%) and knowledge gaps (technical: 40.4%; information: 38.5%) were prevalent, the most critical finding reveals a central paradox: a strong positive correlation ($r \approx 0.98$) between adoption intensity and barriers reported. High adopters (averaging 5.47 practices) cited significantly more obstacles than low adopters (0.64 barriers), particularly in technical knowledge (76.7% vs. 9.5%) and limited finance (73.3% vs. 30.5%). This suggests that barrier recognition and navigation are essential to the adoption process, not simply deterrents. The study concludes that standard intervention models are inadequate. We recommend a multifaceted strategy: leveraging solar energy as a strategic entry point, shifting training from theory to practical implementation support, developing integrated financial products, and implementing tiered support systems tailored to different adoption stages. These findings provide a comprehensive framework for policymakers and practitioners to bridge the intention-action gap and accelerate sustainable development in emerging economies.

Keywords: sustainable practices adoption, MSMEs, sustainability barriers, green finance, developing economies, environmental sustainability

JEL Classification: M14, Q01, Q56

1 Introduction and Background

Sustainability (WCED, 1987) has become a major global goal that shapes fundamental current policies and economic direction. Micro, small, and medium-sized enterprises (MSMEs) play a key role in fulfilling this agenda, as recognised in the UN Sustainable Development Goals (SDGs) and the broader discussion on sustainable development (UN, 2015). The environmental dimension of entrepreneurship has gradually transformed from a marginal issue into an integral part of corporate practice through the introduction of the concept of corporate social responsibility (CSR) (OECD, 2001). While MSMEs are recognised as essential agents of economic development, their integration into the sustainability agenda remains a challenge, particularly in developing economies (Koe et al., 2024; Ceicyte-Pranskune, 2025). A significant amount of literature acknowledges the benefits of environmentally sustainable practices for MSMEs (Zuñiga-Collazos et

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al., 2025), however, a pervasive focus on short-term profitability often leads to the lack of broader socio-environmental impacts, thereby hindering progress towards the United Nations Sustainable Development Goals (Ohioma & Anwar, 2025). Existing research, however, is characterised by an acute weakness in that it often documents either the barriers to adoption, such as high costs, limited financing, and knowledge gaps, or the rates of practice adoption in isolation. This split approach does not explain the paradoxical relationship between the understanding of barriers and the adoption process. Preliminary findings from Zimbabwe suggest a landscape where specific practices like solar energy see significant uptake (62.18%), while others lag, all amidst widespread reporting of financial and knowledge constraints. This study suggests that the key to unlocking sustainable transformation lies not only in cataloguing these elements separately but in thoroughly examining the interplay between them. Therefore, this research moves beyond a descriptive account to quantitatively examine the adoption patterns of diverse sustainable practices and, most critically, to analyse the complex correlation between the intensity of adoption and the perception of barriers among MSMEs in Zimbabwe. By examining this dynamic, the study aims to provide a clear understanding that can form more effective, targeted interventions to address the intention-action gap in resource-constrained contexts.

2 Methods

2.1 Research Design and Data Collection

This study employed a quantitative, cross-sectional research design to investigate the adoption of sustainable practices and the challenges faced by MSMEs in Zimbabwe. A structured survey questionnaire was administered to a sample of 312 registered MSMEs across all ten provinces of the country, ensuring national representation. Data collection was conducted between March 2025 and June 2025, capturing a wide range of economic sectors, including wholesale and retail, manufacturing, agriculture, mining and quarry, accommodation and food services, and entertainment and culture.

The sampling strategy employed a multi-stage approach. First, stratified sampling was employed to ensure proportional representation across major economic sectors. Furthermore, a systematic random sampling technique was employed to select individual MSMEs within each stratum. Solvin's formula determined the sample size of 312 to be representative of the national MSMEs population, providing a reliable basis for analysis. The questionnaire was tested with a pilot group of 25 MSMEs to ensure clarity, contextual information, and reliability.

The survey instrument was developed by a comprehensive analysis of the literature on sustainability in the MSMEs sector. It was designed to capture data across several key domains. Firstly, sustainable practice adoption measured the implementation of six specific practices: solar or renewable energy, waste recycling, water conservation, eco-friendly packaging, energy-efficient equipment, and other sustainability initiatives. The selection of the six sustainable practices was based on their regular identification in the literature as the most common and impactful interventions for MSMEs seeking to improve their environmental footprint (Klewitz & Hansen, 2014; Jabbour et al., 2019). The MSMEs adoption status was denoted as "Yes" for entrepreneurs who practised and "No" for entrepreneurs who did not implement any sustainability practice. Secondly, the implementation barrier assessed the prevalence of six major barriers, these are high costs, lack of information, limited access to finance, technical knowledge gaps, regulatory restrictions and other. The six implementation barriers were chosen as they represent the most consistently reported obstacles in previous studies on MSME sustainability adoption (Klewitz & Hansen, 2014 ; Dressler, 2023). Thirdly, green finance knowledge categorised respondents into three levels, that is, knowledge, no knowledge, and heard but not sure. Lastly, demographic and firmographic data collected information on gender, sector, and other relevant characteristics.

2.2 Data Analysis

The data was analysed using R statistical software (version 4.4.2). The analysis was conducted in three sequential stages. Firstly, descriptive statistics were calculated to characterise the adoption rates of individual sustainable practices, the prevalence of barriers, and the demographic profile of the sample. The analysis of the total number of practices adopted and challenges was also conducted to identify central tendencies and patterns. Secondly, bivariate analysis, which used cross-tabulations with chi-square tests to examine the correlation between categorical variables, such as adoption patterns by gender and green finance knowledge level. This led to the identification of significant relationships without implying causality. Lastly, correlational and comparative analysis were employed to examine the central paradox of the study, the relationship between the total number of practices adopted and the total number of barriers cited was examined. Furthermore, the profiles of low adopters who implement zero (0) to one (1) practices and high adopters who implement

between four (4) to six (6) practices were systematically compared across all barrier types to identify significant differences in their perceived challenges.

2.3 Ethical Considerations

The study adhered to strict ethical standards. All participants received informed consent prior to survey administration. Participants were informed of the study's purpose, their right to withdraw, and the measures implemented to ensure anonymity and confidentiality. The data was kept secure and anonymised prior to the analysis.

3 Research Results

3.1 Sustainability adoption analysis

Based on the adoption rates analysis, the findings reveal different patterns in sustainability practice adoption among the MSMEs in Zimbabwe, see table 1. Solar energy emerges as the most widely adopted practice with a significant 62.18% adoption rate, significantly outperforming other sustainability practices. In contrast, waste recycling (41.67%), energy-efficient equipment (43.27%), and water conservation (42.31%) reveal moderate adoption levels within a narrow range of 41-44%. Packaging sustainability practices have the second-lowest adoption rate at 40.06%, while "other" sustainability practices have a significant increase at only 30.45%. The higher proportion of solar adoption suggests that there is greater accessibility, perceived benefits, or targeted promotion of renewable energy solutions compared to other sustainability practices. These results suggest a clear hierarchy of sustainability adoption, with energy-related interventions receiving superior implementation over waste management and conservation practices. The findings are consistent with the literature ; Nwokolo et al., 2023).

Table 1 Adoption summary

Sustainable Practice	Adopters	Non-Adopters	Adoption Rate
Solar	194	118	62.18
Waste Recycling	130	182	41.67
Packing	125	187	40.06
Energy Efficient Equipment	135	177	43.27
Water Conservation	132	180	42.31
Other	95	217	30.45

Source: Own processing

3.2 Gender sustainability adoption analysis

Based on gender analysis, MSMEs genders demonstrate similar adoption patterns across sustainability practices, see table 2. Females have a significantly higher average adoption rate of 2.64 practices compared to males 2.54 practices, indicating near-equivalent engagement levels. However, this consistency spreads to specific practices, for example, with solar adoption at 63.0% for males versus 61.6% for females, and waste recycling at 42.5% for males compared to 41.1% for females, revealing no substantial gender-based disparities in sustainability practice adoption. These trends are consistent with the literature (Pistilli et al., 2023).

Table 2 Adoption by gender

Gender	Average practices	Solar rate	Waste rate
Male	2.54	63.0	42.5
Female	2.64	61.6	41.1

Source: Own processing

3.3 Adoption by green finance knowledge level

Table 3 Adoption by green finance knowledge level

Green finance knowledge	Average practices	Number of respondents
High knowledge	2.75	134
No knowledge	2.49	126
Heard, but not sure	2.46	52

Source: Own processing

The analysis shows a clear positive relationship between green finance knowledge and sustainability practice adoption, see table 3. Respondents with the highest level of green finance knowledge demonstrate the greatest adoption intensity, averaging 2.75 practices per person, significantly higher than those with no knowledge (2.49) or those who have heard but are not sure (2.46). This gradient pattern suggests that financial literacy in green initiatives is a key factor for implementing sustainability measures, with knowledge gaps potentially leading to barriers to broader environmental practice adoption. Recent literature suggests that understanding green financial mechanisms is a critical enabler towards sustainability practices (Liu et al., 2025).

3.4 Practice Combinations Analysis

Table 4 Most common practice combinations

Pattern	YNNNN N	NNNNN N	YNNNY N	YYYYY Y	YNNYN N	NNNNY N	NYYYY Y	YNNYY N	YYYYY N	NNYNN N
Number of MSMEs	34	22	19	17	15	13	11	10	10	9

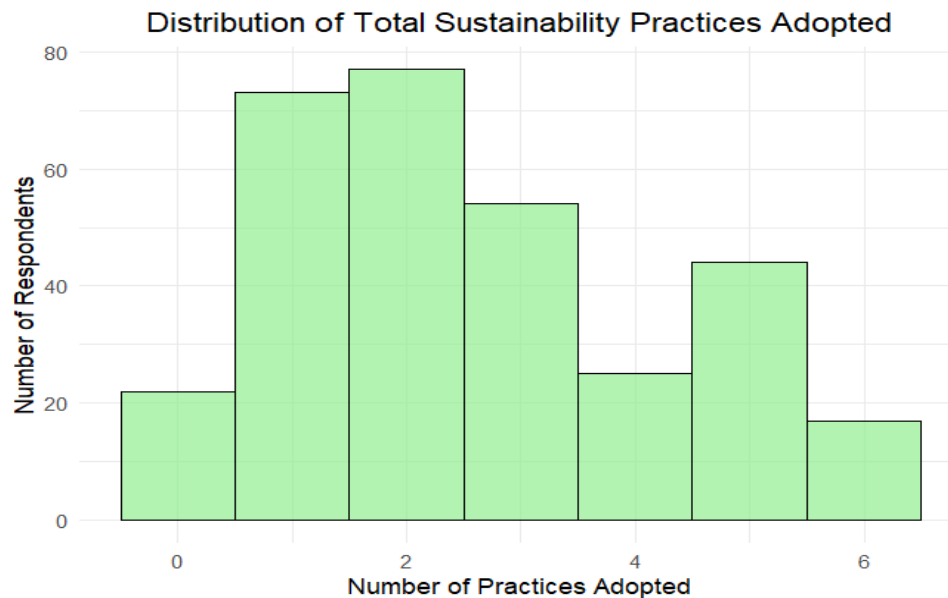
Source: Own processing

According to the practice combination analysis, the findings reveal distinct adoption patterns among the MSMEs, see tab 4. The most common approach is selective adoption, with "YNNNNN" (solar-only) being the predominant pattern among 34 entrepreneurs, indicating many MSMEs focus exclusively on solar energy implementation. Notably, two contrasting extremes emerge with 22 respondents who adopted no sustainability practices ("NNNNNN"), while 17 implemented all six practices ("YYYYYY"), indicating differentiated engagement levels. The dominance of solar-inclusive combinations across the top patterns highlights its role as either an entry point or priority practice, with most entrepreneurs adopting between one to three practices rather than comprehensive sustainability portfolios.

3.5 Analysis of the distribution of total sustainability practices adopted

Based on the distribution of sustainability practices adopted by MSMEs in Zimbabwe, the figure 1 shows a relatively right-skewed pattern with most entrepreneurs adopting between 2 and 4 practices. The distribution peaks around 2 and 3 practices adopted, indicating this range is the typical engagement level, while fewer respondents are at the extremes of either no adoption (zero practices) or comprehensive adoption (six practices). This bell-shaped distribution with a central tendency suggests that most MSMEs employ a selective, moderate portfolio of sustainability measures rather than embracing all available practices or completely abandoning environmental efforts. Again, this trend is consistent with literature (Aragón-Correa & Sharma, 2003)

Figure 1 Distribution of total sustainability practices adopted



Source: Own processing

3.6 Analysis of challenges in adopting sustainability practices

According to the challenge prevalence analysis, financial barriers become the primary obstacles to sustainability adoption, with high costs cited by 50.3% of MSMEs and limited financing by 48.1%. Knowledge-related challenges follow closely, as technical knowledge gaps (40.4%) and information deficiencies (38.5%) affect substantial portions of the entrepreneurs. Regulatory issues are the least cited barrier at 34.0%, suggesting that while institutional factors matter, economic constraints are the primary impediment to effective practice implementation among respondents. This trend is consistent with the literature (Zuñiga-Collazos et al., 2025; Nautiyal et al., 2025).

3.7 Analysis of challenges faced by MSMEs

Based on the distribution of challenges faced, table 5 reveals a left-skewed pattern, indicating that most entrepreneurs cite multiple barriers to sustainability adoption. The distribution peaks two to three challenges, with very few MSMEs reporting no challenges (zero) or facing all six potential barriers simultaneously. This concentration in the mid-range suggests that sustainability adoption is typically hindered by a combination of two to three interrelated obstacles rather than single dominant barriers or comprehensive constraint scenarios. This finding aligns with a growing body of research suggesting that MSMEs typically navigate a 'web of constraints' rather than isolated barriers (Costache et al., 2021)

Table 5 Distribution of total challenges faced by MSMEs

Number of challenges cited	0	1	2	3	4	5	6
Number of MSMEs	14	117	62	34	28	49	8

Source: Own processing

3.8 Correlation

The analysis shows a remarkable paradox in sustainability adoption patterns. A higher Pearson correlation coefficient ($r = 0.98$) indicates an exceptionally strong and positive linear relationship between the number of practices adopted and challenges faced, with non-adopters (zero practices) achieving only 0.64 challenges while comprehensive adopters (six practices) report 5.47 challenges on average, see tab 6. Low adopters have significantly fewer barriers in all categories, particularly technical knowledge (9.5% vs 76.7%) and limited finance (30.5% vs 73.3%), see tab 7. On the contrary, high adopters paradoxically report significantly more obstacles, suggesting they are more aware of or willing to acknowledge

implementation barriers despite their successful adoption, probably indicating that overcoming challenges is integral to achieving higher sustainability implementation levels.

Table 6 Adoption challenge analysis

Total practices adopted	0	1	2	3	4	5	6
Average challenges	0.636	1.25	1.87	2.74	2.96	4.18	5.47
Number of MSMEs	22	73	77	54	25	44	17

Source: Own processing

Table 7 Low adopters Vs High adopters challenge profile

Challenge	Low Adopters (0-1 Practices)	High Adopters (4-6 Practices)
High cost	41.0	62.8
Lack of information	25.3	55.8
Limited finance	30.5	73.3
Technical knowledge	9.47	76.7

Source: Own processing

3.9 Implications of practices

This study proposes a multifaceted approach for accelerating sustainability adoption among MSMEs, advocating for, firstly, utilising solar energy's high adoption as a strategic entry point to introduce bundled sustainable solutions. Secondly, strengthening training beyond theoretical knowledge to provide practical, hands-on implementation support that addresses the complex barriers that high adopters successfully navigate. Thirdly, developing integrated financial products that combine affordable credit with technical assistance to overcome the compound challenges of high cost and limited finance. Lastly, implementing tiered support systems tailored to the specific needs of non-adopters, the selective majority, and comprehensive adopters. This coordinated approach is essential for overcoming the documented intention-action gap and transforming widespread market interest into tangible green implementation.

4 Conclusions

This study provides a comprehensive examination of the sustainability adoption landscape among MSMEs in Zimbabwe, extending beyond a simple cataloguing of practices and barriers to reveal their critical interplay. The findings indicate a clear hierarchy of adoption, with solar energy becoming a dominant entry point due to its perceived benefits and accessibility, while other practices, such as waste recycling and water conservation lag. This selective adoption pattern, where most MSMEs maintain a moderate portfolio of two to three practices, emphasises a pragmatic approach rather than an ideological approach to sustainability.

The study's most significant theoretical contribution is to uncover and quantify the central paradox of sustainability adoption: the strong positive correlation between adoption intensity and the number of obstacles reported. This challenges conventional models that assume barriers solely hinder action. Instead, our findings suggest that barrier recognition and navigation are crucial to the adoption process itself. High adopters are not those who have fewer obstacles, but rather those who successfully engage in and overcome a complex web of financial, technical, and informational obstacles. This understanding calls for a shift in theoretical frameworks from those that view barriers as simple limitations to those that account for the vigorous process of problem-solving and resource mobilisation in resource-constrained environments.

These findings require a move beyond one-size-fits-all interventions. The evidence strongly supports the necessity for a complex approach that leverages solar energy as a strategic gateway, develops integrated financial products that combine credit with technical assistance, and shifts training programs from theoretical knowledge dissemination to practical implementation support. Crucially, support must be tailored to the distinct needs of non-adopters, the select majority, and comprehensive adopters.

For future research, longitudinal studies are needed to examine the evolution of barrier perception and overcoming throughout the adoption process. Qualitative analysis of the cognitive and behavioral strategies employed by high adopters could provide valuable insights into successful navigation mechanisms. Finally, implementing this analytical framework in other emerging economies would demonstrate its generalizability and further refine our understanding of the

sustainability intention-action gap. Finally, accelerating the green revolution of MSME sectors in developing economies depends on acknowledging that the path to sustainability is not obstacle-free, but rather defined by the systematic identification and removal of the very barriers that indicate commitment and progress.

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Intermunicipal Cooperation in Slovak Conditions

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Abstract: In the face of growing global uncertainty, ranging from climate change to geopolitical instability, regional resilience depends increasingly on the ability of local governments to coordinate, adapt, and act collectively. Intermunicipal cooperation (IMC) provides a governance mechanism through which municipalities can pool resources, enhance administrative capacity, and jointly deliver essential services. As such, IMC not only promotes efficiency, but also strengthens the institutional and social fabric necessary for regional sustainability and resilience. This paper analyzes inter-municipal cooperation (IMC) in Slovakia and its crucial role in improving the quality and availability of public services, particularly in the context of enhancing regional resilience. The study aims to identify the specific benefits, prevalent challenges, and untapped potential of IMC within the Slovak local government landscape and to propose concrete measures to enhance its efficiency and effectiveness. The methodology is based on a comprehensive questionnaire survey conducted among Slovak municipalities. The results show that IMC brings significant benefits, such as cost savings and improved service quality, which directly contribute to regional robustness. However, it also faces persistent challenges like administrative complexity and lack of stable funding. The paper provides strategic recommendations for future cooperation and emphatically underscores the need for systemic legislative and financial changes at the state level to fully realize IMC's potential for sustainable and resilient regional development.

Keywords: inter-municipal cooperation, public services, ICA, drivers, barriers

JEL Classification: H41. H73

1 Introduction

The primary objective of this paper is to analyze inter-municipal cooperation in Slovakia and its role in improving the quality and availability of public services. This topic is crucial because municipalities, as the fundamental units of local self-government, face challenges such as limited financial resources, vertical fiscal imbalance, and a lack of personnel. Inter-municipal cooperation offers a potential solution by allowing municipalities to share resources, reduce costs, and improve service quality for their residents. The analysis focuses on specific aspects of IMC, including its advantages, challenges, and potential for future development, to provide a comprehensive overview of the issue in Slovakia. This research is particularly relevant for the broader European context, as many EU member states grapple with local government fragmentation and the need to enhance service delivery efficiency and regional resilience through collaborative mechanisms.

Currently, IMC is a subject of extensive research and discussion as it offers benefits such as economies of scale, better adaptation of services to local needs, and increased efficiency of public administration. However, cooperation among municipalities also faces several challenges, including administrative complexity, differing priorities, and a lack of funding (Nižňanský et al., 2009).

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The paper's methodology is based on a questionnaire survey conducted among Slovak municipalities. The goal is to identify the main reasons for IMC, its benefits and obstacles, and to propose measures to increase its efficiency. The paper is structured into several chapters, each contributing to the overall objective. This chapter provides an introduction to the topic, while subsequent sections will cover the theoretical framework, research methodology, analysis of findings, and a final conclusion with recommendations.

2. Theoretical Background

Inter-municipal cooperation (IMC) in the provision of public services is a mechanism by which municipalities jointly address local self-government tasks to more effectively use available resources, improve service quality, and optimize costs. This model of cooperation is based on the principles of decentralization and subsidiarity, allowing municipalities to collectively respond to challenges they would be unable to manage individually. Theoretically, IMC is based on concepts of public administration, fiscal decentralization, and institutional economics. It also involves the issues of collective action and the dilemmas of cooperation that can arise from the different interests of individual self-governing bodies. Key success factors include the legislative framework, availability of financial resources, administrative capacity, and the willingness of municipalities to engage in joint projects.

The following sections will focus on the legal, economic, and organizational aspects of IMC, reflecting its advantages, challenges, and specific forms of cooperation in both the Slovak and international contexts. According to Act No. 479/2010 Coll. on municipal government, a municipality is an independent territorial self-governing unit. Its primary task is to ensure the development of the territory and meet the needs of residents through services. Fiscal decentralization, according to Feld and Kirchgaessner (2001), offers benefits such as more efficient expenditures and better tailoring of services to local needs, while a lack of funding can lead to a decrease in service quality (Buchanan, 1997).

A common problem for local governments is vertical fiscal imbalance, where revenues do not match expenditures. This often manifests in public services like road maintenance or water supply systems. Remunicipalization—the return of services to municipal management—is one response to dissatisfaction with privately contracted services. Another solution is IMC, which allows municipalities to share resources and improve services (Gajdoš, 2006).

Despite the advantages, IMC faces challenges such as varying levels of development and needs among municipalities, which can complicate consensus. Additionally, a lack of funding and personnel required for project coordination and implementation can be a significant obstacle (Pusta, Dolna, 2010). State and international support can play a crucial role in overcoming these obstacles, as can financial aid and the exchange of experiences from abroad. The trend toward collaborative governance has intensified due to the realization that complex challenges, such as implementing the sustainable development goals or ensuring effective crisis management, transcend individual municipal boundaries (Sorensen & Torfing, 2021). Contemporary literature emphasizes the shift from purely cost-driven cooperation to resilience-driven and strategic collaboration, focusing on building regional capacity for adaptation to shocks and long-term sustainability. (Feiock, 2013; Gajdoš, 2013; Teles & Swianiewicz, 2018).

IMC also has the potential to bridge gaps in service provision resulting from inadequate resources or capacities of individual municipalities. Smaller municipalities can achieve better results in public services like education, healthcare, or transport through cooperation. Furthermore, IMC can contribute to regional development and increase the region's attractiveness to investors and tourists. An example of successful IMC is the creation of micro-regions that can more effectively apply for EU and national grants.

To function effectively, IMC requires clear rules and mechanisms for management and control, including setting responsibilities and transparently allocating finances. The similarities and differences between potential partners are also important. Homophily (similarity) provides protection against power asymmetry and facilitates a fair distribution of benefits (Gerber, Henry, Lubell, 2013).

The Institutional Collective Action (ICA) framework provides a lens for understanding the dilemmas of IMC. It helps identify mechanisms to overcome cooperation risks and transaction costs. These dilemmas arise horizontally (when governments are too small or large for effective service production), vertically (between different government levels), and functionally (when decisions in one area affect others). The ICA framework emphasizes that municipalities face dilemmas

such as a lack of coordination, financial unsustainability, and legislative barriers. While these challenges exist, IMC offers benefits like economies of scale, improved service quality and availability, and stronger regional integration and social cohesion (Feiock, 2013). The Slovak experience, as a small, fragmented local government system, offers a high-utility case study for countries like the Czech Republic, Hungary, or Poland, which share similar historical and structural characteristics, thus providing generalizable lessons on managing ICA dilemmas in Central and Eastern Europe. (Teles & Swianiewicz, 2018; Csachová & Dická, 2013; Sedmihradská, 2018).

3 Materials and Method

This chapter focuses on analyzing inter-municipal cooperation in Slovakia from the perspective of efficiency, economic and social benefits, and identifying factors that either support or hinder cooperation among municipalities. The objective is to use the Institutional Collective Action (ICA) framework to understand the problems of IMC and identify mechanisms to overcome them. This framework shows how to overcome cooperation risks and other transaction costs to create effective cooperation in local self-government for the provision of local public services.

The subjects of this study are Slovak self-governing bodies (municipalities and cities) that are involved in inter-municipal cooperation. The practical part of the study focuses on the self-governments that provided data through a questionnaire survey. The main research question is: What factors support or hinder effective inter-municipal cooperation in Slovakia?

Research Methods:

- **Analysis and Synthesis:** Used for the theoretical part of the work, where literary sources, scientific articles, legal regulations, and studies related to public services, IMC, and the ICA concept were analyzed. The results were then synthesized to formulate the theoretical basis.
- **Comparative Method:** Served to compare different approaches to IMC in selected regions and their impact on service efficiency.
- **Questionnaire Survey:** The key tool for collecting data for the practical part of the work. Questionnaires were distributed to Slovak municipalities to determine the extent and forms of cooperation, identify obstacles and benefits, and assess its effectiveness.
- **Statistical Analysis:** Used to identify trends, relationships, and factors influencing IMC from the collected data.

Nearly all municipalities in Slovakia were surveyed via email using Brevo.com and Google Forms. As of March 14, 2025, 356 responses were received. Of these, 206 municipalities (approximately 58%) use inter-municipal cooperation to provide public services. The rest of the data analysis focuses only on these 206 municipalities that provided a complete response.

4 Results and Discussion

Based on the analysis of the questionnaire responses, several key statistics and conclusions can be drawn, providing a comprehensive picture of IMC in Slovakia. The research findings align with several existing academic studies, confirming the relevance of the data.

A total of 79 municipalities cooperate with more than 20 other municipalities, indicating that IMC is widespread in Slovakia. Another 66 municipalities cooperate with 11 to 20 municipalities, and only 10% cooperate with 2 to 5. This high number of participating municipalities demonstrates that they see the benefits of cooperation, especially in sharing resources and costs. This trend is confirmed by Nižňanský et al. (2009), who state that municipalities often form associations to provide services more efficiently and optimize costs.

Furthermore, the number of participating actors appears to be directly linked to transaction costs. The analysis revealed a moderate, highly significant correlation between a large number of cooperating municipalities (more than 20) and the perception of a "Very difficult administrative load": $\rho=0.299$, $p=0.000$. This finding directly supports the core assumption of the Institutional Collective Action (ICA) framework, which posits that as the number of actors increases, so do

coordination and transaction costs. A larger number of partners necessitates more complex negotiation, monitoring, and management (Feiock, 2013). The high number of partners (more than 20 municipalities) was also correlated with specific difficulties, showing a link to "Problems with coordination" ($\rho=0.143$, $p=0.013$) and "Complex administrative processes" ($\rho=0.171$, $p=0.003$). This confirms that the sheer scale of the cooperation intensifies the administrative and coordination burdens. This correlation, while originating from Slovak data, provides a generalizable insight: policy interventions should focus on optimizing cooperation scale to manage administrative transaction costs.

The most common legal forms of cooperation are Municipal Associations and Joint Municipal Offices. These forms are preferred for their administrative simplicity and better access to funding, which aligns with the study by Fageda, Bel, and Warner (2010). Less frequent forms are Local Action Groups and contractual cooperation, as they are often more complex and involve higher transaction costs. (Table 1)

Table 1 Legal Forms of Inter-Municipal Cooperation

Legal Form of Cooperation	Number of Municipalities	Percentage of 206
Joint Municipal Offices	131	63.6%
Municipal Associations	121	58.7%
Local Action Groups (LAGs)	114	55.3%
Contractual cooperation	61	29.6%

Source: authors

The main reasons for IMC are financial savings, a lack of personnel, and the improvement of public service quality. Municipalities also reported that cooperation allows them to secure external funding like grants. (Table 2)

Table 2 Main Reasons for Cooperation

<i>Reason for Cooperation</i>	<i>Number of Municipalities</i>
<i>Financial savings</i>	111
<i>Lack of personnel capacity</i>	121
<i>Legislative requirements</i>	83
<i>Sharing resources and costs</i>	56
<i>Improved quality of public services</i>	100
<i>Obtaining external financial resources</i>	78
<i>Improved efficiency of administration and organization</i>	53
<i>Protection and improvement of the environment</i>	18
<i>Securing expert capacities</i>	87
<i>Solving common problems (e.g., transport, roads)</i>	68
<i>Other</i>	3

Source: authors

The respondents, reported reduced costs and reported improved service quality. Additionally, perceived better service accessibility and noted more efficient use of equipment and personnel. This confirms that IMC is a key tool for increasing efficiency and quality in public services, which is consistent with the research of Nižňanský et al. (2019) and INEKO (2021). (Table 3)

The consistency between municipalities' motivations and their realized benefits was also demonstrated through moderate to strong correlations: The motivation of "Financial savings" showed a strong correlation with the realized benefit of "Reduced costs" ($\rho=0.363$, $p=0.000$). Similarly, the expectation of "Improved quality" was strongly correlated with the perceived benefit of "Increased quality" ($\rho=0.351$, $p=0.000$). These findings indicate that the expected benefits, which

motivate municipalities to overcome the initial barriers to cooperation, often translate (at least partially) into tangible, perceived benefits, reinforcing the rational choice element of IMC. This strong correlation confirms the utility of the rational choice institutionalism perspective in predicting IMC success, a finding that holds validity across diverse local government systems.

Table 3 Main Benefits and Services Provided

Benefit	Number of Municipalities	Percentage of 206
Improved service quality	123	59.5%
Reduced costs	94	45.5%
Improved service accessibility	85	41.5%
More efficient use of resources	73	35.5%

Source: authors

Municipalities primarily rely on their own budgets and state subsidies for funding IMC. EU grants are used by about 27% of municipalities, while private and business contributions are minimal. This confirms that state support is crucial for the sustainability of inter-municipal initiatives. The most frequently provided services through IMC are joint construction offices, waste management, education, and social services. These areas are resource-intensive and require specialized expertise, making cooperation highly beneficial. Our findings align with studies by Agranoff and McGuire (2003) and Bel, Fageda, and Warner (2009), which highlight that sharing resources in these specific areas can significantly reduce costs and improve service quality.

Table 4 Services Provided Through Inter-Municipal Cooperation

<i>Service Provided</i>	<i>Number of Municipalities</i>
<i>Construction Office</i>	88
<i>Crisis management and security</i>	16
<i>Cemetery administration</i>	19
<i>Public lighting</i>	10
<i>Transport and infrastructure</i>	6
<i>Social services</i>	84
<i>Schooling and education</i>	75
<i>Waste management</i>	62

Source: authors

A majority of municipalities have a rather cautious approach to the risks associated with IMC, with 65 municipalities describing their approach as conservative. This caution reflects an awareness of potential risks, such as financial losses and administrative complexity, a finding that is consistent with Feiock's (2013) research on the risks of collective action. The main obstacles identified were a lack of funding, complex administrative processes, and insufficient personnel. These challenges highlight the need for systemic changes at the state level to facilitate cooperation. (Table 5)

Table 5 Problems Encountered by Municipalities in Providing Services via IMC

Problem Encountered	Number of Municipalities	Percentage
Lack of funding	136	53.1%
Reluctance of municipalities to cooperate	25	9.8%
Problems with coordination and management	50	19.5%
Employee resistance	7	2.7%
Reluctance to cooperate with smaller municipalities	19	7.4%
Conflicts between municipalities	12	4.7%
Complex administrative processes	65	25.4%
Fear of losing autonomy	21	8.2%
Lack of personnel	79	30.9%
Other	11	4.3%

Source: authors

We also examined the possible correlation between the perception of administrative difficulty and the complexity of administrative processes as a deterrent to cooperation using Spearman's analysis. A weak but statistically significant correlation was found between the perception of a "Rather difficult" administrative load and the statement that "Complex administrative processes" would act as a deterrent: $\rho=0.145$, $p=0.012$. This suggests that when municipalities perceive the administrative burden as relatively high, it significantly increases the likelihood that the complexity of the processes will discourage them from continuing or initiating cooperation. High administrative difficulty can thus actively deter collaboration.

A weak correlation was also observed between the perception of administrative difficulty and problems with coordination. Specifically, a statistically significant correlation was found between "Very difficult administrative load" and "Problems with coordination": $\rho=0.190$, $p=0.001$. This indicates that complex processes can hinder effective management and coordination of cooperation, confirming that excessive bureaucracy represents a significant transaction cost.

Further analysis of the problems encountered revealed that coordination costs and administrative transaction costs frequently coincide: "Problems with coordination" were weakly but significantly correlated with "Complex administrative processes" ($\rho=0.224$, $p=0.000$). This suggests a dual barrier where complex bureaucracy complicates coordination, and poor coordination, in turn, can exacerbate the feeling that the administration is overly complicated. Another finding points to a co-occurrence of resource scarcity, with "Lack of funding" correlating with "Lack of personnel" ($\rho=0.181$, $p=0.002$). This means that municipalities facing one type of shortage are likely struggling with the other, increasing the pressure to seek solutions through IMC while also complicating the ability to invest in it. Finally, a weak, but noteworthy, correlation was found in the financial domain: "Financial savings" as a reason for cooperation correlated weakly with "Lack of funding" as a subsequent problem ($\rho=0.147$, $p=0.011$). This suggests that even when financial savings are a primary motivator, the problem of insufficient funding can persist during the cooperation, complicating the assessment of net benefits.

Municipalities would most appreciate an increase in funding, a simplification of legislation, and better coordination from the state. Other suggestions included training for employees and the introduction of new technologies. These proposals

indicate that municipalities recognize the need for systemic changes to make IMC more effective and less burdensome. These recommendations are consistent with the conclusions of Nižňanský et al. (2009). (Table 6)

Table 6 Measures to Improve the Effectiveness of Cooperation

<i>Measure to Improve Effectiveness</i>	<i>Number of Municipalities</i>
<i>Increased funding</i>	150
<i>Legislative simplification</i>	140
<i>Better coordination from the state</i>	85
<i>Training and education for employees</i>	51
<i>Implementation of technologies and data sharing</i>	46
<i>Other</i>	5

Source: authors

The majority of municipalities rated the level of trust among cooperating municipalities as very high, with 21% rating it as average and only 1% as low. This high level of trust is a key factor for successful cooperation, aligning with the findings of Valach and Cifranič (2021). Administrative complexity was rated as average by 56.8% of municipalities and rather difficult by 19.4%. This confirms that administrative processes are a significant obstacle that requires attention, as noted by Feiock (2013).

In the context of social capital, the study observed weak negative correlations that are nevertheless theoretically relevant. "Very high trust" in cooperating partners showed a negative correlation with "Conflicts between municipalities" ($\rho = -0.125$, $p = 0.031$) and "Employee resistance" ($\rho = -0.165$, $p = 0.004$). Although weak, these results support the idea that high levels of trust can reduce social transaction costs (less need for formal control, easier dispute resolution) and mitigate some common collective action problems (conflicts, internal resistance). This finding implies that social capital is a crucial non-monetary asset in overcoming the social dilemmas of IMC.

The generalizability of these findings is subject to certain limitations. First, the data relies on a self-reported questionnaire survey, which may introduce a risk of response bias, particularly an over-reporting of positive outcomes (e.g., improved service quality) and an under-reporting of internal conflicts. Second, the correlation analysis establishes associations, but not necessarily causality, meaning the link between administrative difficulty and coordination problems, while significant, cannot be definitively proven as cause and effect. Third, a significant limitation was the low willingness of some local governments to participate in the research, which may affect the overall representativeness of the sample, and the variable quality of questionnaire completion. Fourth, the sample exhibits a disproportionate representation of municipalities that actively utilize inter-municipal cooperation (IMC) compared to the overall population of municipalities, potentially leading to a survival bias, as municipalities that failed to establish or maintain cooperation may be underrepresented.

In conclusion, the findings support the idea that inter-municipal cooperation is a vital tool for Slovak municipalities to overcome financial and personnel limitations and improve service quality. However, it requires a supportive institutional and legal framework. The study highlights the need for systemic reforms to simplify administrative processes, increase funding, and foster an environment of trust and collaboration to unlock the full potential of IMC. The strong evidence linking the number of partners to higher transaction costs is a major insight that applies to any fragmented governmental system facing collective action dilemmas.

5 Conclusion

The analysis of inter-municipal cooperation (IMC) in Slovakia confirms its vital role in improving the quality and accessibility of public services. Through a questionnaire survey, the study identified that IMC is widespread and primarily driven by the need for financial savings, a lack of personnel, and the desire to enhance service quality. Crucially, the strong positive correlation found between the motivations (e.g., Financial savings as a reason) and the perceived benefits (e.g.,

Reduced costs as a benefit) validates the rational choice foundation of IMC in the Slovak context, showing that initial expectations often translate into realized gains. The most common forms of cooperation are Municipal Associations and Joint Municipal Offices, which are favored for their administrative simplicity.

The research demonstrates that while IMC brings significant benefits, such as economies of scale and better service provision, it faces considerable challenges rooted in transaction costs. The primary obstacles include a lack of funding, complex administrative processes, and coordination issues. The correlation analysis directly confirms a central premise of the Institutional Collective Action (ICA) framework: as the number of cooperating municipalities increases, so too does the administrative difficulty and the risk of coordination problems. Furthermore, the finding that perceived administrative difficulty is associated with the complexity of processes acting as a deterrent shows that bureaucracy is an active hindrance to collaboration. This highlights a crucial, generalizable finding for international policymakers: to foster effective IMC, systemic simplification must take precedence over mere encouragement.

To increase the efficiency of IMC, municipalities have clearly expressed the need for systemic changes at the state level. Key recommendations include increasing state funding, simplifying legislation, and improving inter-municipal coordination. On the internal side, the high level of trust among collaborating municipalities suggests a solid foundation of social capital already exists. This trust is empirically relevant, as indicated by a weak but significant negative association between Very high trust and both Conflicts between municipalities and Employee resistance, suggesting that social capital acts as an important mechanism for mitigating social transaction costs.

By addressing the identified administrative and financial barriers and leveraging the existing high social capital policymakers can create a more conducive environment for municipalities to successfully manage transaction costs and unlock the full potential of IMC to better serve their citizens.

Based on the findings, the following concrete improvements are proposed: The key measure is the introduction of Systemic Financial Support, which extends beyond the framework of project grants. It is proposed to establish a dedicated, stable, and non-project-based state funding stream specifically to cover the administrative costs (personnel and coordination) of formal IMC structures, such as joint municipal offices, thereby strengthening their institutional sustainability. Parallel to this, it is necessary to carry out Administrative Simplification through the implementation of a "one-stop-shop" legislative amendment that would streamline reporting, accounting, and decision-making processes exclusively for legally established forms of IMC, radically reducing the transaction costs identified within the Institutional Collective Action (ICA) framework. Finally, at the human resources level, it is necessary to introduce mandatory, state-funded Capacity Building programs, focused mainly on developing collaborative management and negotiation skills for municipal employees, to proactively mitigate coordination problems and conflicts.

As for future research, three main directions are suggested to deepen understanding and generalize the findings. First, Causal Link Analysis should replace correlational evidence; future studies should employ qualitative methodologies (e.g., case studies, process tracing) or advanced econometric models (e.g., fixed-effects panel data analysis) to establish the causal relationship between specific legislative complexity and actual coordination failure, thereby gaining more robust knowledge of ICA mechanisms. Second, it is crucial to conduct a study, which would track the performance of IMC engaged versus non engaged municipalities during major external shocks (e.g., a national economic crisis, flood event, or pandemic) with the goal of empirically quantifying the contribution of IMC to regional resilience. And finally, it is necessary to perform a cross national comparison of transaction Costs; this would involve developing a standardized quantitative index for measuring administrative transaction costs within IMC and applying it to a comparative study across multiple fragmented EU member states (e.g., Slovakia, Czech Republic, Portugal), thereby providing highly generalizable policy recommendations for administrative best practices.

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Institutional Limits of Housing Subsidies in the Czech Republic: A Regional Development Perspective

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Abstract: The study analyzes the system of subsidies for affordable housing in the Czech Republic in the context of economically and socially disadvantaged regions. The main objective is to assess the extent to which the current public support framework fulfills its declared purpose of ensuring affordable housing for low-income households and to identify the institutional and economic factors influencing its effectiveness. The research uses qualitative comparative analysis of academic studies, statistical data, and strategic documents from 2012–2025. An interdisciplinary approach combines insights from economics, regional development, and public administration theory to critically evaluate the institutional framework of housing policy in the Czech Republic. The findings point to persistent systemic shortcomings, insufficient coordination between levels of public administration, fragmentation of competences, and a strong dependence on market mechanisms in addressing the issue of housing affordability. These factors contribute to the residualization of the public housing sector, which is narrowing to narrowly defined groups of the population and losing its stabilizing and developmental function. The study concludes that housing policy should be seen as a long-term and institutionally anchored tool for regional development, linking public investment, regulatory frameworks, and local capacity building to promote social cohesion and economic resilience.

Keywords: affordable housing; housing policy; institutional capacity; public administration; regional development; Czech Republic

JEL Classification: R21, R38, H53, O18

1 Introduction

Affordable housing constitutes a fundamental pillar of social stability and regional cohesion. In the Czech context, however, it has long been evident that the system of public support for housing faces institutional constraints that limit its effectiveness and spatial equity. The problem is not merely economic but primarily structural, stemming from the fragmentation of competences among different levels of public administration, weak policy coordination, and the insufficient absorptive capacity of regions (Organisation for Economic Co-operation and Development, 2024; Smékalová et al., 2015). These factors create a paradox in which the structurally disadvantaged regions, those for which subsidy programmes are primarily intended, tend to be less successful in accessing them.

Since 1990, Czech housing policy has undergone a profound transformation involving the privatisation of the housing stock, the strengthening of market principles, and the withdrawal of the state from its role as an active housing provider. This process has led to the residualisation of the public sector, whereby social housing has been reduced to narrowly defined groups of very low-income households (Berry, 2012; Milligan & Gilmour, 2012). As a result, public interventions often focus more on crisis situations than on their stabilising and developmental functions. At the same time, residualisation weakens the institutional framework that should ensure the long-term availability and sustainability of the housing stock.

In addition to institutional factors, housing affordability is also influenced by macroeconomic conditions, cyclical dynamics in the real-estate market, changes in interest rates, and investment volatility (Favilukis et al., 2023; Hromada, 2024). Rising prices and limited supply contribute to widening regional disparities, with economically weaker areas, particularly the Ústí nad Labem, Karlovy Vary, and Moravian-Silesian regions, showing the highest share of households at risk of excessive housing costs (Organisation for Economic Co-operation and Development, 2021; Eurostat, 2025). These regions therefore represent crucial areas for analysing the institutional mechanisms of public support, not only because of the scale of the problem but also due to the different strategies adopted to address structural disadvantages.

Similar challenges are evident across other post-transitional Central European countries, where the privatisation of housing stock likewise led to the residualisation of the public sector and a dependence on market mechanisms (Časni, 2022;

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Tsenkova, 2017). This broader regional context situates the Czech experience within a wider European framework in which institutional quality and public-administration capacity are key determinants of effective subsidy policy (Peters, 2019). From this perspective, the success of public housing-support programmes is determined not only by the volume of allocated resources but, above all, by the degree of institutional preparedness among actors, ministries, regional authorities, municipalities, and specialised funds (Lux & Sunega, 2014). A well-functioning institutional framework enables policy coordination, transparent resource allocation, and long-term planning, whereas weak governance leads to fragmentation and short-term, often reactive measures.

This paper therefore focuses on analysing the institutional limitations of the housing-subsidy system in the Czech Republic, with particular attention to economically and socially disadvantaged territories. Its aim is to identify the factors that influence the fulfilment of declared policy objectives and to assess the extent to which the current support framework genuinely contributes to housing affordability for low-income households. The approach builds on the assumption that housing policy should be understood not only as a social agenda but also as an instrument of regional development, whose effectiveness depends on the ability of institutions to coordinate public investments and regulations over the long term. Within this analytical framework, the paper addresses three research questions: What institutional barriers constrain the coordination of housing policy across different levels of public administration? How are these barriers reflected in regional disparities in access to subsidy support? To what extent does the current subsidy system contribute to achieving the objectives of regional development?

2 Methods

The research is based on a qualitative comparative analysis, which makes it possible to capture the institutional limitations and governance patterns within the system of affordable housing support in the Czech Republic. This approach is suitable for examining complex public policy systems in which economic, administrative, and social dimensions intersect, and where standard quantitative models cannot be applied (Ragin, 2009; Schneider & Wagemann, 2012). The methodological framework of the research combines three theoretical foundations: institutional theory (North, 1990; Peters, 2019), public policy analysis (Wu et al., 2015), and thematic content analysis (Mayring, 2014). This combination makes it possible to capture the complex relationships between the structure of institutions, modes of governance, and the effectiveness of subsidy programme implementation.

The unit of analysis is the institutional framework of housing policy, which was examined at the macro and meso levels. At the macro level, strategic documents and legislative frameworks were analysed, with the main sources including publications and other materials from the Ministry of Regional Development and the Ministry of Labour and Social Affairs. The meso level was represented by regional housing development strategies in the Ústí nad Labem, Karlovy Vary, and Moravian-Silesian regions, which have long exhibited structural disadvantage (MMR, 2024). This multi-level approach made it possible to observe not only the formal design of policies but also the institutional capacity and practical modes of implementation. The data corpus consisted of a total of 39 policy and strategic documents and a set of statistical indicators from the Czech Statistical Office (CZSO, 2024), Eurostat, and the OECD. Key sources included the Housing Strategy of the Czech Republic 2021+ (MMR, 2021), the Social Inclusion Strategy 2021–2030 (MPSV, 2021), the Concept of Social Housing of the Czech Republic 2015–2025 (MPSV, 2025), and the publication Housing Affordability in Cities in the Czech Republic (OECD, 2021). Additionally, a thematic analysis of academic studies focused on housing affordability in post-transitional economies was conducted (Časni, 2022; Lux & Sunega, 2014; Tsenkova, 2009).

The analytical process took place in four consecutive phases: coding, comparison, data triangulation, and synthesis of results. First, all documents were coded according to predefined categories that made it possible to identify institutional patterns and relationships between levels of governance. The structure of the categories used is summarised in Table 1.

Table 1 Analytical categories and coding framework

Main category	Subcategory / Indicator	Example source
Policy objectives	Declared priorities, implementation methods	MMR (2021)
Resource allocation	Regional distribution, volume of subsidies	Eurostat (2025)
Governance coordination	Inter-ministerial cooperation, vertical coordination	MMR (2024)
Effectiveness evaluation	Existence of evaluation reports, assessment methodologies	Lux & Sunega (2014)
Institutional capacity	Professional background and absorptive capacity of regions	Smékalová et al., (2015)

Source: Own processing based on MMR, Eurostat, OECD and academic studies (2012–2025)

After the coding phase, a comparison of institutional arrangements and subsidy mechanisms was carried out. The findings from the content analysis were further verified through triangulation with statistical data (CZSO, 2024; Eurostat). The results were subsequently synthesised into a comparative table summarising the institutional conditions affecting the effectiveness of subsidy policy. The main limitations of the research lie primarily in the uneven availability of data on local programmes and the limited possibility of quantifying causal relationships between institutional factors and social outcomes. The study therefore interprets its findings mainly at the analytical and interpretative level rather than in strictly causal terms. All data used were obtained from publicly available sources and do not contain any sensitive information.

3 Research results

The analysis of strategic, evaluation, and statistical documents shows that the system of public support for affordable housing in the Czech Republic exhibits a significant institutional imbalance between the central, regional, and local levels of governance. At the national level, the Ministry of Regional Development (MMR) plays a dominant role in formulating strategic objectives and managing key subsidy programmes. However, these frameworks are implemented through fragmented mechanisms. Public administration institutions often operate in parallel, lacking unified methodological guidance or systemic coordination. The results of the qualitative comparative analysis further confirm notable differences among structurally disadvantaged regions, specifically the Ústí nad Labem, Karlovy Vary, and Moravian-Silesian regions. These regions have a high proportion of households at risk of excessive housing costs, yet they differ in the degree of institutional coordination. In the Ústí nad Labem and Karlovy Vary regions, housing policy is implemented mainly in a reactive, subsidy-dependent manner, relying on individual calls and municipal projects often without a long-term strategic framework. In contrast, the Moravian-Silesian Region integrates housing support into a broader regional strategy of territorial revitalisation, linking it to the objectives of social inclusion and economic restructuring.

The analysis also identified four recurring institutional patterns that influence the effectiveness of subsidy policy:

1. a low level of inter-ministerial coordination between the Ministry of Regional Development (MMR), the Ministry of Labour and Social Affairs (MPSV), and the Ministry of Finance, which leads to fragmented policy objectives;
2. the absence of a unified framework for evaluating the impacts on housing affordability;
3. a strong reliance on market mechanisms, whereby the state primarily regulates the supply of loans while playing a limited role in the direct provision of housing;
4. persistent administrative inequalities between regions, which are reflected in varying levels of success in obtaining subsidies.

A summary of the main findings is presented in Table 2, which synthesises five key dimensions of the institutional conditions influencing the effectiveness of the subsidy policy in the Czech Republic.

Table 2 Institutional conditions affecting the effectiveness of housing subsidy policy in the Czech Republic

Analytical dimension	Findings
Coordination across government levels	Fragmented responsibilities between MMR, MPSV and MF, lack of uniform methodology
Allocation of funds	Concentration in Prague and Central Bohemia; low share for ÚK and MSK
Institutional capacity (absorptive capacity)	Low capacity in weaker regions, affecting project success rate
Evaluation and monitoring	Lack of impact assessment tools on housing affordability
Policy orientation	Shift from construction to renovation; market reliance increasing

Source: Own processing based on MMR, NRB, OECD and academic studies (2012–2025)

The results indicate that the effectiveness of the housing subsidy system in the Czech Republic is constrained by a combination of three interrelated mechanisms: administrative fragmentation, low absorptive capacity, and a persistent reliance on market-oriented solutions. This combination prevents public interventions from being effectively translated into the territories that need them most. Although recent years have brought positive examples of integrated approaches, particularly in the Moravian-Silesian Region, the system as a whole remains largely reactive and short-term. To achieve stable and lasting effects, it is therefore essential to strengthen institutional coordination, enhance the capacity of regional and local governments, and implement systematic evaluation of subsidy programme impacts.

These findings are further reinforced by the analysis of institutional barriers that constrain housing policy coordination and have a pronounced impact on regional disparities. A key obstacle to effective implementation remains the fragmentation of the institutional system. Competences among different levels of public administration are insufficiently interconnected, and there is a lack of multi-annual cooperation mechanisms between the state, regions, and municipalities. Although the Ministry of Regional Development sets the strategic frameworks, their implementation is predominantly project-based and short-term. Municipalities often focus on individual subsidy calls without linkage to long-term programmes, while regions lack a clearly defined coordinating role.

Another significant barrier is the horizontal misalignment between ministries, whose agendas are insufficiently harmonised and rely on differing metrics of success. These institutional barriers are reflected in regional disparities in access to subsidy support. Structurally weaker regions, such as the Ústí nad Labem and Karlovy Vary regions, face limited absorptive capacity due to a shortage of professional staff and financial resources for project preparation. As a result, the subsidy system tends to favour regions with higher administrative readiness, creating an imbalance between the formal openness of subsidy calls and the actual ability of municipalities to participate. Short deadlines, complex rules, and demanding project documentation requirements reinforce the so-called “shovel-ready bias”, directing support towards areas where projects are already prepared rather than where housing needs are most acute. Consequently, the current subsidy system contributes to achieving the goals of regional development only partially. While it generates important investment impulses and supports the regeneration of the housing stock, it contributes only marginally to long-term social stability and regional convergence. The dominant focus on physical outputs, such as the number of housing units built, does not allow for adequate assessment of actual outcomes, including housing affordability, sustainability, or the reduction of social exclusion. To enhance the system’s effectiveness, it is necessary to strengthen institutional coordination, establish systematic impact evaluation, and expand technical assistance to municipalities, so that the subsidy policy can serve not only economic but also socially integrative and regionally cohesive objectives.

4 Discussion and Conclusions

The results of the analysis confirm that the system of public support for affordable housing in the Czech Republic suffers from long-standing institutional weaknesses that significantly affect its impact on regional development and social cohesion. The problem does not lie solely in the volume of allocated funds but primarily in the quality of the institutional framework, which determines the ability of public actors to coordinate, implement, and evaluate housing support across territories. Three key factors, administrative fragmentation, limited absorptive capacity, and a strong reliance on market instruments, create an environment in which public interventions often fail to meet the real needs of regions. A comparative analysis of the Ústí nad Labem, Karlovy Vary, and Moravian-Silesian regions shows that the decisive factor in the success of subsidy policy is institutional preparedness and the quality of coordination at the regional level.

In recent years, the Moravian-Silesian Region has demonstrated the ability to link housing policy with a comprehensive strategy of social and economic revitalisation, enabling synergistic effects between investment, employment, and social integration. In contrast, in the Ústí nad Labem and Karlovy Vary regions, the approach to housing support remains more fragmented and dependent on individual municipal projects, lacking a strong regional framework. This contrast underscores that financial resources alone are not a guarantee of effectiveness; what truly matters is the institutional foundation, the ability to integrate different policies, and the continuity of strategic governance. From a theoretical perspective, these findings can be interpreted in the context of the residualisation of the public sector (Berry, 2012; Milligan & Gilmour, 2012), in which the state retreats from its active role as a housing provider and focuses mainly on compensatory measures targeting the most vulnerable groups. This trend, also confirmed by international literature, reduces the ability of housing policy to act as a systemic development instrument. At the same time, the situation can be analysed through the lens of new institutionalism (Peters, 2019), which emphasises that the quality of coordination, institutional stability, and the capacity to learn from practice are critical factors determining the effectiveness of public interventions.

The Czech case illustrates that the absence of these features leads to a predominance of short-term, administratively burdensome projects with limited territorial and social impact. The discussion of the results therefore points to the need to redefine housing policy as a structurally embedded component of regional development, rather than merely as a social agenda. Sustainability and regional balance cannot be achieved without linking financial instruments, regulatory frameworks, and local capacities into a coherent and coordinated system. The effectiveness of housing subsidies should thus be assessed not only in terms of quantitative indicators, such as the number of housing units built or the total investment volume, but also in terms of qualitative outcomes, including improvements in affordability, stability, and social inclusion within the given territory. In this regard, the success of subsidy policy is more a reflection of institutional quality, transparency, and continuity than of the financial resources invested.

Based on the conducted analysis, three key recommendations can be formulated for public administration practice:

1. Establish a unified framework for evaluating the impacts of subsidy programmes on housing affordability, enabling the monitoring of not only quantitative outcomes but also social and regional effects.
2. Strengthen the capacities of regional and local governments in the areas of project management, inter-ministerial coordination, and strategic planning.
3. Stabilise the financial and institutional instruments aimed at supporting the construction and regeneration of the housing stock, ensuring their long-term predictability and alignment with the objectives of regional policy.

In conclusion, the effectiveness of the housing subsidy system in the Czech Republic depends primarily on the quality of the institutional framework and the ability to integrate the economic and social objectives of public administration. Only a coordinated, continuously evaluated, and adaptive housing policy can fulfil a developmental function and contribute to reducing regional disparities. This conclusion also supports the broader argument that institutional quality is a fundamental determinant of the success of public policies in post-transformational economies, without it, even well-designed instruments remain fragmented, short-term, and only weakly effective.

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Session:
Recent and Future Trends and Challenges in Retail,
International Trade, Marketing and Tourism

Mental Health Care as a Specific Tourism Product

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Abstract: The concept of wellness is traditionally understood within a holistic, multidisciplinary framework (Hettler, Dunn), where the psychological and mental components are key to achieving maximum potential. Despite this theoretical consensus, in practice, wellness on the Czech market, and especially in the accommodation sector, is predominantly reduced to the physical dimension (swimming pools, saunas, massages). This article aims to explore the discrepancy between the theoretical holistic concept of wellness and the practical services offered in the Czech Republic and to identify gaps in the mental health care segment. The methodology combines systematic literature research with an analysis of the content of the websites of 50 selected luxury accommodation facilities (N=50) in the Czech Republic and an exploratory qualitative survey of demand (structured interviews with clients).

The results show that the vast majority (92%) of the facilities surveyed offer only one-dimensional, physically focused services, while comprehensive mental health care packages (including retreats, meditation, and yoga with an instructor) are offered by only 8% (4 facilities). The results also show that although client demand is primarily directed towards traditional services (swimming pool, sauna), respondents actively express interest in expanding the offer to include relaxation and meditation exercises as a counterbalance to a stressful lifestyle.

Based on data triangulation, the article confirms a significant gap in the offer of holistic wellness stays (retreats) on the Czech market. It formulates recommendations for tourism entities that want to take advantage of the growing trend of mental health care.

Keywords: wellness, mental health care, retreat, holistic health, tourism, wellness dimension

JEL Classification: L83, L84, I12

1 Introduction

The concept of wellness is traditionally understood as a harmony between the body and the soul, and its psychological component, which is key in professional terms, is often emphasised. The term "wellness" represents a distinct field of science with multidisciplinary overlap. Research in the field of wellness encompasses social sciences and natural sciences, particularly biology, physiology, psychology, pedagogy, philosophy, ethics, sociology, anthropology, and kinanthropology (Krejčí, 2013). Goeldner & Ritchie (2014) emphasize the increase in leisure time and broader access to recreational opportunities for people in the Western world, which has led to an increase in demand not only within the entire tourism segment, but also in interest in health and spa stays.

This article aims to familiarize readers with the perception of the concept of wellness from both a theoretical and practical point of view, to familiarize readers with the differences in the theoretical concept of wellness, and to identify differences in the perception of this widely used term. The article also aims to identify gaps in the provision of wellness services on the Czech market and explore the possibilities of offering retreat stays.

2 Methods

The methodology of this article is based on a combination of theoretical research and empirical research with the aim of comprehensively examining the concept of wellness and identifying gaps in its practical application in the Czech accommodation sector, with a specific focus on Mental Health Care.

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2.1 Review of literature

The aim of this section of the article is to identify and synthesize key concepts, trends, theories, and current knowledge in the field of wellness. To create an adequate theoretical framework, a systematic literature review was used, focusing on the comparison and analysis of high-quality publications and key concepts in the field of wellness, with an emphasis on historical, contemporary, and multidisciplinary approaches to the concept (biology, psychology, philosophy, etc.). Based on precise work with information sources, approaches to the researched issue were described and basic concepts of the perception of the terms *wellness* and *well-being* were presented. The results of the research were used to create a coding scheme for the subsequent analysis of documents, especially with regard to the identification of elements of mental health care.

2.2 Website Content Analysis

The empirical part of the research is based on the Content Analysis method (Burgess, 1990). The range of wellness services offered on the websites and booking portals of Czech accommodation facilities was analyzed. Fifty (N=50) selected accommodation facilities in the Czech Republic were analyzed, with the selection primarily focusing on higher-category facilities (e.g., 4* and 5* hotels, resorts, and facilities rated on prestigious portals such as Amazing Places and Tripadvisor).

The analysis focused on the main topic of the work – Mental Health Care for Clients. The occurrence, description, and categorization of products that explicitly mention or primarily care for the mental, emotional, or spiritual dimension of wellness (e.g., retreats, *Mindfulness* programs, yoga, guided meditation, consultations, etc.) were monitored (Chandran et al., 2021). The offer on the official websites of the facilities was compared with the information provided on booking and review portals (e.g., Tripadvisor, Amazing Places) in order to validate the findings and identify examples of good practice in the comprehensive concept of wellness services in the Czech Republic.

2.3 Exploratory qualitative demand survey

To gain insight into clients' perceptions of wellness and demand, an exploratory qualitative survey was conducted in the form of structured interviews (Hendl, 2023). The interviews were conducted with clients of various wellness facilities in different geographical locations (Barcelona, Basel, and Prague). The interviews were conducted according to a pre-prepared script to ensure data comparability. All respondents were asked the same questions, and after the interview, the answers were recorded on prepared answer sheets.

The questions focused on:

1. the issue of in-demand products and procedures;
2. identifying missing products/procedures;
3. willingness to try newly proposed (especially mentally focused) products.

The survey inquired about their preferences for existing facilities and their opinions on how the offer could be further expanded. The data obtained provided direct feedback from the target group and served to support findings about gaps in the offer of retreats and mental health care.

2.4 Data processing

Data from literature reviews and structured interviews were processed using qualitative analytical methods.

Data obtained from website content analysis (n=50) were processed using frequency quantification and categorization. MS Excel software was used to process, sort, and record data, and a frequency analysis of the occurrence of specific products and services was performed. Later, the frequency (number of occurrences) and percentage of facilities offering key physical wellness products (swimming pools, saunas, massages) and those offering products explicitly focused on mental/holistic care were determined.

The identified offerings were categorized based on theoretical wellness models to determine whether the facility provided one-dimensional (predominantly physical) or multidimensional/holistic care. The findings were used to verify the thesis of a gap in the market offering. After conducting a literature review and analysing the interviews, a synthesis method was employed. This consisted of systematically linking and summarizing key theoretical concepts of wellness with practical findings from website analysis and interviews. The synthesis serves to create a comprehensive picture of the issue and to formulate the main findings of the article. The induction method (drawing general conclusions from partial observations) was used to interpret the data from the website analysis, where, based on repeated observation of the offer, it was possible

to categorize the dominant types of wellness services offered, identify existing trends, and formulate general conclusions about the state of the comprehensive concept of wellness on the Czech market.

The validity of the data is determined by data triangulation, i.e., mutual verification of findings obtained from three independent sources, which was used to strengthen the validity of the conclusions. If theoretical knowledge is confirmed by practical findings, the credibility of the results will be increased.

3 Research results

3.1 Review of literature

The notion of wellness was conceptually used in English literature as early as the 17th century (Zimmer, 2010). It roughly meant "good health." In a series of articles and lectures in the late 1950s, Halbert L. Dunn⁴ defined his concept of "high-level wellness" as "an integrated method of functioning that is aimed at maximizing the potential that an individual is capable of" (Schellong, 2012). Wellness is a way of life oriented towards achieving an elevated state of physical and mental well-being and described as a disciplined commitment to the pursuit of personal excellence (Dunn, 1959). It is a continuum (not a static state) between death and optimal condition, encompassing physical, mental, social, cultural, and spiritual dimensions (Dunn, 1961). This model emphasizes that mental wellness is an individual's responsibility, and the key to progressing to higher levels is self-knowledge and inner integrity.

A comprehensive perception of wellness can be found in Hettler (1976), who developed "The Six Dimensions of Wellness Model," which recognizes six dimensions: Physical, Emotional, Intellectual, Social, Spiritual, and Occupational. Roscoe (2009) expands on this model and emphasizes wellness as a balanced state consisting of seven dimensions of wellness: social, emotional, physical, intellectual, spiritual, occupational, and environmental. However, some authors focus mainly on the physical aspect, e.g., Müllerová (2008); Blahušová (2008), or Cathala (2014). Corbin (1979) defined health and well-being primarily in terms of achievable physical fitness, similar to Kaufman (2018), for example. Corbin's model is often used in school and sports environments, representing a reduction of wellness to its physical and cognitive components within the framework of exercise. These approaches measure and define well-being based on objective physiological data, thereby suppressing subjective, emotional, and spiritual dimensions. This approach focuses on factors affecting physical health and well-being at different stages of life, and its primary goal is to optimise physical health depending on age and environmental pressures (Kelly, Panchal, & Palmer, 2010), or the Global Wellness Summit (2023). However, the Czech Wellness Institute (2019) provides the definition: "Wellness is not just spas and hot tubs, but a holistic model of healthy human functioning." Contemporary wellness is defined as "active activities, choices, and lifestyles that lead to a state of holistic health" (Global Wellness Institute, 2023).

Myers (2000) systematically divides wellness into interrelated tasks and dimensions. The basis of this theory is a holistic model based on individual psychology that perceives the spiritual dimension, self-direction, work and leisure, friendship, and love. For our article on tourism, the area of Self-Direction is significant. It is purely psychological and encompasses a sense of worth, realistic beliefs, stress management, emotional awareness and management, problem-solving and creativity, a sense of humour, and self-care. Myers' 2000 model is referred to as the "Wheel of Wellness," but the same author later refined it and refers to it as "The Indivisible Self." At the same time, he introduced the measurement tool *The Five-Factor Wellness Inventory*, shifting the model to an empirically based framework (Myers, 2004). In some cases, the model works with six factors (e.g., National Wellness Institute, 2024). The advantages of a holistic approach are discussed in Oxford University Press (2023).

Representatives of the Deutscher Wellness Verband state that the widely used definition of wellness today, which considers wellness to be a made-up word composed of "well-being" and "fitness," is misleading (Deutscher Wellness Verband, 2023). For example, Travis & Ryan (2004) describe how Dunn, mentioned earlier in this article, used the old, forgotten term wellness and redefined it to describe an active process toward maximum potential, thereby distinguishing it from the state of well-being. Although the word "well-being" exists, the word "wellness" did not originate primarily in connection with this concept. Academic and etymological sources point out that the word wellness is significantly older and has different roots than the modern "well-being" (Ardell, 1977). AlNujaidi et al. (2025), who define wellness as active engagement and personal responsibility in the pursuit of a balanced life, whereas well-being focuses on the subjective experience of happiness and life satisfaction (i.e., a state). Barnes-Waychus, Uribe, & Collins (2023) add that while

⁴ Then-director of the National Office of Vital Statistics

consumers are changing their perceptions of health and physical fitness, these changes are motivated by a broader concept of wellness that goes beyond mere well-being.

In the 21st century, the global wellness movement and market reached a dramatic turning point when concepts and offerings related to fitness, diet, healthy lifestyles, and well-being proliferated wildly. It is also interesting to note that in 2024, more than half of the world's employers used health promotion strategies and a third invested in full-fledged wellness programs. Thanks in part to these activities, medical professionals who promote wellness (such as Dr. Mehmet Oz, Deepak Chopra, and Andrew Weil) have become well known. Wellness has thus entered the collective global psyche and is firmly rooted in the vocabulary (Global Wellness Institute, 2024).

3.2 Results of website content analysis (Content Analysis)

To confirm the theses from literary sources, an analysis of accommodation facility websites was conducted. The results of the analysis show that only 4 of the 50 facilities surveyed mention a product that includes multi-component wellness care in their offer. These products can be found in ***** accommodation facilities, mostly in the Special Offers (packages) section.

In some facilities, products labelled "holistic" or "body and soul care," etc., are offered, but they only address the physical aspect. The Tripadvisor website identified facilities that can be considered examples of good practice in the Czech Republic, including:

- Mosaic House Design Hotel in Prague, winner of the TripAdvisor portal in the category Best Wellness Hotels in the Czech Republic (Tripadvisor, 2025), which offers a Finnish sauna, whirlpool, cooling shower, private spa, and fitness centre (Mosaic House, 2025)
- Diamant Wellness Hotel & Spa, Hluboká nad Vltavou, featuring a swimming pool, whirlpool, sauna, Kneipp baths, salt cave, fitness centre, solarium, massages, relaxation rituals, peels and wraps, water treatments, and spa treatments (CO2 wrap and bath) (Hotel Diamant, 2024).

According to the Amazing Places website, the best-rated accommodation facilities are

- Wellness & Wine Hotel Volarik (Mikulov)
- Chateau Herálec (Vysočina)
- Hotel Sladovna (Černá Hora u Brna)
- Endemit Boutique Hotel & Spa (Horní Bečva, Beskydy)
- Hotel Lanterna (Velké Karlovice, Beskydy)
- Hotel U Zlaté Studně Spa & Wellness (Prague)
- Ondrášův Dvůr (Beskydy)
- Maximus Resort (Brno) (Amazing Places, 2025)

These facilities are among the highest-rated by customers, who praise luxurious services, clean wellness facilities, and top-notch staff. However, when analyzing their offerings on the web, most of the facilities surveyed do not mention the possibility of wellness stays with retreats.

The survey also identified facilities that meet the definition of comprehensive services and can thus be considered examples of good practice in the field of mental health care.

- The Mandarin Oriental Hotel in Prague is the winner of the Best Hotel Spa in the Czech Republic category according to the World Spa & Wellness Awards⁵ (World Spa Awards, 2025) and offers a wellness package called On the Silk Road, which is a three-day program with a private consultation with a master of traditional Chinese medicine, including dietary recommendations and the creation of a personal menu to balance qi, massages, fitness, relaxation rituals, peels and wraps, skin care, a nutrition program, and yoga (Mandarin Oriental Hotel Club, 2025).
- In Počátky, at the St. Catherine Resort, there are several combinations of Ayurveda packages available. Ayurvedic doctors, therapists, and chefs from Kerala, India, offer authentic natural medicine. This program includes the use of wellness facilities (St. Catherine Resort, 2025).

⁵ An award for excellence in spa and wellness tourism through a 30-year-old annual awards program organized by the UK-based Professional Beauty Group. Its goal is to inspire exceptional standards and connect spa consumers with the best in spa and wellness tourism.

- The Seeberg Hotel in Františkovy Lázně offers a four- or eight-day stay called Harmonization of Body and Soul, which includes meditation, yoga, self-discovery, as well as access to the pool, sauna, massages, and baths (Seeberg, 2025).
- Orea Spa Hotel Cristal in Mariánské Lázně sells an Activity Program package that includes yoga, meditation, breathing exercises, Nordic walking, and the use of the hotel's wellness facilities (Orea Spa Hotel Cristal, 2025).
- The Augustinian House in Luhačovice offers a Mindfulness program in a meditation yurt. The program includes meditation, teaching how to cope with stressful situations and reduce stress in everyday life, developing the ability to concentrate better and consciously control one's own psyche (Augustinian House, 2025).

3.3 Results of exploratory qualitative demand survey

The respondents' answers indicated that the guests surveyed at wellness facilities are interested in a healthy lifestyle, which is understandable, as wellness and a healthy lifestyle are often intertwined. The same people declare that they use wellness services during their stay at the facility. The most popular activity is swimming in the pool, followed by a visit to the sauna and a massage. Another frequently used facility is the whirlpool. These services are perhaps the most used because they are the most common facilities in these establishments; in other words, often nothing else is offered.

The most common response to the question about expanding existing services was the introduction of meditation, which respondents specified as relaxation exercises, relaxation with visualization, meditation exercises, and even meditation. They often added that this should be the last step immediately after a massage, with the idea being that the client would remain lying on the massage table and would only be given headphones with instructions or relaxing music. Less common were requests for more privacy in wellness facilities, music therapy, aromatherapy, the addition of floating, or the introduction of digital-free zones.

This part of the survey also showed that wellness businesses offer care for the physical aspect of a person (swimming pool, hot tub, massage), which people use the most, but they don't really have the opportunity to use anything else. Their wishes included more relaxation and meditation as a counterbalance to their busy lives.

4 Conclusions

Most current concepts of wellness are based on early holistic frameworks, dominated by the Six Dimensions of Wellness model introduced by Hettler (1976) and popularised by the National Wellness Institute. This model bases well-being on the balance of six interconnected and equal dimensions (physical, intellectual, emotional, social, spiritual, and occupational), none of which has a superior position over the others. In contrast to this view are models based on psychological theories and factor analysis (such as the aforementioned Wheel of Wellness model). While Hettler's model is often used for broad education and as a theoretical framework, models such as the Indivisible Self with an emphasis on the Essential Self are used primarily in counselling and clinical psychology, where an individual's well-being is inextricably linked to their self-awareness and sense of purpose in life.

An analysis of the concept of wellness shows that, in professional terms, caring for mental well-being and mental health is just as important as physical activity and regeneration (e.g., Dunn's definition of wellness as a way of life oriented toward an elevated state of physical and mental well-being). However, there are also professional sources that do not address this issue and focus on the "physical side of wellness." In practice and in the perception of the general public, the term wellness is still strongly associated primarily with services such as swimming pools, massages, saunas, and water parks. Although these procedures have been proven to reduce stress, they are perceived more as physical regeneration and a luxurious reward. Active mental health care often remains a neglected component, suggesting that despite the growing popularity of wellness, there is still a need for education about all its dimensions. Businesses offering wellness services in the South Bohemian Region on their websites often explain how to perceive Mental Health Care, but they often downplay this issue and work only with the idea that relaxation (e.g., in water) helps the psyche.

The German Wellness Association (Deutscher Wellness Verband, 2023), which certifies facilities in Germany, introduces the concept of wellness as follows: *"For most people in German-speaking countries, wellness is a term for relaxed well-being. You think of relaxing massages, a visit to the sauna, a day at a thermal spa, or a long weekend at a wellness hotel where you go to the sauna, relax in the pool, book a Lomi massage, and maybe even get your skin treated. Admittedly, a good massage has never hurt anyone. Nor has a relaxing weekend in a nice hotel or thermal spa. However, the fact that such experiences are considered the epitome of wellness shows a fundamental misunderstanding and wasted opportunities."*

The client reviews of the facilities surveyed show that stays focused primarily on the mental health of guests were not in demand. The question is, what is the reason for the lack of demand? It could be due to a lack of knowledge about the

products, a general unfamiliarity with the products, or a lack of demand. Follow-up research could focus on finding this and other answers

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What Are the Antecedents to Fast-Food Customer Loyalty?

Mariami Denosashvili¹

Abstract: Customer retention and loyalty are paramount in the restaurant industry, especially in the fast-food sector. Although customer loyalty in the fast-food industry has received extensive attention from practitioners and academics worldwide, researchers have yet to establish the critical factors of fast-food customer loyalty. This paper aims to reveal the antecedents of fast-food customer loyalty by synthesizing the results of recent studies. Methodologically, this research develops a systematic literature review following the PRISMA framework. Thirty-one publications available on Scopus and Web of Science databases were included in the review and analyzed to identify the most researched antecedents of fast-food customer loyalty in recent years. Overall, this research provides valuable insights for academics and practitioners interested in fast-food customer loyalty.

Keywords: Fast-food customer loyalty, fast-food industry, fast-food restaurant chains, customer loyalty, satisfaction, trust

JEL Classification: M31, M10, O32, Q56

1 Introduction

In recent years, companies have been drawing resources to increase customer retention and loyalty (Anantharaman et al., 2022; Dandis and Al Haj Eid, 2021; Dandis et al., 2023; Khan et al., 2020; Liu-Thompkins et al., 2022; Quoquab et al., 2020; Samsa, 2024) since consumers are becoming more demanding and tend to easily switch brands (Dandis et al., 2023; Gasparetto et al., 2025; Samsa, 2024; Šerić et al., 2020).

Customer retention and loyalty are paramount in the restaurant industry, especially in the fast-food sector (Ahmed et al., 2022; Ali-Alsaadi et al., 2025; Dandis et al., 2023; Javed et al., 2021; Martinez-Ruiz et al., 2023; Mobarak et al., 2024; Uddin, 2019). Since its establishment in the 1920s, the fast-food restaurant industry has been one of the most rapidly growing industries worldwide (Dandis et al., 2023; Gallarza-Granizo et al., 2020; Izquierdo-Yusta et al., 2022; Javed et al., 2021; Samsa, 2024; Singh et al., 2021; Uddin, 2019; Veas-González et al., 2024). As one of the critical contributors to the global economy, the industry is projected to reach an average market share of \$231.7 billion from 2020 to 2027 (Samsa, 2024).

Fostering loyalty has been one of the most challenging objectives for fast-food brands (Khan et al., 2020; Samsa, 2024) as customers typically visit 3.4 different fast-food chains and only 28% of satisfied consumers can be classified as highly loyal (Pleshko & Dawes, 2024). Thus, customer loyalty in the fast-food industry has been receiving extensive attention from practitioners and academics worldwide (Ahmed et al., 2022; Dandis et al., 2023; Gallarza-Granizo et al., 2020; Gasparetto et al., 2025; Hassan et al., 2023; Javed et al., 2021; Kadavil & Usha, 2024; Mobarak et al., 2024; Quoquab et al., 2020; Rajeh Hanaysha et al., 2021; Singh et al., 2021; Watson et al., 2024; Zhong & Moon, 2020; Šerić et al., 2020).

Despite the existence of a significant body of literature, researchers have yet to establish the critical factors or key antecedents/ determinants/components of fast-food customer loyalty (Anantharaman et al., 2022; Dandis and Al Haj Eid, 2021; Gasparetto et al., 2025; Khan et al., 2020; So et al., 2025). Thus, this paper aims to reveal the antecedents of fast-food customer loyalty by synthesizing the results of recent studies.

The article will answer the following research questions:

- Q1: What are the most researched regions/countries in fast-food customer loyalty studies?
- Q2: What methodologies are most frequently employed in fast-food customer loyalty studies?
- Q3: What are the most researched antecedents of fast-food customer loyalty?

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Methodologically, this research systematically reviews papers published in the last five years (2020-2025) and available in the Scopus and Web of Science databases. To increase transparency, the PRISMA reporting guidelines are employed.

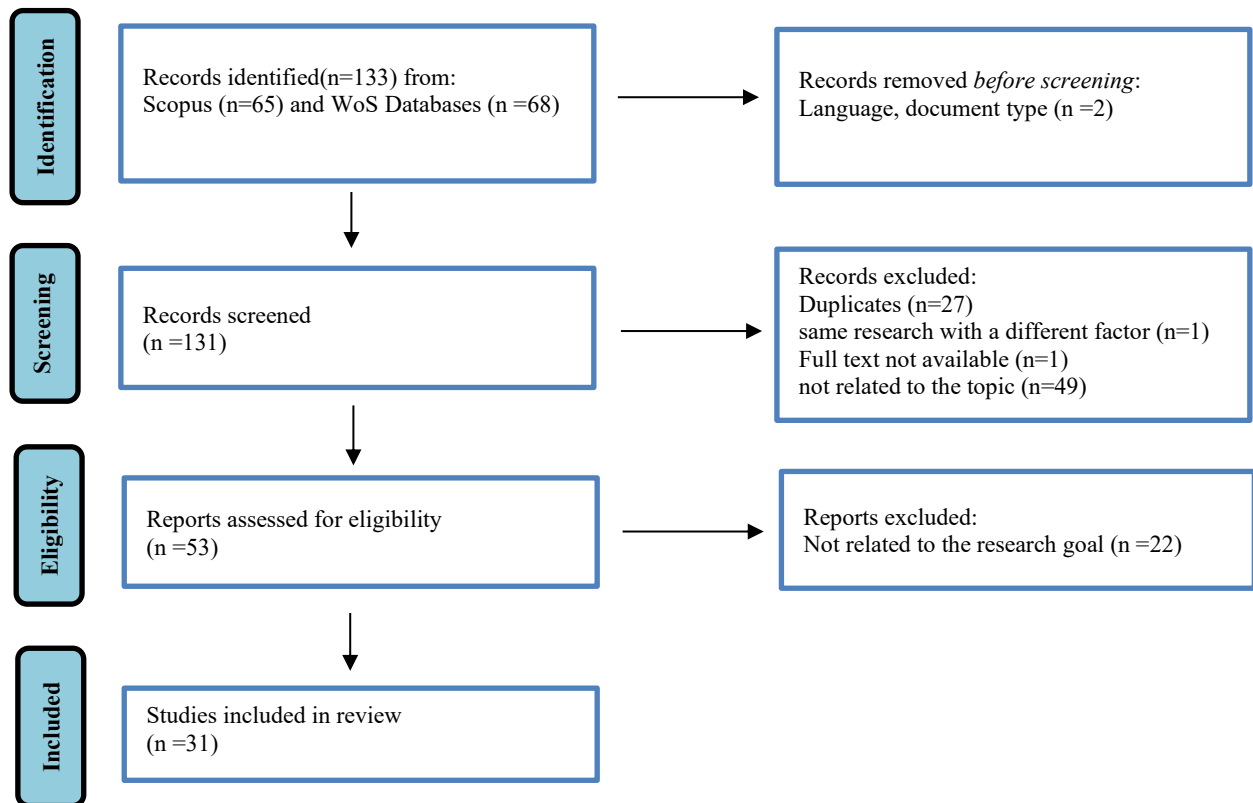
The article contributes to the theoretical literature on customer loyalty and the fast-food industry. It highlights the importance of various factors, including satisfaction, trust, image, and experience in fostering customer loyalty within the fast-food restaurant industry. Furthermore, it provides valuable insights to practitioners interested in increasing fast-food customer loyalty.

The paper is organized as follows. After the introduction section, the author presents the methods and the research results. Finally, the paper ends with conclusions.

2 Methods

A systematic literature review (SLR) was employed to achieve the research objective and address the research questions. The review followed the PRISMA framework (Figure 1).

Figure 1. Systematic literature reviewn PRISMA flow diagram



Source: Author's own

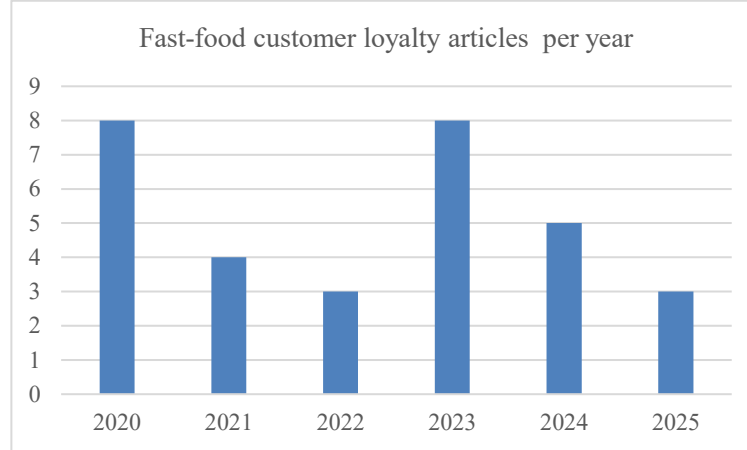
The Scopus and Web of Science (WoS) — Core Collection databases were used to identify the recent publications (from 2020 to 2025) for the systematic review. The article identification stage took place in August 2025. The keywords were the same for both databases: fast-food and loyalty. The search was limited to articles and proceedings in the English language. Due to the large number of documents, the titles, abstracts, and keywords were screened to determine whether the papers were related to the research topic, specifically whether they directly addressed customer loyalty (loyalty, customer loyalty, or brand loyalty) in the context of the fast-food industry. After that, 53 full-text articles were assessed for eligibility. Finally, 31 scientific articles were included in the systematic review.

3 Research results

3.1 The most researched regions/countries in fast-food customer loyalty studies

The analysis revealed that most articles were published in 2020 and 2023 (Figure 2). The number of publications in 2021, 2022, and 2024 was relatively low. As for 2025, three publication has been released, which can be attributed to the fact that the year is not yet over.

Figure 2 Articles connected to customer loyalty in the fast-food industry per year



Source: Author's own

Traditionally, the primary focus of previous research was mainly on the USA. However, since the fast-food restaurant industry has rapidly expanded worldwide, the number of publications from Europe, Asia, and emerging markets has also increased in recent years (Table 1). As noted in the table, the most researched region is Asia, particularly countries like Indonesia and Malaysia. As for Europe, North America, South America, Africa, Australia, and Oceania, the research is still scarce.

Table 1 Articles related to customer loyalty in the fast-food industry

Research Area	Country	Author(s)
<i>North America</i>	Mexico	Izquierdo-Yusta et al., 2022
	Guatemala	Gallarza-Granizo et al., 2020*
<i>South America</i>	Brazil	Gasparetto et al., 2025
	Chile	Veas-González et al., 2024
<i>Europe</i>	Croatia	Šerić et al., 2020
	France	Watson et al., 2024
	Germany	Gallarza-Granizo et al., 2020*
	North Macedonia	Saneva & Chortoseva, 2020
	Spain	Gallarza-Granizo et al., 2020*; Martinez-Ruiz et al., 2023;
<i>Asia</i>	Bangladesh	Ahmed et al., 2022; Chowdhury et al., 2023;
	China	Li et al., 2025; Zhong & Moon, 2020;
	India	Kadavil & Usha, 2024; Syuhadah et al., 2023;
	Indonesia	Sugiarti et al., 2023; Susilowati & Novita Sari, 2020; Syah et al., 2022;

	Jordan	Dandis et al., 2023
	Malaysia	Hassan et al., 2023; Phang et al., 2021; Quoquab et al., 2020; Khan et al., 2020;
	Pakistan	Azeem et al., 2020; Javed et al., 2021;
	Philippines	Lacap et al., 2023
	Kuwait	Pleshko & Dawes, 2024
	UAE	Ali-Alsaadi et al., 2025; Rajeh Hanaysha et al., 2021;
<i>Africa</i>	Egypt	Alshreef et al., 2023; Mobarak et al., 2024;
<i>Australia and Oceania</i>	Fiji Island	Singh et al., 2021
<i>*Cross-country study</i>		

Source: Author's own

3.2 The most frequently employed methodologies

The researchers studying customer loyalty in the fast-food restaurant industry primarily employ a quantitative research approach (Table 2). 29 out of 31 articles are quantitative and use survey questionnaires to gather customer insight. Only two articles use the mixed-method approach. Gallarza-Granizo et al. (2020) combined a qualitative approach (two focus groups and one in-depth interview with an expert) with a quantitative approach (questionnaire) to investigate national differences and similarities between Spain, Germany, and Guatemala regarding customer perceptions of quick service restaurants. Mobarak et al. (2024) also used a mixed method (semi-structured interviews with the managers and a self-administered semi-structured questionnaire for customers) to study the impact of cause-related marketing on brand image and loyalty of international fast-food chains in Egypt.

Table 2 Frequently employed methods in fast-food customer loyalty studies

Research method	Articles	Author(s)
<i>Quantitative</i>	29	Ahmed et al., 2022; Ali-Alsaadi et al., 2025; Alshreef et al., 2023; Azeem et al., 2020; Chowdhury et al., 2023; Dandis et al., 2023; Gasparetto et al., 2025; Hassan et al., 2023; Izquierdo-Yusta et al., 2022; Javed et al., 2021; Kadavil & Usha, 2024; Khan et al., 2020; Lacap et al., 2023; Li et al., 2025; Martinez-Ruiz et al., 2023; Phang et al., 2021; Pleshko & Dawes, 2024; Quoquab et al., 2020; Rajeh Hanaysha et al., 2021; Saneva & Chortoseva, 2020; Singh et al. 2021; Sugiarti et al., 2023; Susilowati & Novita Sari, 2020; Syah et al., 2022; Syuhadah et al., 2023; Veas-González et al., 2024; Watson et al., 2024; Zhong & Moon, 2020; Šerić et al., 2020;
<i>Mixed</i>	2	Gallarza-Granizo et al., 2020; Mobarak et al., 2024;

Source: Author's own

As for a result analysis (Table 3), common methods include a PLS-SEM (17 articles), SEM (9 articles), multiple regression (3 articles), correlation (1 article), and descriptive statistics (1 article).

Table 3 Frequently employed analytical methods in fast-food customer loyalty studies

Analytical method	Articles	Author(s)
<i>PLS-SEM</i>	17	Ahmed et al., 2022; Ali-Alsaadi et al., 2025; Azeem et al., 2020; Chowdhury et al., 2023; Gallarza-Granizo et al., 2020; Izquierdo-Yusta et al., 2022; Khan et al., 2020; Lacap et al., 2023; Li et al., 2025; Martinez-Ruiz et al., 2023; Phang et al., 2021; Quoquab et al., 2020; Rajeh Hanaysha et al., 2021; Susilowati & Novita Sari, 2020; Veas-González et al., 2024; Zhong & Moon, 2020; Šerić et al., 2020;
<i>SEM</i>	9	Alshreef et al., 2023; Gasparetto et al., 2025; Hassan et al., 2023; Javed et al., 2021; Saneva & Chortoseva, 2020; Singh et al. 2021; Sugiarti et al., 2023; Syah et al., 2022; Watson et al., 2024;
<i>Multiple regression</i>	3	Dandis et al., 2023; Kadavil & Usha, 2024; Mobarak et al., 2024;
<i>Correlation</i>	1	Pleshko & Dawes, 2024;
<i>Descriptive statistics</i>	1	Syuhadah et al., 2023;

Source: Author's own

3.3 The most researched antecedents of fast-food customer loyalty

Researchers have been trying to identify antecedents/determinants/drivers/factors affecting loyalty in the fast-food industry context (Gasparetto et al., 2025; Ong et al., 2018). Several factors/variables/constructs, including satisfaction, trust, image, and experience have been researched in the literature (Table 4), however, there is no **generally accepted model**.

Table 4 The researched antecedents/determinants/drivers/factors affecting loyalty in the fast-food industry

Constructs/factors	Article count	Author(s)
<i>Satisfaction/Customer satisfaction/Food Satisfaction</i>	12	Ahmed et al., 2022; Ali-Alsaadi et al., 2025; Chowdhury et al., 2023; Gallarza-Granizo et al., 2020; Javed et al., 2021; Martinez-Ruiz et al., 2023; Pleshko & Dawes, 2024; Saneva & Chortoseva, 2020; Syah et al., 2022; Syuhadah et al., 2023; Veas-González et al., 2024; Zhong & Moon, 2020;
<i>Trust/Brand trust/Customer trust/Social trust</i>	7	Azeem et al., 2020; Gasparetto et al., 2025; Javed et al., 2021; Singh et al., 2021; Quoquab et al., 2020; Syah et al., 2022; Šerić et al., 2020;
<i>Image/Brand Image/ Green brand image</i>	6	Mobarak et al., 2024; Singh et al., 2021; Syah et al., 2022; Syuhadah et al., 2023; Veas-González et al., 2024; Watson et al., 2024;
<i>Experience/Brand Experience/ Customer experience</i>	4	Azeem et al., 2020; Dandis et al., 2023; Gasparetto et al., 2025; Hassan et al., 2023;
<i>Brand Awareness</i>	3	Kadavil & Usha, 2024; Sugiarti et al., 2023; Susilowati & Novita Sari, 2020;
<i>Perceived quality/ Perceived service quality</i>	3	Ahmed et al., 2022; Saneva & Chortoseva, 2020; Susilowati & Novita Sari, 2020;
<i>Brand Love</i>	3	Alshreef et al., 2023; Izquierdo-Yusta et al., 2022; Khan et al., 2020;
<i>Attitude/Brand Attitude</i>	2	Gasparetto et al., 2025; Lacap et al., 2023;
<i>Brand association</i>	2	Sugiarti et al., 2023; Susilowati & Novita Sari, 2020;
<i>Perceived value</i>	2	Lacap et al., 2023; Li et al., 2025;
<i>Relational benefits</i>	1	Dandis et al., 2023

<i>Importance of relationship</i>	1	Syuhadah et al., 2023
<i>Perceived reputation</i>	1	Quoquab et al., 2020
<i>Perceived price fairness</i>	1	Ahmed et al., 2022
<i>Perceived novelty</i>	1	Lacap et al., 2023
<i>Perceived enjoyment</i>	1	Lacap et al., 2023
<i>Perceived communication consistence</i>	1	Šerić et al., 2020
<i>Brand Attachment</i>	1	Li et al., 2025
<i>Cause-related marketing</i>	1	Mobarak et al., 2024
<i>Social media marketing</i>	1	Rajeh Hanaysha et al., 2021
<i>Marketing cues</i>	1	Hassan et al., 2023
<i>Happiness</i>	1	Zhong & Moon, 2020
<i>Subjective norm</i>	1	Izquierdo-Yusta et al., 2022
<i>Customer engagement</i>	1	Phang et al., 2021
<i>Corporate social responsibility</i>	1	Javed et al., 2021
<i>Positive word of mouth</i>	1	Ali-Alsaadi et al., 2025

Source: Author's own

Some of the most cited factors in recent years have been:

Satisfaction is the most researched and cited factor in the fast-food customer loyalty studies. It can be defined as the customers' favourable emotions/contentment post consumption of any good/service (Ahmed et al., 2022; Chowdhury et al., 2023) or summary judgments/overall assessment of any good/service based on the experience with the purchase and/or consumption (Javed et al., 2021; Pleshko & Dawes, 2024; Syah et al., 2022; Zhong & Moon, 2020). Although satisfaction is subjective and influenced by different factors, generally, satisfied customers tend to repurchase and share positive WoM (Ahmed et al., 2022; Chowdhury et al., 2023; Javed et al., 2021; Pleshko & Dawes, 2024; Syah et al., 2022). Customer satisfaction has a significant positive influence on loyalty (Ahmed et al., 2022; Ali-Alsaadi et al., 2025; Chowdhury et al., 2023; Gallarza-Granizo et al., 2020; Javed et al., 2021; Pleshko & Dawes, 2024; Saneva & Chortoseva, 2020; Syah et al., 2022; Veas-González et al., 2024; Zhong & Moon, 2020). It also mediates between customer loyalty and other variables, such as value (Gallarza-Granizo et al., 2020) and perceived service quality and price fairness (Ahmed et al., 2022). However, satisfaction may not necessarily translate into loyalty, e.g., Pleshko and Dawes (2024) argue that approximately 70% of fast-food brand consumers are satisfied, but only 28% of them can be classified as highly loyal.

Trust is integral to fostering loyalty according to commitment-trust and social-exchange theories (Azeem et al., 2020; Li et al., 2025). It serves as a close bond/connection between a company and a customer (Azeem et al., 2020; Javed et al., 2021; Kadavil & Usha, 2024) that can be developed through past experiences (Azeem et al., 2020; Gasparetto et al., 2025) when meeting or exceeding customers' expectations and being reliable and trustworthy (Singh et al., 2021). Besides experiences, customer satisfaction and restaurant image build customer trust (Quoquab et al., 2020; Singh et al., 2021). According to research, trust not only positively affects customer loyalty (Azeem et al., 2020; Gasparetto et al., 2025; Javed et al., 2021; Khan et al., 2020; Quoquab et al., 2020; Singh et al., 2021; Syah et al., 2022; Šerić et al., 2020), but also mediates the relationship between loyalty and different variables, such as customer experience (Azeem et al., 2020) and halal logo (Quoquab et al., 2020).

Image influences customer perceptions, attitudes, dining decisions before visiting restaurants, and customer opinions, impressions, emotions, feelings, and experiences after the visit. Brand image can be defined as the set of cognitive and affective mental representations customers have towards a brand/company (Veas-González et al., 2024; Zhong & Moon, 2020). Creating a strong brand image is a critical marketing strategy for companies to attract new or potential customers (Singh et al., 2021), enhance customer trust (Quoquab et al., 2020; Veas-González et al., 2024), retention, and loyalty (Singh et al., 2021; Syuhadah et al., 2023; Mobarak et al., 2024; Watson et al., 2024). Brand image not only positively influences loyalty (Mobarak et al., 2024; Singh et al., 2021; Syah et al., 2022; Veas-González et al., 2024) but also mediates

a relationship between customer loyalty and cause-related marketing (Mobarak et al., 2024). Moreover, Watson et al. (2024) confirmed that the green brand image of mainstream fast-food brands positively influences customer loyalty and acts as a mediator between environmental concern and brand loyalty.

Experience is among the most researched loyalty antecedents as modern customers tend to favour experiential consumption (Khan et al., 2020). Customer/brand experience is a multidimensional concept involving sensory, affective, intellectual, and behavioral dimensions (Dandis et al., 2023; Gasparetto et al., 2025; Khan et al., 2020). These feelings, emotions, impressions, perceptions, senses, and intellectual and behavioral responses accumulate at every stage of the consumption process (Azeem et al., 2020; Dandis et al., 2023; Khan et al., 2020; Hassan et al., 2023). Fast-food dining experiences can be influenced by various factors, such as customers' age, food and service quality, internal and external ambiance, and marketing cues (Hassan et al., 2023). Positive experiences are crucial in cultivating loyalty (Azeem et al., 2020; Dandis et al., 2023; Gasparetto et al., 2025; Khan et al., 2020; Hassan et al., 2023).

Brand Awareness can be defined as a consumer's knowledge and ability to identify or recognize and recall a particular brand under various circumstances (Kadavil & Usha, 2024; Sugiarti et al., 2023; Susilowati & Novita Sari, 2020). It is one of the most critical components of brand equity and a factor affecting customers' trust and decision-making as they usually choose and gravitate towards the brands they are familiar/ had past experiences with (Kadavil & Usha, 2024; Sugiarti et al., 2023). Furthermore, brand awareness positively influences loyalty (Kadavil & Usha, 2024; Sugiarti et al., 2023; Susilowati & Novita Sari, 2020).

Service quality, perceived quality, or service quality are key concepts in hospitality, particularly the restaurant industry (Ahmed et al., 2022). Perceived quality can be defined as the consumer's evaluation/overall perception of superior product/service performances compared to alternatives (Ahmed et al., 2022; Saneva & Chortoseva, 2020; Susilowati & Novita Sari, 2020). It is highly subjective, as the quality of the same product/service may be perceived differently by each customer. According to research, quality (perceived quality, perceived service quality, or service quality) is closely connected to customer-centric outcomes, such as customer satisfaction (Ahmed et al., 2022; Saneva & Chortoseva, 2020), purchasing intentions (Susilowati & Novita Sari, 2020), and loyalty (Saneva & Chortoseva, 2020; Susilowati & Novita Sari, 2020).

Brand love is believed to affect various customer-centric outcomes, including purchase intentions, WOM, and loyalty (Alshreef et al., 2023; Izquierdo-Yusta et al., 2022; Khan et al., 2020). It can be defined as the extent of a customer's emotional attachment to a particular brand (Alshreef et al., 2023; Izquierdo-Yusta et al., 2022). According to brand love theory, excellent brand love consists of intimacy, passion, and commitment components: Alshreef et al. (2023) confirmed the positive influence of only brand love intimacy and commitment on customer loyalty, whereas Khan et al. (2020) found that brand love passion positively influences brand loyalty. Moreover, Izquierdo-Yusta et al. (2022) found that brand love mediates the relationship between subjective norms and behavioral loyalty.

4 Conclusions

Academics have endeavoured to establish the critical factors influencing fast-food customer loyalty in recent years (Anantharaman et al., 2022; Dandis and Al Haj Eid, 2021; Gasparetto et al., 2025; Khan et al., 2020; So et al., 2025). Due to a significant body of literature, this paper aimed to synthesize the results of recent studies and reveal the antecedents of fast-food customer loyalty. The systematic literature review showed that the most researched region in fast-food customer loyalty studies is Asia, particularly countries like Malaysia and Indonesia. Researchers studying customer loyalty in the fast-food restaurant industry primarily employ a quantitative research approach and analyse results using the PLS-SEM analytical method. Regarding the antecedents, some of the most frequently cited factors in recent years have been satisfaction, trust, image, experience, brand awareness, quality, and brand love, among others.

Although fast-food customer loyalty has received considerable attention from academics over the last five years, several areas still require further investigation. It is suggested that academics explore fast-food customer loyalty across different countries, including those in Europe, Africa, Australia, Oceania, and the Americas. Furthermore, they can study whether country-specific characteristics and differences in political, social, economic, and cultural factors have a distinct effect on loyalty antecedents. The influence of new or less researched factors, such as relational benefits, subjective norms, customer engagement, reputation, and marketing cues, could be further explored. Finally, conducting more qualitative or mixed studies could shed further light on customer loyalty from a psychological perspective.

The article contributes to the theoretical literature on customer loyalty and the fast-food industry. It highlights the importance of various factors, including satisfaction, trust, image, and experience in fostering customer loyalty within the fast-food restaurant industry. Furthermore, it provides valuable insights to practitioners interested in increasing fast-food

customer loyalty. Specifically, fast-food restaurant owners, operators, and managers are encouraged to pay more attention to their customer/ brand loyalty, as well as its antecedents. They should investigate whether customer loyalty is influenced by satisfaction, trust, image, and experience, and allocate their resources accordingly to foster loyalty.

The article, like any other study, has several limitations. Firstly, the literature review was based on current literature from the past five years, which may have overlooked earlier foundational research regarding customer loyalty in the context of the fast-food industry. Second, the review focused on publications available only on the Scopus and Web of Science databases, that might have excluded grey literature or regional studies available in other databases, such as Google Scholar. Finally, the choice of search keywords and refining search results, like limiting research results to only articles and conference proceedings in the English language, may have excluded critical perspectives on fast-food customer loyalty.

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Characteristics of Business Model in Retail

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Abstract: The goal is to define the essence, basic characteristics and relationships of retail, as well as the basic aspects of the business model in retail. To fulfill the article's objective, secondary data was gathered for an overview of different authors' opinions on the subject, which were then compared and evaluated. The potential contribution of the article's approach lies in the fact that it explains the fundamental changes in retail, which also strengthens the importance of the supply and demand side in the consumer market. Turbulent changes occur in the environment in which retail units carry out their economic activities. These changes are reflected in the value proposition by speed and adaptation of the product and business models to the customer's requirements. In the conclusion, some suggestions resulting from the characteristics of the retail trade and the business model in the retail trade are presented. To fulfill its mission, retail must make the best use of its capabilities supported by digital solutions.

Keywords: retail, store, retail network, business model, factors

JEL Classification: L22, M0, M31

1 Introduction

Retail is constantly evolving. All the retail sector is characterised by a permanent change (Hallier, 2014). The origin of e-commerce and digital retailers has put pressure on conventional retailers to transform their business models to defend their market share. Many traditional retailers with physical retail units have switched to online sales, use websites and mobile applications or have increased the proportion of digital customer touch points (Jocevski, 2020). We see mobile apps making their way to the forefront, requiring store employees to be equipped and familiar with modern tools. The COVID-19 pandemic has sparked up a need for technologies that work together in order to create an effective shopping experience on all levels. Customers want to be able to shop easily both in the physical store and online. This makes retailers invest in the right tools to ensure stability and consistency between offline and online channels. Customers want to have the option to enjoy both online shopping and in-store delivery or pickup to the same extent they enjoy in-person purchases. Those placed demands on retailers to invest in the right tools to ensure stability and consistency between offline and online channels. Customers have come to love online ordering and in-store delivery or pickup almost as much as in-person purchases, as well as making use of alternative payment methods (e.g. payment by card, payment by bank transfer, contactless payment by smartphone, tablet, watch or wristband). Consumers come into contact with retail stores through multiple channels: catalogue sales, email, institutional websites, mobile phones, social networks, call centres, physical stores, etc., demonstrating that the barrier between physical and digital commerce tends to gradually disappear. In fact, the Internet is so integrated into consumers' daily lives that they do not differentiate between the online and offline environments. As a result, the concept of an omnichannel, an improvement on multichannel, has emerged. The multichannel approach allows the user to decide the means by which they wish to shop: traditional physical stores, personal devices, or smartphones. The omnichannel strategy presents a purchasing system that allows consumers to use as many channels as they see fit. The digital customer is an omnichannel customer: they are the ones who buy what they want, when they want and through the medium they want. It is a new type of consumer, more demanding than any previous type.

Retail units are challenged to connect with the increasingly informed, active, hyper-connected, omnichannel consumers, meaning that small and mid-sized companies, who have not yet invested in the previously mentioned means of communication or payment methods, are at risk of losing customers. Customers expect retailers to provide more means for convenient and flexible shopping, and those who fail to meet these demands are at risk of losing sales. In the future, technology will be a catalyst for growth both in the physical store and in online commerce. The focus of digital transformation is increasingly shifting to product to customer, connecting the "Customer experience" with "Operational

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excellence". To achieve this goal, the retail industry must make the best use of options at hand- supported by digital solutions with the goal to contribute to boost the demand in the economy.

The academic sphere, where the trends in retail practice are being analysed, uses the term "business model" (Beattie, Smith, 2013). This term denotes an economic activity that has a gainful character and is carried out in an organised and systematic way (Sławinska, 2010). The notion "business" is used in the sense of entrepreneurship or business (Freeman et al., 2004). A model is a simplified representation of a process or system (Jensen, 2013). The phrase business model means that it is a schematic representation of a business process.

The growth of interest in academia and economic practice in the issue of business models is reflected in the multiplicity of definitions of a business model (Slávik, et al., 2014; Grandval, Ronteau, 2011; Moigeon, Lehman-Oretega, 2010; Dobre-Baron, 2015) and in published articles on the topic in scientific journals the Journal of Business Models (Yrjölä, 2014), Long range planning (McGrath, 2010), Journal of management (Zott et al., 2011), and in other scientific journals providing an overview of the topic. The multiplicity of approaches to the issue is evidence of the creative nature of its solution (Jensen, 2013).

The business model is considered to be the main driving force of an enterprise regardless of the area of operation and is essential for the performance of any organization (Magretta 2002). According to Dauchy, it is the result of strategic thinking and an operational scheme with the goal of elevating a business (Dauchy, 2013). It denies the originality of the company's activity. Other authors (Detchessahar et al. 2003) define the business model in relation to e-commerce as a way of combining business, logistic and informational resources with the aim of creating value. There is no commonly accepted definition of a business model in the scientific literature. The diversity of the concept of a business model ranges from the highest level, which focuses on the definition of the place of the business model in the 'strategic winters', through a multidimensional concept encompassing the components of the model and their potential variations and logic, how a business comes to be created, delivers and earns value, as well as the way it is organised in a network of stakeholders. Many authors agree that the business model expresses the enterprise's value proposition, resources and competence, the governance mechanism that connects the enterprise's stakeholders (Zott, Amit, 2010). Chesbrough lists the following functions that the business model pays for (Chesbrough, 2010):

(1) It shapes the value proposition that forms the core of the business model. It is the address and the indicator. The offer has no value in itself; it gains value when the customer is persuaded to buy the product and use it in a specific context. Before that, it is just a suggestion for the market. The question of the meaning of the value proposition is the central question. In addition to the attractive features of the offer, it includes advantages for a customer, the solutions that are offered to him, and the benefits gained compared to the monetary and non-monetary sacrifices made. A company's ability to develop arguments to stimulate favourable evaluations is a primary requirement if it is to change consumption habits (Sempels, Hoffmann, 2013, p. 40). Customers are usually offered a whole range of products that could satisfy none of their needs. The main factor on the basis of which customers decide for a particular product is the perception of the value that the product or service might bring them (Kotler, Armstrong, 2004).

(2) It identifies the target market. The dyadic value proposition - the customer is inseparable. The value proposition is closely linked to the customers whose attention it is intended to attract. Segmentation challenges the company to develop a proposition suitable for one or more segments, or for those segments showing issues and problems that need to be specifically addressed. A large number of markets are currently segmented or hypersegmented, which is related to the alignment of customised solutions. The ability to adapt the value proposition to the requirements of the segments becomes a key challenge for competitiveness and the creation of potentially highly profitable specialised activities. Every company strives to provide value to the target customer in a profitable way (Kotler, Keller, Manceau, Dubois, 2009).

(3) It defines the structure of a value chain that is needed to create and distribute the offer. The value chain is a system of corporate activities or functions (Tomek, Vávrová, 2009, p. 135), including the conception, creation and completion of products and services. Each step in the company's value chain is based on the application and integration of various resources and capabilities. Each part of the value chain can provide the company with a specific advantage and a basis for differentiation in relation to competitors. Changes in the way in which the basic individual and sub-functions are performed and in the relationships between them are reflected in the business models. The basic role of retail, the final link in the distribution channel, is to create appropriate conditions for the purchase of products or services by final consumers for their personal consumption. These have the effect of completing the transactions resulting from the activities of the local participants in the supply chain. In this context, the business enterprise must be able to demonstrate a high degree of innovation in the creation of a business model based on changes in consumer behaviour, competition and technological progress.

(4) It refines the mechanism of the company's income. Business models in the retail sector are based mainly on revenues from the sale of goods, which account for more than 90 % of their retail revenues. There are also other sources of business revenues according on the development of resources and competences. Revenues related to the sale of products are at the core of the distributors' activity: the trading margin on pre-owned products is related to the difference between the sale of goods and the cost of purchasing those goods.

Given the fact that distributors have their own brands, they are allowed to accumulate different levels of margin (distribution margin and diastone part of production margin). The commercial margin of the products sold is often supplemented by conditional margins (e.g. a margin on the volume of goods purchased, etc.). The basic business models in retailing, which are based on business margins, include:

- a model based on low margins and high margins (large scale of activity, goods with rich turnover, low operating costs in relation to sales volume);
- a model based on relatively high margins and correspondingly high quality of the services provided.

Distributors can offer products at a low price for a short period of time (high low price policies, HI-LO) or at permanently low prices at any time of the year (EDLP- everyday low price policy). The decision between EDLP and HI-LO (Dekimpe et al., 2011,) depends on assortment characteristics (perishable and heterogeneous assortment), firm characteristics (number of stores, store size), competitors (sales promotion and pricing strategies), and customer characteristics.

(5) It identifies cost structure and potential profit. The revenue stream is related to the cost stream, and the objective is to maximize the difference between them, at least in the medium term. The gross margin rate and the cost structure are highly variable according to the type of sales area. The lower the margin, the more the cost structure changes. The margin can also vary according to the importance of the different product categories.

(6) It describes the position of the firm within the value network linking suppliers to customers, including the identification of potential cooperators (organisations whose business and existence is dependent on the firm) and competitors.

(7) It coheres to the strategic marketing decisions of the company (Yang et al. 2017). Scientific literature offers a multitude of diverse marketing strategies (Jakubíková, 2013). Based on the strategy, the enterprise achieves its goals. The business model expresses the strategy implemented by the firm (Casadesus-Masanelli, Ricart, 2010) and forms its very essence. The strategy expresses the goal of the objectives, while the business model describes in detail the mechanism that the enterprise uses to achieve the objective (Magretta, 2002). The business model, unlike the strategy, includes the partners of the organization, the strategic allies, while the strategy focuses on the competitive struggle. For this reason, the business model often transcends the boundaries of the enterprise, e.g. when it expresses relationships with customers and business partners. In the case of retailing, it is possible to think of several other possibilities for strategy development in terms of activity, starting with concentration on one market segment or one set of needs through different types of diversification strategy (Zook, Allen, 2001), etc.

The morality of strategic development of business enterprises depends primarily on resources (human, financial, technological, tangible and intangible) and on external circumstances resulting from changes in the environment.

The definition of a specific business model depends on the context of the term's use and the research's task. Although different conceptualizations of the business model differ in the number of parameters they specify, these parameters roughly represent four broad areas, e.g., (1) the target customers, (2) the value proposition that the organization offers to its customers, (3) the creation and delivery of value to customers, and (4) the value capture activities that deal with the primes and costs of creating and delivering the value proposition (Boons, Lüdeke-Freund, 2013; Dentchev et al, 2018). The specificity of retailing lies in the fact that it is insufficient to define it as a simple, intermediate link that buys and sells goods to customers. Authors Sorescu, Frambach, Singh, Rangaswamy, and Bridges (2011) highlight two distinctive aspects of the business model in retailing:

- a narrow focus on product assortment does not lead to a modern competitive advantage because comparable products may be easily available in more retail units;
- direct interaction between retailers and the final consumers, which influences the vision of marketing communication (Taranko, 2015).

Given the direct relationships with customers and suppliers, the retailer acts as a coordinator of two-sided platforms that serve as ecosystems in which value is created for the customer and then captured by the retailer and its partners. Teece (2010) understands an ecosystem as a community of multiple interest groups (stakeholders) and ties as a framework of analysis or domain in which new adjacencies emerge, but there are also constraints. Businesses, regardless of their size, must strive to exploit the set of competences and resources available in their ecosystem. The tool or intermediate of the ecosystem (Attour, 2014, p. 36) that enables access to some resources is a mutually supportive platform (Geraudel, Jaouen, 2012, pp. 118-120) around which actors organize themselves to create value for the customer. The ecosystem and the platform are linked by a business model. Each actor is characterised by specific competences capable of acting to varying degrees in the collective process of value creation. Platforms can take the form of a virtual workspace on the Internet, within which the public organises itself into sites or communities or drusy organisations for the purpose of a reciprocal exchange of knowledge.

Retail transforms innovative suggestions from suppliers and customers into implementable business plans. This position in the value network is strategic and determines, to a large extent, the essence of the business enterprise itself and its activities.

It has to be examined with great care and depends to a large extent on the resources and competences at the company's disposal. Each of the activities in the value chain can provide the company with a specific advantage and a basis for differentiation in relation to the competition.

Changes in the way basic and support functions are performed in the value network and in the relationships between the entities are reflected in the business models. Based on the understanding of retail as an area (also virtual area) in which the customer experience is happening (Grewal, Roggeveen, Sisodia, Nordfält, 2017, pp. 55-64), according to the authors Sorescu, Frambach, Singh, Rangaswamy, Bridges (2011, p. 3), a business model can be defined as a specific system of interdependent structures, activities, and processes that serve to create value (for the firm's customer) and provide value (for the firm and its partners).

2 Methods

The research part aims to identify the key elements of business models based on the recherche of theoretical knowledge in the scientific and professional literature, respectively, the internet sources and studying documents and their content analysis. The document study is a method of analysis for the purpose of data collection in the process of research, in which the documents used may be both primary and secondary (Surynek et al., 2001, pp. 22-24). The written documents are analysed by two methods: quantitative and qualitative analysis. At this stage of the research, a qualitative analysis of information from documentary sources was carried out to identify a number of parameters and elements of new business models.

Content analysis is used to research, identify, and define elements and phenomena that may be quantified (Reichl, 2009, 127). It has the potential to provide results not only at the level of description and quantification of apparent elements but also interpretative and explanatory inferences based on the correlation of variables. It is applied in the analysis of texts of various types communicated by different information carriers. The results of the content analysis are now part of many areas of basic and applied research, including marketing. On the basis of these sources, a set of potential elements of new business models has been put together. The sources of identification of the elements are presented in Table 1.

Table 1 The sources of a business model parameters and element

The sources of a business model parameters and element	Author	Year
4/13	Hamel, G.	2000
6/98	Volle, P., Dion, D., Sabbah, S.	2008
4/17	Gołębiewski, Dudzik, Lewandowska, Witek-Hajduk	2008
5/55	Slawinska, M.	2010
3/24	Verstraete, T., Kremer, F., Jouison-Laffitte, E.	2012
6/77	Demil, B., Lecocq, X., Warnier, V.	2013
3/10	Lehmann-Ortega, L. Musikas, H., Schoettl, J.-M.	2017
9/63	Kita, J. et al.	2017
5/44	Konštiak, P.	2018
3/7	Mandli, Y., Taoufik, D.	2019
9/32	Šimberova, I., Kita, P.	2020

Source: Own processing

3 Research results

The given construction of business models in retail requires explicit consideration of the possible relationships and capabilities of their individual elements. There are different approaches to defining the elements of business models in retail. Authors Volle, Dion, Hellies-Hassis, Sabbah (2008) consider the following the basic elements of business models in retailing: resources and competences of the firm, supply and activities carried out by retailers, and the primes and costs of distributors. According to Stawinska (2010), the elements of the business model in retailing are a subject of activity, resources and competences, value chain and the way of their configuration. On the basis of retail strategies authors Sorescu, Frambach, Singh, Rangaswamy, Bridges (2011) propose three elements of business models in retail: the way of organization of activities, the type of activities, the level of participation of entities in the implementation of these activities.

More precisely, it is a matter of definition:

- of the retail format that describes the way in which retail activities will be sequenced and carried out. It is a specific type of store characterised by certain characteristics which distinguish a store of that type from other stores;
- of the different activities carried out with the aim of designing, managing the customer experience and motivating customers;
- of the management of the entities that carry out these activities, their roles and the incentives that motivate them

These three basic elements of the business model define the organisational logic of a retailer and the capture of value. They are related to the fact that the concept of a business model may refer to the whole business enterprise, but when assessing the activities of retail enterprises it is important to indicate how the operational activities, ensuring the sale of goods to final consumers will be implemented. Understanding the concept of the circulation model of a retail outlet is beneficial from the point of view of the numerous questions related to the marketing strategy: Who are the customers of the outlet? How can a business be useful to customers with its value proposition? How does a shop gain customers and how does it develop customer loyalty? Most importantly: why should a customer shop at a particular store? From the perspective of these and other questions, it is necessary to define the potential benefits of business models in terms of the business activities provided by the store to the customer.

The strategic decision problem is the choice of the type or types of operational units referred to as sales formats. It is a matter of defining a multidimensional concept of the store format, i.e., an appropriate combination of the following components: assortment, size of the sales area, method of service, location, price level, range of services, the time required to serve the customer, the conditions of purchase (atmosphere) for the customer, communication with the customer, the relationship with the customer. The retail store format creates a framework for ordering and organizing retail activities into coherent processes that satisfy customer needs. There are different store formats in different product categories, and particular customers choose the format that best suits their needs.

Diversification of the use of different retail formats has been a substantial growth strategy of large retailers in recent years, as the value proposition in retail is changing (new products are offered and others are becoming less popular), which is triggering a change in format. Existing retail formats are changing, and new store formats are emerging, which can be an innovative form of the basic characteristics of the format. This means that, over time, the marketability of products in a given format declines. To increase the number of customers, the company has to take an interest in new store formats. Store format innovations are a potential source of competitive advantage. And although they may be subject to imitation, bringing 2 firsts can secure an attractive market position for the company.

Changes in sales formats are, in some cases, linked to decisions to internationalise. In the case of companies selling branded products, it may be a simple transition of a given selling format without a transition to a new market. In the case of companies selling high-volume goods, it may be a simple transition of a given selling format without a transition to a new market. This process leads to a broadening of the portfolio of formats.

Many retail innovations can be derived from the life cycle of retail units and from the retail cycle hypothesis (Kotler, Armstrong, 1992). To define the profile and classify the different types of retail units, we study the systematization of retail units according to the most important characteristics and essential features, which we call structural and instrumental features.

Structural features are features that are relatively fixed, i.e. unchanging over a short period of time. They include, for example: the definition of the store's product range, the form of sale, the location of the retail unit, or the size of the unit.

Instrumental features include features that are variable over a short time horizon. They include, for example, pricing policy, quality of goods offered, set of services. In terms of these features including for example the sales policy may differ within each of the regions of the world. As an example, in the USA and Great Britain, the definitions of the format are more flexible compared to European definitions, they also come closer to the advancement of sales area in terms of the market, for example a "relatively large supermarket" and so on. The categories of the sales areas change distinctively and have a lesser orientational character. For this very reason, it is necessary to proceed from the generally prevailing features when determining the specific type of retail outlets.

Distribution companies may have a mono-format or multi-format market strategy, for example, in the food sector, Tesco has, similarly to Carrefour, a multi-format strategy (classic hypermarket on the outskirts of towns, smaller hypermarket in smaller towns and cities, supermarkets and convenience stores in the centre of towns).

The format of the physical store is relatively well defined by its material dimensions.

The concept of the virtual store format is quite difficult to characterise considering that it is necessary to characterize the following three synergistic elements:

- the screen dimension, whose characteristics that are necessary to visualise the offer, are proportional to its surface area. The larger the screen, the more effectively visual merchandising can be developed;
- the unlimited possibilities of storing images, texts, videos, sounds, 3D, etc., allowed by new communication technologies. This aspect is one of the strengths of e-commerce;
- the different criteria for the visualisation of products – for example, in a virtual bookstore, the customer can search according to different criteria: author, publisher, subject, price, and conditions of sale, which cannot be implemented in any physical bookstore.

Retailers can arrange and organise the system of activities in different ways depending on their input target (margins, market size and inventory levels) and their output target (level of service provided to customers). Communication with customers is the way in which the retailer structures the exchange process with its customers. Decisions regarding communication not only determine the positioning of the store in terms of location, assortment and overall concept (e.g. whether the store will be organized as a grocery store, specialty store or theme store), but also the choice of communication structure (e.g. c-shop or m-commerce). When it comes to coordinating the distribution channels available to reach the same customer, it is common for retailers to coordinate online and offline channels using multichannel formats such as "click-and-mortar" (Pentina et al. 2009). Business models, therefore, need to specify how activities should be combined in an overall format to achieve a better customer experience.

Governance refers to the actors involved in creating and delivering the customer experience, as well as the mechanisms (e.g. contractual and incentive-based) that incentivise actors to perform their roles in the field. These actors involve not only the retailers and their customers, but also the network of retailer partners across the supply chain. Their roles extend

beyond the transaction landscape, with retailers increasingly relying on the co-creation of suppliers and customers across a wide range of retail activities. For example, customers are co-creators in the shopping area (self-scanning and self-checkout), participate in the sales (handling and removal of goods) and so on. In addition, customer opinions (user reviews) also shape communication in retail. Mass customisation has strengthened the role of customers in the offer and helped to increase the quality of customer service by modifying the delivery chain according to customer needs. Relationships with the community help to exchange information with users of the community. More and more organisations are inviting their customers to share new solutions and thus develop interaction, to exchange and strengthen their image. An important aspect of retail management is the Incentive Structure, which motivates and organizes the actors to perform their roles correctly. Within the framework of the traditional retail paradigm, the manufacturer-distributor management mechanism plays out concepts such as efficient consumer response (ECR-efficient consumer response) and category management, which provide incentives to increase performance (Michon, 2003).

The components of the business model, which are generated on the basis of the Study of Textual Documents, have been identified differently by the above-mentioned authors. Some authors have used Belonging Studies for identification (Lehmann-Ortega et al. 2017; Kita, 2017; Šimberova, Kita, 2020), other authors used market research (Konštiak, 2018). Others offered theories of possible elements of business models concluded in the analysis of the issue (Verstraete, et al. 2017; Demil et al. 2013; Volle et al. 2008), or from the analysis of a particular industry (Slawinska, 2010) or region (Golebiewski et al. 2008). Besides this, in the foreground of interest of some authors, there were the elements of the business model and their interconnection (Hamel, 2000). The configuration of business model parameters (Mandli, Taoufik, 2019) or the definition of business model parameters has been at the forefront of many authors' interest (Sorescu et al., 2011; Afuah, Tucci, 2003). Ritter and Pedersen define the different components in a very comprehensive way (Ritter, Pedersen, 2020).

On the basis of the above sources, complemented by a study of literature dealing with business model development tendencies (Kita et al. 2024a), business model creation (Muehlhausen, 2018) and the creation of a value proposition for customers (MIT, 2021; Kita, Čvirik, 2024b; Joyce, Paquin, 2016; Brabec, 2010, etc.) a set of potential elements of new business models has been compiled.

The most well-known graphical representation of a business model is the business model “canvas” by A. Osterwalder and Osterwalder and Pigneur (2010). The used method of display allows us to show the business logic of a particular company effectively and can be the basis for more general typologies of real business models. This “canvas” model has become the de facto standard for the development of business models.

For Osterwalder and Pigneur, a business model depicts the strategy and organization of an enterprise, i.e. how an enterprise creates, completes and gains value. The descriptive and symbolic function of the business model allows to understand the systemic dimension and complexity associated with the value proposition, given the multiplicity and diversity of related complementary dimensions. The authors aggregate the basic heterogeneous parameters into nine blocks (Osterwalder, Pigneur, 2010):

- customer segments are made up of customers and the different segments to which they belong, with the aim of offering them a product that suits them;
- value proposition: a set of products and services that create value encompassing the three dimensions of sustainable development: environmental, social and economic;
- customer relations are formulated and maintained by the customer segment,
- the marketing channels are those by which the value proposition is delivered to customers on the basis of the communication network, distribution and sales;
- revenue sources are all cash flows generated by the firm on the basis of the translated value proposition;
- the cost structure includes the main costs related to the creation of the offer;
- key resources are the human, financial and material resources required to offer and deliver the elements of the value proposition;
- key activities are those necessary to manage the business;
- the key partner includes a network of significant stakeholders outside the firm with whom the firm is or will be working the firm's ecosystem.

4 Conclusions

The drive to assert itself and compete in a hypercompetitive environment leads firms to pay more attention to their business model and its innovation. The business model is an analytical tool because it creates a link between key components (such as consumers, suppliers and other stakeholders) and explains how retail units operate, leading to understanding and influencing their behaviour. It graphically illustrates the interconnection of its individual components in a systemic way and enables retail unit managers to improve each component separately.

Retail units create a space where everyday life meets managerial practices. For this reason, there is a fundamental link between store development processes and retailer marketing (Operational Excellence), with changes in consumer behaviour, and with new business models that offer different types of Customer Experience with shopping and that require knowledge of consumer behaviour.

Researchers and retailers are expected to focus in the near future on adopting and adapting omnichannel strategies and meeting the needs of omnichannel customers. They also will face challenges of the ongoing and often relatively fast emergence and onset of the new technologies, related to current leapfrogging changes, but also the application of technologies dating back twenty to forty years, whose application has been delayed or slowed for various reasons.

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Cognitive Ergonomics' Impact on Employee Well-being and Performance: A Bibliometric and Thematic Analysis of Research Directions

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Abstract: The aim of this article is to identify and analyze the main research directions and thematic areas within the field of cognitive ergonomics, focusing on its impact on employee performance and well-being. The study aims to provide a comprehensive understanding of how various ergonomic factors contribute to organizational outcomes and employee well-being. The analysis was compiled based on sources available in the Web of Science, Scopus, and Google Scholar databases, published mainly after 2015. The selection criteria were clearly defined and included: publication type – peer-reviewed articles and conference papers; year of publication – 2015 to 2025; relevance to the work environment and cognitive ergonomics; focus on psychological, cognitive, or acoustic factors related to employee well-being. Studies focused exclusively on medical or clinical ergonomics were excluded. The results point to the main research clusters: physical work environment and productivity, acoustic ergonomics and noise factors, psychosocial factors and organizational context, experimental and application approaches. The findings confirm the interdisciplinary link between cognitive ergonomics, the working environment, and subjective well-being, and emphasize the importance of researching this issue not only from the perspective of health protection, but also in terms of maintaining work performance and the long-term competitiveness of organizations. The article also discusses practical and managerial implications that stem from the identified clusters, particularly in relation to workplace design and management strategies that promote sustainable productivity.

Keywords: bibliographic analysis Cognitive Ergonomics, work environment, productivity

JEL Classification: M12,I31, D91

1 Introduction

The increasing complexity of modern workplaces requires a more fundamental examination of cognitive ergonomics and its significant impact on employee well-being and performance. Cognitive ergonomics is a subdiscipline concerned with optimizing the interaction between cognitive processes and workplace demands. It serves as a key element in improving both mental and physical aspects of health in organizational settings. Recent bibliographic analyses reveal that the interconnection between psychosocial dynamics, the physical work environment, and employee engagement is key to understanding employee performance (Subarno et al., 2025; Bajrami et al., 2022) (Wibowo et al., 2024).

The work environment significantly affects employee well-being, as a high-quality environment is associated with increased productivity, job satisfaction, and overall health. Empirical research has shown that factors such as job demands, control, and social support influence well-being, thereby positively affecting engagement and productivity (Subarno et al., 2025; Bajrami et al., 2022). In addition, research emphasizes that organizational culture influences the psychosocial environment, which is directly related to employee well-being (Rasool et al., 2021; Huang et al., 2016). Employees who perceive a high level of support from their organizational culture and superiors are more likely to be positively engaged in their work, thereby promoting a productive and innovative workplace (Wibowo et al., 2024; Korhan et al., 2023).

In addition, the role of acoustic ergonomics and psychosocial factors cannot be overlooked. Noise levels and mental well-being resulting from well-designed spaces significantly affect cognitive functions such as attention, reasoning, and memory (Korhan et al., 2023). The interaction of these elements creates an environment in which organizational support

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mechanisms such as training and teamwork not only increase employee well-being but also strengthen their sense of belonging and commitment to the organization (Ogbonnaya et al., 2018; Koon et al., 2023).

Given the changing dynamics of work, which have been greatly accelerated by the impact of the COVID-19 pandemic, organizations are forced to adapt their measures of employee performance and well-being to include a more comprehensive view of health that encompasses both physical and mental aspects (Lee, 2021). This broader view recognizes that employee well-being is not solely a personal responsibility, but a shared goal of the organization that is essential to supporting a sustainable and competitive workforce (Mohamad & Abiddin, 2024; Gupta, 2024).

This article aims to identify and analyze the main research directions in the field of cognitive ergonomics and employee well-being, reinforcing the need for a comprehensive understanding of how various ergonomic factors contribute to better organizational outcomes. In line with this goal, the study combines bibliometric and thematic analysis to uncover the dominant research areas, key authors, and interdisciplinary connections within the field. In today's data processing and visualization environment, there is a growing demand for technical support. The multifaceted nature of modern data sets, which are characterized by their size, diversity of formats, and variety of sources, poses a significant challenge for researchers and professionals alike. Despite the abundance of text analysis tools available, there is still a strong need for user-friendly yet powerful solutions that can scale effectively while providing advanced visual representations of data (Noshad et al., 2021).

Bibliometrics is a viable means to quantitatively and qualitatively evaluate trends in research activities over time. It uses literature databases and literature metrology characteristics. It has become a popular method of providing insight into research in specific fields (Xie et al., 2020). A new focal point in this area has been the use of VOSviewer, an open-source software tool that offers bibliometric analysis capabilities. VOSviewer allows users to perform in-depth analyses of large data sets and create visualizations that authentically map networks connected through authors, keywords, or institutions (Liu et al., 2022). This tool has gained popularity not only for its effectiveness in illustrating critical research dynamics, including emerging trends and thematic clusters, but also for its acceptance and adaptability within the academic community (Illiashenko et al., 2021). Using bibliometrics in combination with the VOSviewer tool, researchers can identify prevailing research channels and uncover potential gaps that require further investigation (Wang et al., 2020).

The integration of bibliometric tools into the field of cognitive ergonomics is an example of how data visualization can actively support research development. VOSviewer greatly contributes to the transparency of research trajectories and allows the identification of key authors and thematic groups, ultimately leading to a more comprehensive understanding of the field of cognitive ergonomics (Sikdar et al., 2022). This is essential for addressing the growing complexity and multifaceted nature of the phenomena being studied today, bringing visualization methodologies in line with the demands of contemporary research (Lopes et al., 2023).

Recent research into decision-making frameworks for complex problems further emphasizes the importance of multi-criteria assessment using diverse data sources. This is essential for ensuring that spatial and temporal dimensions are accurately reflected in decision-making processes, which improves the interpretability and information richness of the results (Lopes et al., 2023). The demand for effective data processing and visualization tools is therefore not only a prerequisite for individual research, but also signifies broader changes in the methodologies of both academia and industry. The collective knowledge provided by tools such as VOSviewer paves the way for better orientation in the complex network of modern data environments (Asiyabi et al., 2023).

In summary, the use of advanced visualization and processing tools is a key strategy for navigating the complexity of today's data-rich environment. The combination of bibliometric methods and visualization software supports the definition of research directions, facilitates a more detailed understanding of disciplines such as cognitive ergonomics, and thus addresses the urgent need for effective management of the influx of diverse and extensive data. By examining the research clusters identified in the bibliographic analysis, we emphasize the importance of an interdisciplinary approach in an effort to improve the work environment that supports the success of individuals and organizations.

2 Methods

The research was conducted in the form of a bibliographic analysis with the aim of identifying and analyzing the main research directions and thematic areas in the field of cognitive ergonomics and employee well-being. The analysis was designed as a systematic review of the literature supplemented by bibliometric visualization techniques. A similar approach has already been used by several authors, such as Van Eck and Waltman (2009), who laid the foundations for the methodology of visualizing bibliometric networks using VOSviewer software. In the field of ergonomics and related disciplines, bibliometric analysis has also proven its worth in the work *Emerging Applications of Cognitive Ergonomics*:

A Bibliometric and Content Analysis, where the authors mapped the main research clusters using VOSviewer and other analytical tools. Another example is the study Bibliometric analysis on physical ergonomics: A visual analysis (2024), which visualized trends in physical ergonomics and demonstrated the potential of bibliometric techniques in identifying research hotspots. In the field of employee wellbeing, authors such as Xu et al. (2025) applied bibliometric analysis to examine the development and key directions of this research. These studies confirm the relevance of combining a systematic literature review with bibliometric visualizations, which allows for a more comprehensive mapping of the current state of knowledge and its main trends. The purpose of this study was therefore twofold: to identify the dominant research directions and clusters in the field of cognitive ergonomics and employee well-being, and to analyze the thematic and interdisciplinary links between them.

Data sources and selection criteria. The primary data sources were the scientific databases Web of Science, Scopus, and Google Scholar. To ensure validity and comparability, several explicit inclusion and exclusion criteria were applied. The inclusion criteria were as follows:

- **Publication type:** only peer-reviewed journal articles and conference papers.
- **Publication period:** 2015–2025.
- **Language:** English.
- **Relevance:** studies focusing on the relationship between cognitive ergonomics, employee well-being, performance, or workplace design.
- **Thematic focus:** research addressing psychological, cognitive, acoustic, or environmental aspects of ergonomics related to employee functioning.

Exclusion criteria:

- studies focusing solely on medical or clinical ergonomics,
- publications unrelated to the work environment,
- papers with insufficient bibliographic data for analysis (e.g., missing keywords or authorship details).

The search was performed using a defined set of keywords: "cognitive ergonomics," "employee well-being," "workplace design," "auditory environment," "psychosocial factors," "productivity," and "organizational support." Each combination of these keywords was used with Boolean operators (AND, OR) to maximize the coverage of relevant sources.

After the initial search, duplicates were removed, and articles were screened by title, abstract, and keywords. Only studies meeting all the above criteria were included in the final dataset.

Data processing. After reading the titles, abstracts, and keywords, a final set of publications containing 418 relevant sources was created. Bibliographic data (authors, titles, abstracts, keywords, citations) were exported in a compatible format (RIS) and then processed in bibliometric software.

Analytical tools. Co-authorship analysis was chosen for the construction of the network, as it allows the research links between authors to be displayed and a map of collaborating research groups to be created. The fractional counting method was used, which eliminates the overestimation of collaboration in publications with a large number of authors. The LinLog method was chosen for data normalization, which allows for a clearer distinction between individual clusters and highlights the internal cohesion of research communities. At the same time, a minimum number of documents per author was set so that only relevant and repeatedly publishing researchers were included in the map. This threshold criterion was defined as at least three publications or five co-authorship links within the analyzed period, ensuring that only established contributors were visualized.

The result was a map that clearly shows the main directions of research as well as their interconnections.

Interpretation. Each cluster was analyzed in terms of its theoretical basis, most frequently cited authors, and implications for research on the work environment and well-being. The interpretation combined quantitative mapping of bibliographic links with qualitative content analysis of selected publications.

3 Research results

The visual map of co-authorships shows researchers who have proven to be the most significant in a given field of literature based on their publication and citation activity. Only authors who meet the set threshold criteria (e.g., minimum number of

publications or co-authorship links) are included in the analysis, with VOSviewer automatically highlighting the nodes that represent the most important connecting elements in the network. In this study, the threshold was defined as a minimum of three publications or five co-authorship connections, ensuring that only established and repeatedly publishing authors were included.

The visibility of individual names on the map is therefore the result of two factors:

Number of publications and citations – the more an author publishes and the more frequently their work is cited in the field under study, the greater their importance in the network. The size of the name on the map corresponds to the weight of their contribution to the field being analyzed.

Intensity of co-authorship – authors who collaborate with a larger number of other researchers create denser connections and become central nodes of clusters.

The colors on the map reflect the emergence of so-called communities, i.e., groups of authors who cite each other intensively or publish together on related topics. However, not all authors are displayed equally prominently on the map. Those with fewer publications or less citation impact appear only as smaller, less visible nodes, or are not displayed at all, so that the visualization remains clear.

For this reason, the map highlights the names of authors who play a key role in the research network – either as leaders of their clusters or as connecting elements between multiple research communities.

As a result of the analysis, four main research directions have been identified:

- Physical work environment and productivity (purple cluster),
- Acoustic ergonomics and noise factors (orange cluster),
- Psychosocial factors and organizational context (yellow cluster),
- Experimental and application approaches (blue cluster).

The research was based on the analysis of a basic corpus of 418 sources, in which the authors dealt with the issue of cognitive ergonomics. Based on the examination of the existence of mutual connections and connections to a specific cluster, a set of 167 sources was identified. Figure 1 shows a citation map created in the VOSviewer software. The LinLog method was chosen for normalization, which allows for clearer differentiation of clusters and highlights the internal cohesion of individual research groups. The size of the nodes represents the publication activity of the authors, and the thickness of the connections represents the intensity of their collaboration.

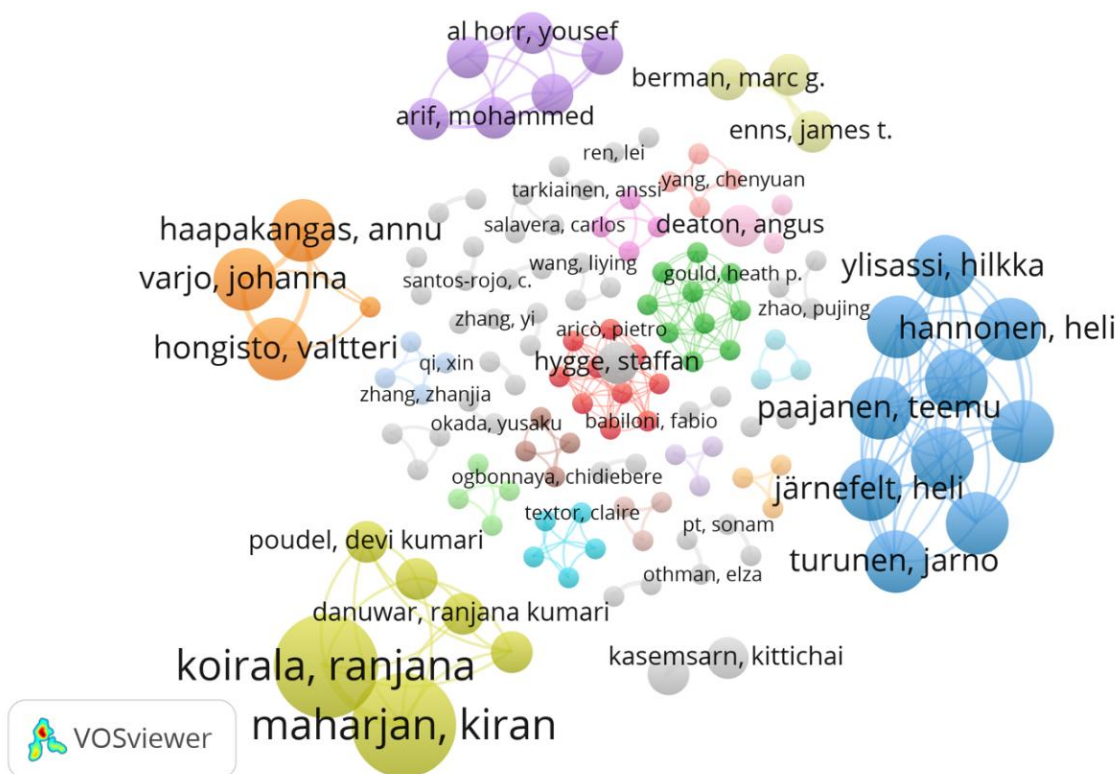
The purple cluster (Al Horr, Arif et al.) brings together authors who focus on the impact of the physical work environment on well-being and productivity. Research in this group focuses on factors such as the quality of the indoor environment of buildings, lighting, and temperature and their impact on cognitive performance and employee satisfaction. An important contribution is the linking of cognitive ergonomics with the fields of architecture and facility management, which makes it possible to design workplaces that promote not only efficiency but also health and well-being.

The Orange Cluster (Haapakangas, Hongisto, Varjo et al.) focuses primarily on acoustic ergonomics and the impact of the sound environment on well-being at work. Their studies examine how noise, open-plan offices, and distractions affect cognitive load, concentration, and employee satisfaction. A significant finding of this line of research is that acoustic conditions have a direct impact on subjective well-being and long-term productivity, and they also propose specific measures, such as acoustic panels or flexible workspaces.

The yellow cluster (Koirala, Maharjan et al.) represents authors who link psychosocial aspects of work with cognitive ergonomics. Their research focuses on factors such as work stress, organizational support, and subjective perceptions of the work environment. Studies in this group point out that employee well-being is influenced not only by physical conditions but also by social and organizational ties, which opens up space for managerial interventions and support for a healthy work environment.

The blue cluster (Ylisassi, Hannonen, Paaanen et al.) focuses on experimental approaches and applied research in the field of ergonomics. Authors from this group are involved, for example, in assessing working conditions in specific industries, testing new methodologies, and verifying the impact of ergonomic measures on employee performance and well-being. Research in this area provides practical knowledge that can be used to develop recommendations for employers and design work.

Figure 1 Citation Map Generated in VOSviewer



Source: Own processing

Summary

A number of thematically distinct clusters are depicted in the co-authorship map that was produced by the VOSviewer program. These clusters represent a variety of approaches to the investigation of cognitive ergonomics and its relationship with the well-being and performance of employees. Collectively, these clusters constitute a landscape that is diverse, and within this landscape, cognitive ergonomics emerges as a multidisciplinary field that connects design, psychology, management, and occupational hygiene. The identification of these clusters fulfills the main goal of this study – to map and analyze the dominant research directions in the field of cognitive ergonomics and employee well-being. Each cluster provides a unique perspective on how environmental, psychosocial, and organizational factors influence employee outcomes.

The synthesis of these findings confirms that cognitive ergonomics serves as an integrative platform linking mental processes, workplace conditions, and managerial practices. This insight not only strengthens the theoretical understanding of the field but also creates a foundation for practical recommendations aimed at improving the design of work environments and promoting sustainable employee performance.

The findings also underscore the importance of cognitive ergonomics in promoting employee well-being and work performance. Consequently, it is of significant practical importance to organizations that are making efforts to achieve sustainable productivity.

4 Conclusions

Bibliographic analysis has shown that cognitive ergonomics, especially in the context of the auditory environment, is an important factor influencing employee wellbeing and performance. The identified clusters confirm the interdisciplinary nature of this issue and open up space for practical applications in the design of work environments.

The results of the bibliometric mapping revealed four dominant research directions that form the conceptual framework of the field: (1) physical work environment and productivity, (2) acoustic ergonomics and noise factors, (3) psychosocial factors and organizational context, and (4) experimental and application approaches. These clusters demonstrate that cognitive ergonomics is not an isolated domain but a multidisciplinary field combining insights from psychology,

management, architecture, and occupational health. Each of these areas contributes to a better understanding of how cognitive demands and environmental stimuli jointly shape employee performance and well-being.

In practice, it is important to focus on:

- implementing ergonomic principles in the design of workspaces,
- reducing noise pollution and optimizing the auditory environment,
- promoting subjective wellbeing through meaningful and value-oriented work.

These recommendations stem directly from the identified research clusters. Studies in the physical environment cluster emphasize measurable links between environmental comfort and productivity, which supports the call for evidence-based workplace design. The acoustic ergonomics cluster highlights that noise and auditory distraction are consistent predictors of cognitive fatigue, suggesting the need for acoustic management in open-plan offices. The psychosocial and organizational cluster indicates that employee well-being is significantly influenced by leadership quality, organizational culture, and social support, pointing to managerial interventions as a key lever for improvement. Finally, the experimental and application cluster demonstrates how ergonomic interventions can be empirically tested and implemented in various industries. Together, these findings provide a strong empirical basis for the proposed managerial and design implications.

The conclusions also underline that cognitive ergonomics has a strategic value for organizations striving for sustainable performance. By integrating ergonomic principles into everyday management and workplace design, companies can not only improve health outcomes but also foster innovation, engagement, and long-term competitiveness.

Future research should focus on empirical verification of the identified relationships, particularly through experiments with sound stimuli and questionnaire surveys in the trade and services sector. Such empirical studies could validate the conceptual clusters identified in this analysis and expand the understanding of causal mechanisms between cognitive factors, the work environment, and well-being. Future research should therefore focus particularly on the acoustic dimension of cognitive ergonomics — specifically on the effects of white and pink noise on attention, concentration, and perceived well-being in various work settings. Building on the studies analyzed in this paper, further experimental research could clarify how controlled auditory stimuli contribute to reducing cognitive load and enhancing employee performance. The results of such research can serve as a basis for the creation of effective management strategies that promote mental health and employee productivity.

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Partnership Competences and Barriers in Destination Offer Development

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Abstract: This paper explores perspectives of regional DMOs (Destination management organizations) from selected regions of the Czech Republic on competencies, collaboration, and barriers in selected Czech destinations, linking empirical evidence with contemporary literature in destination management. The study aims to identify the most critical factors that enable or hinder cooperation with an emphasis on destination offer development. By combining recent theoretical insights with data from the questionnaire among DMOs, the research contributes to a deeper understanding of collaborative governance in tourism. It provides practical implications for DMOs, policymakers, and practitioners.

Keywords: tourism management, destination management, partnership, stakeholder collaboration, destination management organization

JEL Classification: Z30, Z32, Z39

1 Introduction

Tourism destinations represent complex and dynamic systems where multiple stakeholders, including public authorities, private sector entities, local communities, and visitors, interact and influence each other's decisions. The management of such systems, therefore, requires coordination that transcends the capacities of individual organizations. Collaborative governance has become a key concept in this regard, as it allows diverse actors to jointly plan, implement, and evaluate tourism development in a transparent and participatory way (Wan et al., 2022; Sentanu et al., 2023). The absence of such cooperation often leads to fragmented decision-making, duplication of efforts, and unsustainable use of resources (Humsona et al., 2023; Vermeulen-Miltz et al., 2023).

In the literature, a clear distinction is made between destination governance and destination management. *Destination governance* refers to the institutional structures, rules, and processes that define how decisions are made and how various stakeholders interact in the destination (Bichler & Lösch, 2019). It emphasizes the distribution of power, participation, transparency, and accountability. *Destination management*, on the other hand, focuses on the operational coordination and implementation of strategies, policies, and actions that result from governance processes (Laesser et al., 2025). In practice, both dimensions are closely interlinked: governance provides the framework for collaboration and legitimacy, while management ensures the effective realization of shared objectives.

Within this system, Destination Management Organizations (DMOs) play a pivotal role. Originally established primarily as marketing agencies, DMOs have evolved into facilitators of governance processes and coordinators of destination management (Erneker et al., 2024; Laesser et al., 2025). Their mission now extends beyond promotion to include strategic planning, partnership development, and balancing diverse stakeholder interests to ensure the sustainable prosperity of the destination (Romão et al., 2021). By linking governance and management functions, DMOs serve as intermediaries that translate strategic visions into coordinated actions.

Effective destination management and governance rely on a set of key competencies. These include strategic leadership, communication and negotiation skills, the ability to facilitate partnerships, and the capacity for innovation and digital transformation (OECD, 2021; Sentanu et al., 2023; Pham et al., 2023). Modern DMOs must also combine traditional marketing expertise with sustainability-oriented thinking and data-driven decision-making. According to Buhalis (2020) and Laesser et al. (2025), the future of destination management lies in integrating digital fluency, stakeholder co-creation, and collaborative governance to enhance resilience and competitiveness.

Nevertheless, cooperation in destination governance is often hindered by barriers such as a lack of trust, limited resources, political influence, poor communication, or divergent stakeholder priorities (Tichá & Farsari, 2020; Vašaničová

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et al., 2022). These obstacles can be reduced through transparent communication, clearly defined roles, and facilitative leadership that promotes fairness and long-term commitment (Bichler & Lösch, 2019; Pham et al., 2023).

Empirical research shows that well-functioning partnerships contribute to more innovative and competitive tourism offers, more efficient resource use, and higher legitimacy among local stakeholders (Keyim, 2018; Pham et al., 2023). However, the relative importance of individual competencies and barriers may differ between destinations, depending on institutional maturity, local governance culture, and the development stage of the tourism system.

The study aims to identify the most critical factors that enable or hinder cooperation with an emphasis on destination offer development. Based on the theoretical insights presented above, the research addresses the following research questions:

RQ1: Which competences and partnership factors are perceived as most important by DMOs in selected regions?

RQ2: What are the main barriers to collaboration identified by DMOs?

RQ3: How can the defined competences and barriers be clustered according to their perceived importance?

2 Methods

The empirical part of this study is based on a questionnaire survey conducted among representatives of Destination Management Organizations (DMOs) in three Czech regions: South Bohemia, the Pilsen Region, and the Vysočina Region. These regions were selected for their geographical proximity, similar tourism structures, and established cooperation in destination development. In total, 18 DMOs participated in the survey. This pilot study focused only on three mentioned regions to test the questionnaire and verify the analytical approach. Future research will extend the survey to include the remaining DMOs in the Czech Republic, allowing for a broader generalization of findings.

The questionnaire was designed to capture perceptions of DMOs regarding key competences and barriers affecting partnership collaboration in destination offer development. It consisted of three sections: evaluation of competences relevant to partnership collaboration, evaluation of barriers that limit cooperation, and one open-ended question allowing respondents to describe additional or underestimated barriers.

Both competences and barriers were assessed on a five-point Likert scale, where 1 = not important and 5 = crucial. Descriptive statistics were used to calculate weighted mean values for each item.

To explore the underlying patterns in the data, a k-means cluster analysis was applied separately to competences and barriers. The clustering aimed to identify groups of items that respondents perceived with similar levels of importance. Because all variables were measured on the same 1–5 Likert scale, data standardization was not performed. The analysis was conducted using the Statistica software package (TIBCO Software Inc.).

3 Research results

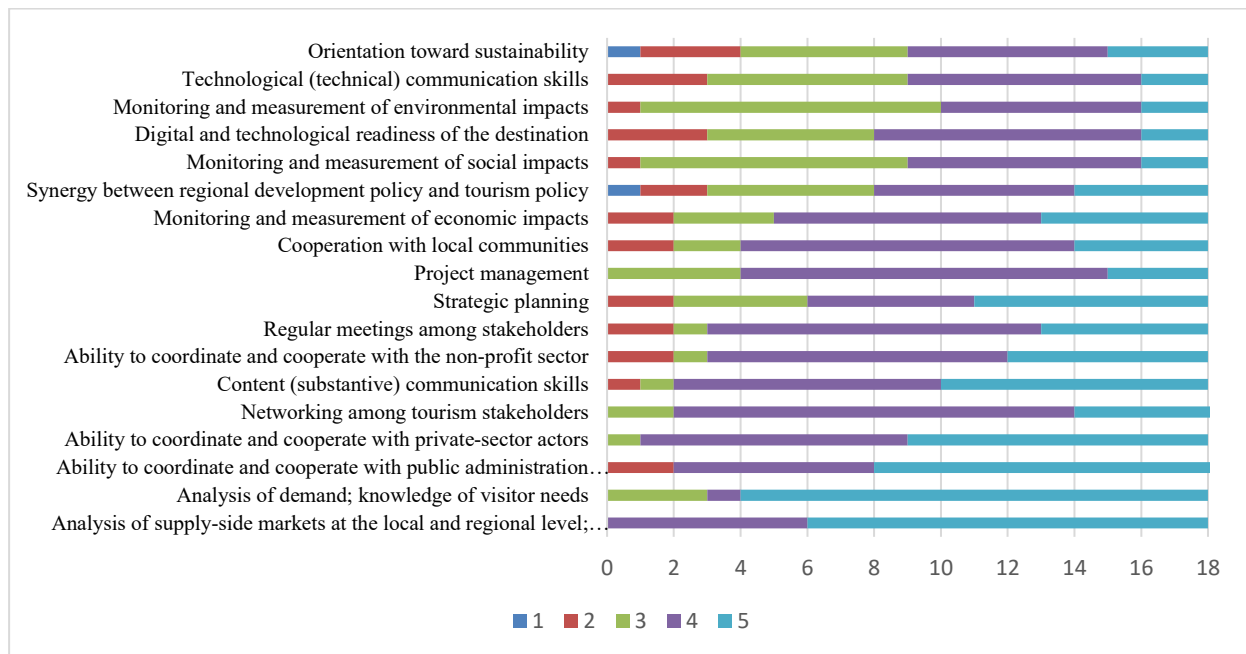
Respondents rated most competences as highly important, with weighted mean values ranging from 3.4 to 4.7. The most essential competences included analysis of supply-side and demand markets, knowledge of local specificities, and coordination with public administration ($M \approx 4.6$ – 4.7). These results highlight the importance of analytical insight and institutional collaboration as the foundation of effective destination governance.

High average ratings were also recorded for cooperation with private and non-profit sectors, networking among tourism stakeholders, and communication skills ($M \approx 4.1$ – 4.4). These findings underline the need for continuous cooperation, stakeholder engagement, and effective communication across institutional boundaries.

Competences such as strategic planning, project management, community collaboration, and monitoring of economic impacts ($M \approx 3.9$) were rated moderately. This suggests that while they are relevant, they are viewed as supporting competences rather than key drivers of partnership success.

Competences associated with sustainability, innovation, and digital readiness including monitoring of social and environmental impacts, technological communication skills, and orientation toward sustainability ($M \approx 3.4$ – 3.6), received the lowest scores. This indicates that although these areas are recognized as emerging priorities, they have not yet reached the same level of strategic importance as analytical or collaborative skills. The distribution of rating of individual competences and factors is visualized in Figure 1.

Figure 1 Rating of Individual Competences and Factors



Source: Elaborated by authors based on conducted questionnaire

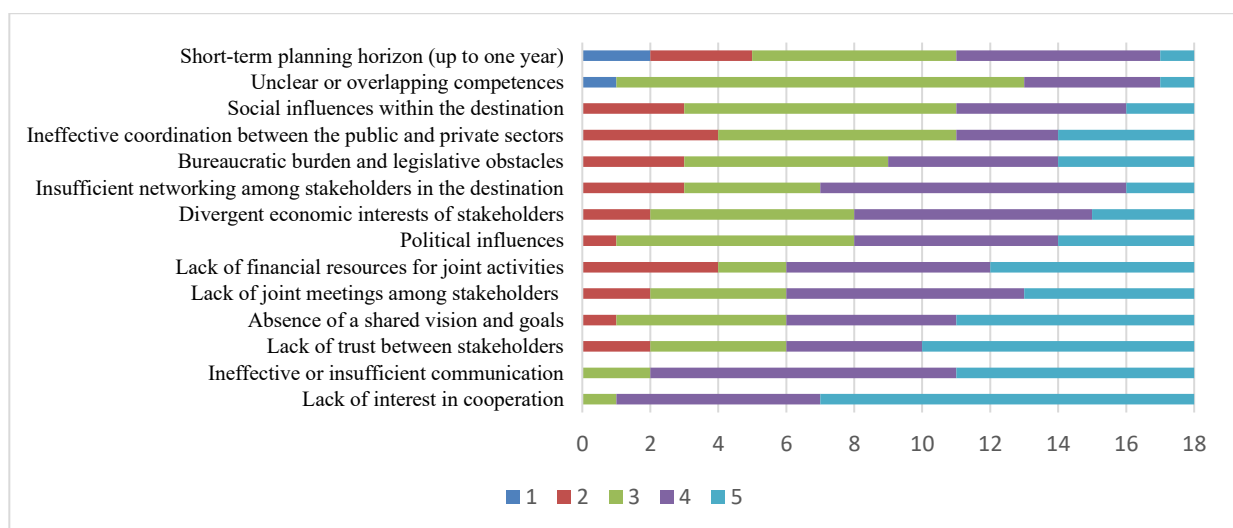
Barriers were generally rated as moderately to highly important, with mean values between 3.1 and 4.6. The most critical barriers were lack of interest in cooperation ($M = 4.56$) and ineffective or insufficient communication ($M = 4.28$), emphasizing that soft factors, such as motivation, trust, and communication, represent the main challenges to partnership collaboration.

Lack of trust and absence of shared vision and goals ($M = 4.00$) were also rated highly, pointing to persistent difficulties in building mutual confidence and shared strategic direction. Moderately significant barriers, including insufficient stakeholder meetings, lack of financial resources, and political influences ($M \approx 3.7$ – 3.8), indicate that organizational and resource constraints further limit the effectiveness of collaboration.

Lower-rated items, such as bureaucratic burdens, unclear competences, and short-term planning horizons ($M \approx 3.1$ – 3.5), reflect systemic and procedural barriers that, while less immediate, undermine long-term coordination and strategic stability.

Overall, the results suggest that the greatest barriers arise not from formal structures or legislation but from relational and communicative gaps among stakeholders. Figure 2 illustrates the distribution of ratings for barriers

Figure 2 Rating of Individual Barriers



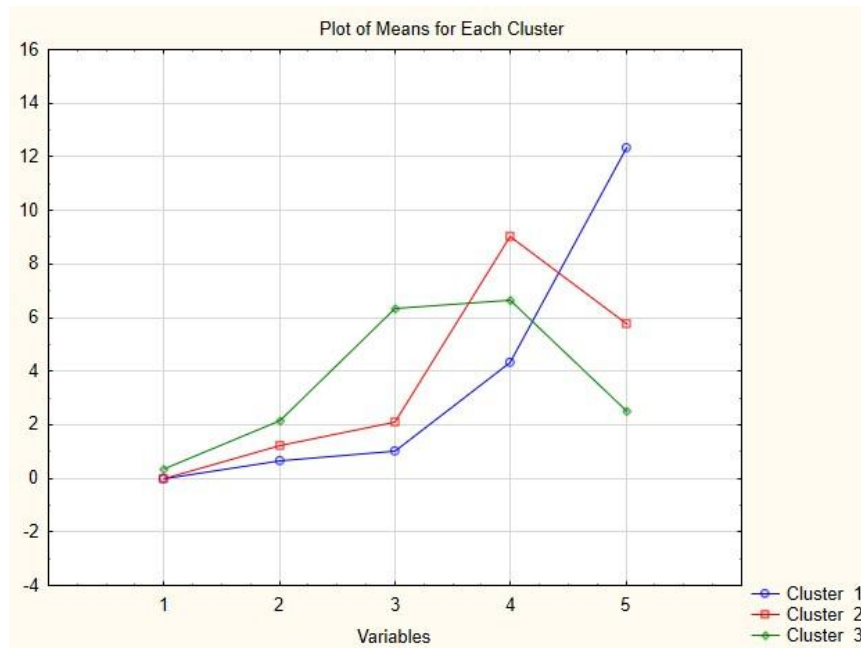
Source: Elaborated by authors based on conducted questionnaire

Next a k-means cluster analysis was conducted to identify groups of competences and barriers with similar perceived levels of importance. Respondents rated each item on a five-point Likert scale (1 = not important, 5 = crucial). The clustering thus reflects shared evaluation patterns rather than predefined thematic categories.

Competence Clusters

The analysis revealed three groups of competences that differ in their rating by the DMOs and thematic focus. The identified clusters and the distribution of ratings within each of them are displayed in the plot of means in Figure 3.

Figure 3 Distribution of Ratings in Revealed Clusters - Competences



Source: Elaborated by authors based

Cluster 1 – Core Analytical and Administrative Competences

This cluster includes analysis of supply and demand markets, knowledge of local specificities, and coordination with public administration.

These competences achieved the highest proportion of “5” ratings, indicating strong consensus among respondents regarding their crucial importance for destination management. They represent the analytical and institutional foundation upon which effective destination governance is built ensuring data-driven planning and alignment with public policy.

Cluster 2 – Collaborative and Managerial Competences

This cluster comprises competences such as networking among tourism stakeholders, communication skills, cooperation with private and non-profit sectors, strategic planning, and project management.

These items were most frequently rated between 4 (“important”) and 5 (“crucial”), suggesting that respondents perceive them as essential for the operational and relational functioning of destination partnerships. The cluster highlights that continuous cooperation, coordination, and mutual understanding among stakeholders are key drivers of destination success.

Cluster 3 – Strategic and Innovative Competences

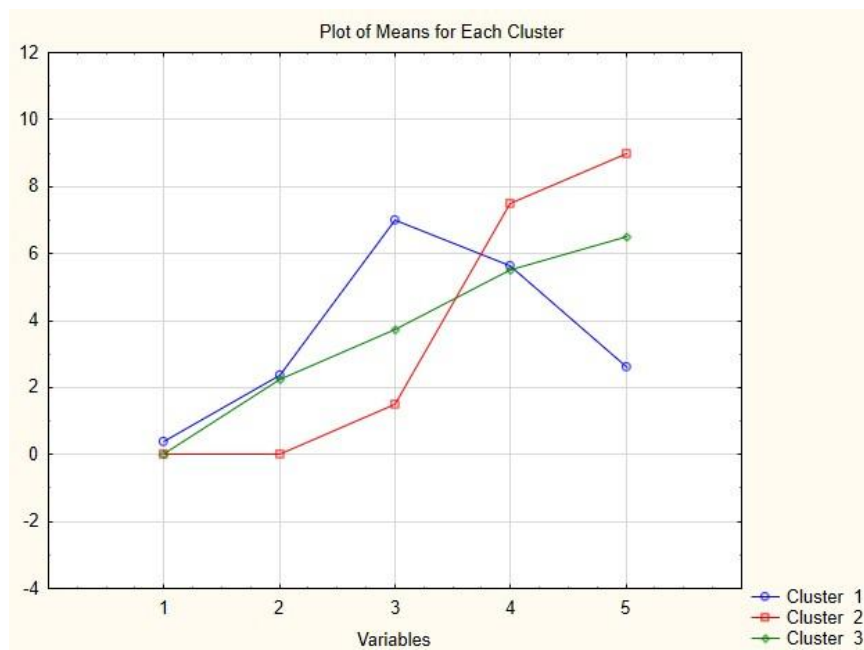
The third cluster includes policy synergy between regional development and tourism, digital readiness, monitoring of social and environmental impacts, and orientation toward sustainability.

These competences received a higher frequency of ratings in the middle of the scale (3–4), indicating that while respondents recognize their relevance, they are not yet seen as critical in everyday practice. This suggests that innovation, technology, and sustainability are viewed as emerging rather than fully established competences in destination management.

Barrier Clusters

Similarly, three clusters of barriers were identified based on perceived importance. Figure 4 presents the plot of means, illustrating the identified clusters and the distribution of ratings across them.

Figure 4 Distribution of Ratings in Revealed Clusters - Barriers



Source: Elaborated by authors

Cluster 1 – Structural and Systemic Barriers

This cluster consists of political influences, bureaucratic burdens, unclear division of competences, and ineffective coordination between public and private sectors.

These barriers were most often rated 3 or 4, indicating that respondents view institutional and governance-related problems as persistent and highly influential factors, limiting effective cooperation.

Cluster 2 – Communication and Engagement Barriers

Due to a lack of interest in cooperation and ineffective communication, this cluster showed the strongest concentration of maximum ratings (“5”), indicating that these two barriers are perceived as the most critical and immediately relevant to partnership functioning. Respondents clearly identified the absence of motivation and poor communication as the most pressing collaboration challenges.

Cluster 3 – Relational and Resource Barriers

This cluster includes lack of trust, absence of shared vision and goals, insufficient stakeholder meetings, and limited financial resources.

Ratings in this cluster were most frequently between 4 and 5, suggesting that trust, shared commitment, and resource availability play a substantial role in shaping cooperation quality, even if their urgency is perceived as slightly lower than direct communication failures.

Underestimated Barriers

Lastly, the respondents were asked in an open question, “Which barriers to cooperation do you consider underestimated?” Three main thematic areas emerged from the respondents’ answers:

Cooperation, Communication, and Trust among Actors – respondents frequently mentioned poor communication, lack of trust, and insufficient understanding of stakeholder roles as persistent yet underestimated obstacles. Personal relations and competitive attitudes were also highlighted as issues that reduce the effectiveness of collaboration.

External and Political-Administrative Influences – answers emphasized the impact of political interference, short-term planning cycles, and bureaucratic complexity, which hinder strategic continuity and the establishment of stable governance frameworks.

Functional Management and Organizational Synergies – respondents noted problems such as unclear competences, weak coordination between public and private sectors, and absence of a unified vision. These issues illustrate that organizational fragmentation and lack of clear leadership remain significant challenges in destination governance.

Overall, the open-ended responses underscore that relational and organizational factors are often underestimated, even though they strongly influence the effectiveness and sustainability of partnership collaboration.

4 Conclusions and Discussion

The findings of this pilot study provide a deeper understanding of how Destination Management Organizations (DMOs) in the Czech Republic perceive competences and barriers that influence partnership collaboration in destination offer development. In addressing the first research question concerning the competences perceived as most important for partnership collaboration, the results show that DMOs attribute the highest importance to analytical and coordination competences, particularly market analysis, knowledge of local specificities, and cooperation with public administration. These competences represent the analytical and institutional foundations of effective governance, confirming earlier theoretical assumptions about the importance of data-driven and coordinated management practices (Laesser et al., 2025; Pham et al., 2023). In addition, competences related to stakeholder networking, communication, and strategic planning were also viewed as highly relevant, emphasizing the growing role of collaborative and managerial skills in building effective destination partnerships.

At the same time, competences associated with sustainability, innovation, and digital transformation were evaluated as less important, suggesting that these areas, though increasingly discussed in the literature (Buhalis, 2020; OECD, 2021), are still in the early stages of integration into everyday DMO practice. While many organizations have already begun incorporating digital tools and data-driven approaches into their daily operations, digital transformation does not yet receive the same strategic attention as traditional management or coordination competences. This indicates a gap between the theoretical direction of destination governance, which highlights smart and sustainable management approaches, and the operational priorities perceived by practitioners.

The analysis of the data also revealed that the greatest challenges in destination partnerships are not institutional but relational. In line with the second research question, which focused on identifying the main barriers to collaboration, the most critical issues rated by respondents were lack of interest in cooperation, ineffective communication, and limited trust, followed by absence of a shared vision and inconsistent coordination between sectors. These findings suggest that communication and motivation play a more decisive role in shaping collaboration than formal structures or regulations. This confirms that successful destination governance depends on transparent communication, mutual trust, and shared strategic commitment among stakeholders (Bichler & Lösch, 2019; Sentanu et al., 2023). Open-ended responses further revealed that many obstacles, such as political influences, unclear roles, and short-term planning horizons, are often underestimated, even though they significantly affect long-term collaboration.

The k-means cluster analysis provided additional insight into how DMOs group competences and barriers according to their perceived importance thus addressing the third research question. Among competences, three distinct clusters emerged: core analytical and administrative competences, which achieved the highest proportion of maximum ratings; collaborative and managerial competences, characterized by strong agreement on their operational importance; and strategic and innovative competences, which respondents considered moderately significant. A similar pattern was observed among barriers, where communication and engagement barriers (particularly lack of cooperation and communication) were perceived as the most pressing, followed by structural and resource-related barriers. These results illustrate that DMOs differentiate between interpersonal challenges and systemic obstacles, mirroring the dual nature of destination governance, which connects human relationships with institutional coordination (Romão et al., 2021; Laesser et al., 2025).

From a theoretical perspective, the study contributes to the growing discussion on the interrelation between destination governance and destination management. It empirically supports the argument that governance provides legitimacy, participation, and coordination structures, while management translates shared objectives into concrete actions through collaboration, innovation, and communication among stakeholders.

From a managerial point of view, the findings underline the need to strengthen communication, trust-building, and stakeholder engagement mechanisms as essential preconditions for overcoming cooperation barriers. DMOs should also invest in the development of digital, analytical, and sustainability-oriented competences to align operational practice with

modern governance frameworks that emphasize innovation, resilience, and long-term destination competitiveness (Buhalis, 2020; OECD, 2021).

Nevertheless, the research has several limitations. It represents only a pilot phase involving DMOs from three Czech regions: South Bohemia, the Pilsen Region, and the Vysočina Region, also this paper includes only a limited set of questions from the questionnaire focusing on competences and barriers. The results should therefore be interpreted as exploratory, providing initial insights rather than general conclusions. However, the study successfully validated the questionnaire and confirmed its analytical potential.

Future research will expand the survey to include DMOs from all regions of the Czech Republic, which will allow for a more comprehensive analysis of regional variations, governance maturity, and partnership structures. A larger dataset will also enable the use of more advanced statistical methods and a stronger empirical foundation for theoretical generalization.

In summary, the results of this pilot study demonstrate that the effectiveness of destination governance depends on both managerial competencies and the quality of stakeholder relationships. The findings clearly show that the most crucial factors are relational aspects, motivation to cooperate, and the willingness to engage in genuine collaboration among stakeholders. Strengthening mutual trust, improving communication, and fostering innovation and sustainability-oriented skills will therefore be essential for building resilient and collaborative destination management systems in the Czech tourism context.

At the same time, there is a need to develop practical tools and measures to encourage stakeholders to recognize that, even in a competitive market environment, cooperation within the destination can enhance their collective performance and long-term competitiveness. Creating supportive frameworks, joint initiatives, and incentive mechanisms could help shift perceptions from competition toward coopetition, enabling more effective and sustainable destination governance.

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The Impact of Marketing Strategies on the Sustainable Purchasing Behavior of the Young Generation: A Generational and Communication Perspective

Lea Rubínová¹, Elena Horská²

Abstract: Sustainable consumption is currently one of the key topics in social and economics discourse, especially in the context of growing environmental awareness among consumers. Young generations, particularly Generation Z, represent a significant consumer group whose purchasing behavior is influenced by environmental values, digital communication, and an emphasis on authenticity. This work focuses on the role of green marketing, transparency, brand credibility, emotional appeals, and digital media – including influencer marketing – which significantly support the shift from environmental attitudes to actual behavior. The influence of environmental knowledge and social factors on purchasing intentions is also important. The analysis further highlights the growing importance of modern technologies such as artificial intelligence, which enhances the effectiveness of green marketing tools. The findings emphasize the need for a comprehensive approach that combines education, authentic communication, and technological innovation to promote sustainable consumption among the younger generation.

Keywords: sustainable consumption, marketing strategies, consumer behavior, ecological marketing, green marketing, young generation, purchasing decisions, environmental awareness, marketing communication, brand credibility

JEL Classification: M31, M37

1 Introduction

In recent years, there has been a growing societal interest in sustainability and environmentally responsible behavior, which are becoming increasingly important topics in both social and economic contexts. Consumer decision-making is gradually shifting under the influence of rising awareness about climate change, the depletion of natural resources, and the negative consequences of excessive consumption. This shift is particularly pronounced among the younger generation, especially Generation Z, which has grown up in a digital environment and is exposed to a wide range of environmental information.

Social responsibility—which includes emotional engagement, personal involvement, and societal expectations—along with external stimuli such as material or social rewards, significantly shapes Generation Z's interest in sustainability. This interest is subsequently reflected in specific behaviors, particularly in the purchase of eco-friendly products. In contrast, cultural factors such as collectivist values, according to research by Carla (2024), do not have a significant impact, similarly to learned helplessness or perceived barriers.

Green marketing plays a crucial role in shaping Generation Z's consumer behavior. Dragolea et al. (2023) emphasize that key factors in converting environmental intentions into actual purchases are sustainability knowledge and positive attitudes toward ecological products. However, financial constraints remain a major barrier that marketing strategies must effectively address to strengthen the environmental awareness of young consumers.

According to Song and Qin (2020), green marketing is most effective when it is authentic and transparent, thereby increasing consumer trust and engagement. Social media and influencers play an important role in spreading ecological values and significantly influencing Generation Z's decision-making.¹

Similarly, El-Shihy and Awaad (2025) point out that both brand-generated content (BGC) and user-generated content (UGC) on platforms such as Instagram and TikTok increase interest in sustainable fashion, with audience engagement playing a

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mediating role in campaign effectiveness. Influencer marketing thus represents a key tool in shaping sustainable purchasing behavior among young people.

Generation Z is particularly receptive to influencer communication, especially when influencers appear authentic, trustworthy, and focus on environmental topics. Emotional appeal further enhances their engagement and encourages a positive shift in attitudes. Influencers convey ecological values in a way that enables young people to identify with the brand and prefer sustainable products (Munaro, 2024).

Personality traits and knowledge-related characteristics of young consumers are also essential. Research by Vishnoi et al. (2025) shows that environmental knowledge, altruistic attitudes, and perceptions of innovativeness significantly influence Generation Z's interest in ecological products. Similarly, László and Wahlen (2024) emphasize that in evaluating local food, consumers value freshness, quality, health safety, and credibility. "Local" does not only refer to geographical proximity but also to social ties and transparency.

Cyfert et al. (2024) highlight the importance of environmental competencies, where a higher level of knowledge and skills related to sustainable development correlates with more positive attitudes toward eco-friendly behavior. The sources of this knowledge include schools, media, and civic initiatives, which significantly influence how young people adopt and apply sustainability principles in their daily decisions.

Liu (2022) points out that environmental awareness, combined with effective CSR communication through social media, helps close the gap between ecological attitudes and actual behavior. Social networks are therefore an essential tool for spreading clear and trustworthy information that increases consumer engagement and interest.

Finally, according to Song Y. et al. (2024), price is not the main barrier to sustainable consumption—young people are willing to invest in high-quality and environmentally beneficial products. However, education, transparent communication, and brand credibility are key factors that strongly influence their purchasing decisions. Green marketing is particularly effective for Generation Z due to its authentic and transparent messaging. Social media and digital platforms play a crucial role in spreading ecological values and supporting environmentally responsible purchases. A combination of education and emotional engagement helps translate interest in sustainability into concrete purchasing decisions (Eandhizhai P.G. et al., 2025).

Aldaihani et al. (2024) emphasize that eco-friendly packaging is the only green marketing element that has a direct impact on Generation Z's purchase intentions. Other marketing tools, such as green advertising and labeling, act more indirectly through attitude change. The effectiveness of these strategies is significantly enhanced by modern technologies, particularly generative artificial intelligence. The combination of traditional marketing elements with technological innovations is a key factor in promoting sustainable consumption among the younger generation.

2 Methodics

This paper explores the impact of marketing strategies on the sustainable purchasing behavior of the young generation, emphasizing generational and communication aspects. The research investigates how modern marketing communication tools and digital platforms influence the attitudes and decisions of young consumers toward sustainable consumption. By analyzing both rational and emotional factors that shape purchasing behavior, the study aims to identify ways in which businesses can effectively design marketing activities that promote sustainability while engaging young consumers. The findings of this study may serve as a foundation for developing strategies that integrate social responsibility with engagement and the effectiveness of marketing campaigns in the digital environment.

Research assumptions

For the processing and evaluation of data obtained from the questionnaire survey, specific research assumptions were formulated and subsequently evaluated.

Data Collection and Respondent Characteristics

Primary data were collected through a questionnaire survey created using Google Forms, which was distributed via social media platforms (primarily Facebook and Instagram) to effectively reach the young generation. The research sample consisted of 300 respondents, with an equal gender distribution of 50% female and 50% male.

The questionnaire method was employed as the main data collection tool to assess the impact of marketing strategies on sustainable purchasing behavior. The survey sample of 300 respondents was considered relevant and sufficient for this study. Data collection took place between November 1, 2024, and January 15, 2025. Respondents were contacted electronically and informed about the voluntary and anonymized nature of the research. The questionnaire included items

aimed at assessing respondents' awareness of sustainability, their attitudes toward marketing communications promoting sustainable products, and the influence of these campaigns on their actual purchasing behavior.

Data Processing and Statistical Analysis

The data obtained from the questionnaire survey were processed, organized into tables and graphs, and subsequently interpreted. The first step involved verifying the representativeness of the sample, including gender distribution, using appropriate statistical methods.

To determine potential relationships between variables, the Chi-square test of independence was applied at a significance level of $\alpha = 0.05$. The test statistic was calculated using the following formula:

$$\chi^2 = \sum_{i=1}^k \frac{(E_i - T_i)^2}{T_i} \quad (1)$$

Where:

- χ^2 – test statistic
- E_i – observed frequencies
- T_i – expected frequencies

In Microsoft Excel, the CHINV function was used to determine the critical value at $\alpha = 0.05$. If the calculated test statistic exceeded the critical value, the null hypothesis was rejected; otherwise, it was accepted.

Additionally, the Friedman test was employed as a nonparametric method suitable for comparing several dependent samples. It serves as a nonparametric alternative to two-way analysis of variance (ANOVA). The test statistic was calculated as follows:

$$F = \left(\frac{12}{n \cdot k \cdot (k + 1)} \right) \cdot \sum_{j=1}^k R_j^2 - 3 \cdot n \cdot (k + 1) \quad (2)$$

Where:

- n – sample size
- k – number of variants
- R_j – sum of ranks within each column

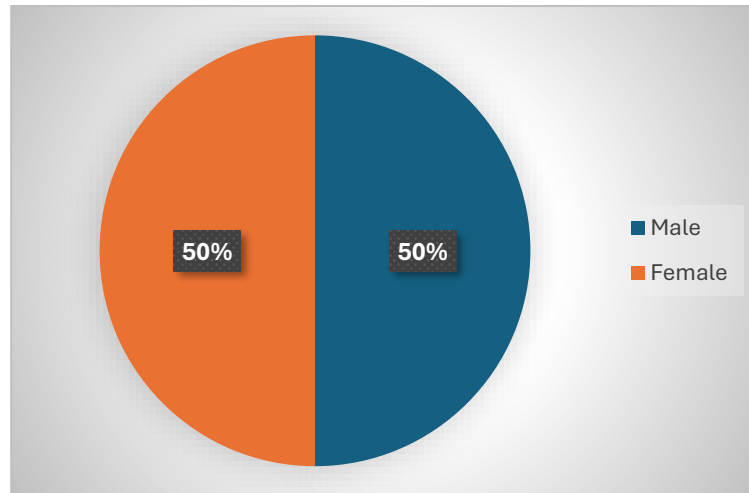
The null hypothesis H_0 was rejected if $F \geq \chi^2(\alpha, k - 1)$.

To further identify statistically significant differences between groups, Nemenyi's post-hoc test was applied as a complement to the Friedman test. This allowed for a detailed evaluation of relationships between variables and provided deeper insights into the impact of marketing strategies on the sustainable purchasing behavior of the young generation.

3 Research results

In today's rapidly evolving market environment, understanding how marketing strategies influence the sustainable purchasing behaviour of the young generation has become increasingly important. Young consumers represent a key segment whose values, digital engagement, and social awareness shape the future of sustainable consumption.

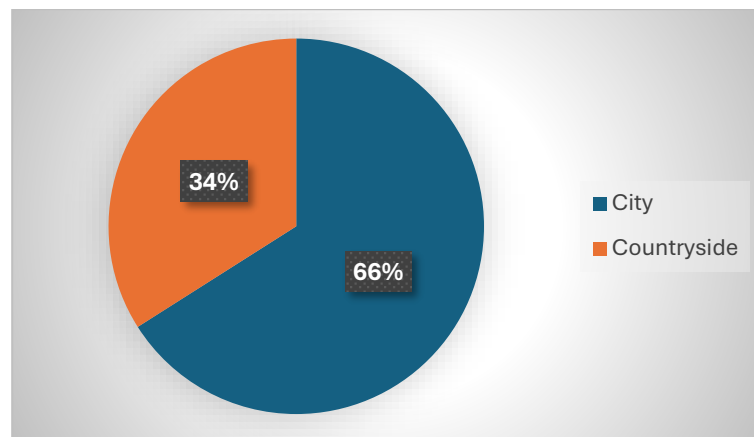
Figure 1 Gender of respondents



Source : own processing

The research sample consisted of an equal number of male and female respondents, with 150 males (50%) and 150 females (50%) participating in the survey. This balanced gender distribution ensures representativeness and eliminates potential bias related to gender differences in attitudes or purchasing behavior. Such equality in the sample composition allows for a more objective comparison of responses and supports the validity of subsequent statistical analyses.

Figure 2 Where do the respondents come from?



Source : own processing

Regarding the place of residence, the majority of respondents reported living in the city (198 respondents; 66%), while 102 respondents (34%) indicated that they live in the countryside. This distribution suggests that the research sample is more urban-oriented, which may reflect the lifestyle and consumption patterns typical of younger city residents. Urban respondents are often more exposed to digital marketing and have greater access to healthy and sustainable products compared to those living in rural areas. Consequently, their purchasing behavior may be more strongly influenced by online communication and marketing strategies.

In response to the question “*What does a healthy diet mean to you?*”, the most frequently mentioned answers were as follows:

Respondents most commonly associate the concept of a healthy diet with the consumption of fresh and natural foods, particularly fruits and vegetables, which are important sources of biologically active compounds such as vitamins, minerals, antioxidants, and dietary fiber.²

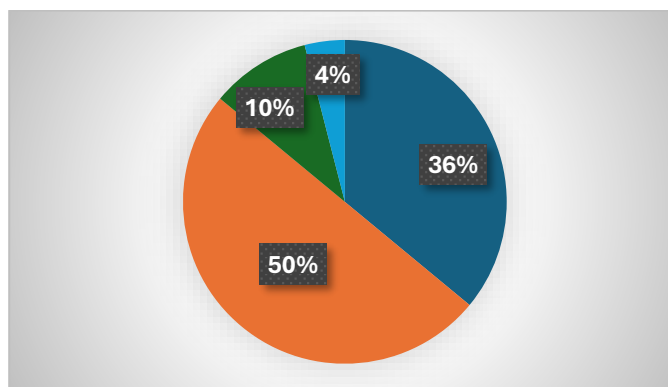
³ Data collected through the questionnaire applied to prepare this text.

They also emphasize the importance of a nutritionally balanced diet that ensures an adequate ratio of macronutrients (proteins, fats, and carbohydrates) as well as a sufficient intake of micronutrients.

Furthermore, respondents define a healthy diet as one free from artificial additives, preservatives, and chemical substances, reflecting a preference for minimally processed foods.

Some participants also perceive a healthy diet as one that involves the reduction of risk nutrients, particularly fats, sugars, and salt, while others associate it with a plant-based approach to eating, including vegetarian or vegan options.

Figure 3 What does a healthy diet mean to respondents?



Source: Own construction

The respondents in the survey defined the concept of healthy foods through several key characteristics that were repeatedly mentioned across different answers. Their opinions can be categorized into several thematic areas, with certain motives dominating from a quantitative perspective.

The largest group of respondents (150 individuals) perceive healthy foods as those with a higher content of proteins, fiber, vitamins, and minerals, while also emphasizing the importance of a balanced diet and the absence of artificial additives and chemicals. This perspective indicates an awareness of the nutritional value of foods and a preference for natural, minimally processed ingredients.

Another 108 respondents associate healthy foods primarily with fresh fruits and vegetables, highlighting their focus on the natural origin and freshness of food, as well as the perception of plant-based products as the foundation of a healthy lifestyle. Within this group, the emphasis on dietary balance and the absence of artificial substances was also common, confirming a trend toward natural and clean nutrition.

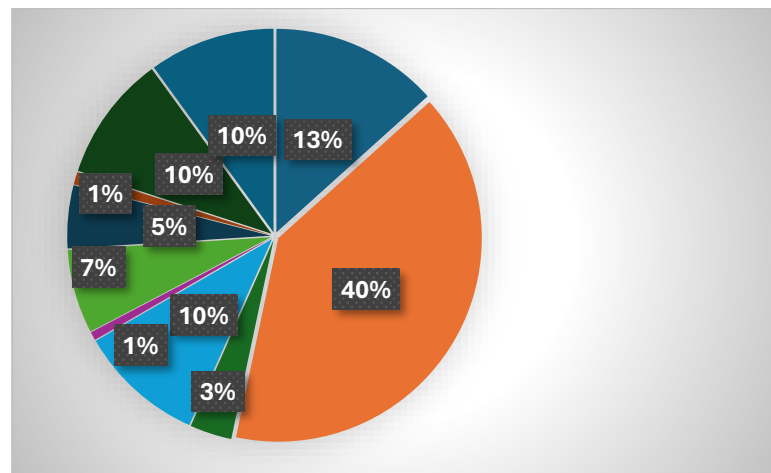
A smaller group of respondents (30 individuals) defined healthy foods as those with a lower content of fats, sugars, or salt. This group also emphasized the consumption of fresh fruits and vegetables and the importance of a balanced nutrient composition. Such a viewpoint suggests a focus on the prevention of lifestyle diseases, such as obesity, cardiovascular diseases, or diabetes mellitus.

The smallest group (12 respondents) associates healthy foods with specific dietary patterns, such as vegetarian and vegan products, considering them part of a balanced and ethically sustainable diet. This opinion reflects the growing interest in plant-based eating and related environmental and ethical aspects of nutrition.

Overall, it can be concluded that the majority of respondents consider healthy foods to be those that are natural, fresh, nutritionally valuable, and free from artificial additives. The emphasis on balance, ingredient quality, and nutritional composition confirms that consumers approach healthy eating in a comprehensive way – not only in terms of calories or macronutrients, but also regarding its overall impact on health and lifestyle.

For our study, we decided to focus on the question of which marketing elements most influence the young generation when making purchasing decisions regarding sustainable food products. We chose this focus because young consumers represent a growing segment that is sensitive to the environmental and ethical aspects of products, and at the same time, they are very active on social media, where they encounter various forms of marketing communication. By analyzing the preferences for different marketing tools, we aimed to determine which strategies are most persuasive for them and how they influence their purchasing decisions, which is crucial for the effective planning of marketing campaigns targeting sustainable products.

Figure 4 What marketing elements influence you the most when deciding to buy sustainable food?



Source: own construction

The collected data indicate that influencers have the greatest impact on the young generation's decision-making when purchasing sustainable food products, receiving 120 votes. This result suggests that young consumers trust the recommendations of people they follow on social media more than traditional marketing tools. In second place were social media ads, with 40 votes. This result suggests that young consumers trust the recommendations of people they follow on social media more than traditional marketing tools. In second place were social media ads, with 40 votes, which confirms that the online presence of a product is important for young consumers, although advertising alone is not as persuasive as influencers. Factors such as eco-friendly packaging (30 votes), product tastings (30 votes), and traditional advertising (30 votes) play a moderate role. This indicates that young consumers value the visual presentation of sustainability and the opportunity to try the product, while traditional advertising still contributes to brand awareness, even though it is not a decisive factor. On the other hand, elements such as certifications (20 votes), special offers (15 votes), and product branding (10 votes) have a smaller influence. The young generation therefore does not primarily purchase sustainable products based on brand logos, certifications, or discounts, but rather focuses on recommendations and actual experience with the product. An interesting finding is the very low number of votes for storytelling (3 votes) and product or packaging design (2 votes). Although the literature often emphasizes the importance of storytelling in sustainable products, these data show that young consumers prefer the concrete value of the product and authentic communication over abstract brand narratives or aesthetic design. Overall, these results support the assumption that when developing marketing strategies aimed at the young generation, it is crucial to utilize influencer marketing and maintain an³ active social media presence, while traditional forms of communication and aesthetic elements play only a supplementary role.

Assumption1: It is assumed that there are statistically significant differences among the factors that discourage young consumers from purchasing healthy products. To verify this assumption, we applied the Friedman test, which is suitable for comparing several related samples based on ordinal data.

⁴Data collected through the questionnaire applied to prepare this text.

Table 1 Friedman test

Q	404,259
p-value (one-tailed)	<0,0001
alpha	0,05

Source: Own processing

The results of the Friedman test ($p < 0,0001$) confirmed that there are statistically significant differences among the factors that discourage young consumers from purchasing healthy products. This indicates that not all barriers are perceived equally and that some factors play a much stronger role in shaping sustainable purchasing behaviour than others. Consequently, a non-parametric post-hoc comparison using Nemenyi's procedure was conducted to determine which factors differed significantly from one another. After confirming the overall significance with Friedman's test, a detailed pairwise comparison was carried out using Nemenyi's method to determine which factors differed significantly.

Table 2 Nemenyi's method

Sample	Frequency	Sum of ranks	Mean of ranks	Groups			
Family traditions	300	1219,500	4,065	A			
Lack of time	300	1274,000	4,247	A			
Lack of interest	300	1321,500	4,405	A			
Lack of information	300	1565,000	5,217		B		
Eating Habits	300	1705,500	5,685		B	C	
Taste	300	1755,000	5,850		B	C	
Less availability	300	1758,500	5,862		B	C	
Quality	300	1821,000	6,070			C	
Durability	300	1858,500	6,195			C	
Higher price	300	2221,500	7,405				D

Source: own processing

The Nemenyi test divided the examined factors into four statistically distinct groups (A–D) according to their mean ranks and relative importance perceived by respondents.

- **Group D** – “Higher price” was identified as the most significant barrier, showing the highest mean rank (7.405). This confirms that price sensitivity remains a crucial factor discouraging the young generation from choosing healthy or sustainable products, despite their environmental and social awareness.
- **Groups B and C**, including factors such as availability, taste, quality, and durability, represent moderately important barriers. These aspects indicate that while young consumers appreciate the benefits of healthy products, they may still encounter practical limitations (e.g., limited accessibility or perceived lower convenience).
- **Group A**, comprising family traditions, lack of interest, and lack of time, showed the lowest mean ranks, meaning these factors are least discouraging. This suggests that external cultural or time-related barriers play a smaller role in influencing purchasing decisions among younger consumers.

Overall, the findings confirm that economic considerations outweigh social or personal factors when it comes to purchasing healthy and sustainable products. This insight can be valuable for marketers and policymakers in

designing communication and pricing strategies that make sustainable choices more affordable and appealing to younger generations.

Assumption2: Marketing stimuli and activities have a statistically significant influence on consumer decision-making when choosing healthy and sustainable food products. To verify this assumption, we applied the Friedman test, which is suitable for comparing several related samples based on ordinal data.

Table 3: Friedman's test

Q	245,788
p-value (one-tailed)	<0,0001
alpha	0,05

Source: Own construction

Since the p-value (< 0.0001) is lower than the significance level $\alpha = 0.05$, we reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1). This means that the test results demonstrate a statistically significant influence of marketing stimuli and activities on consumer decision-making when choosing healthy and sustainable food products.

The findings suggest that marketing tools—such as product labeling, the origin of food, eco-certifications, social media advertising, and promotional campaigns—significantly influence consumer behavior. Consumers, therefore, perceive marketing communication as an important factor in their decision-making process when purchasing healthy and sustainable products.

Based on these results, it can be recommended that companies and farms focus more on targeted, trustworthy, and transparent communication that emphasizes the quality, origin, and sustainability of their products.

To further examine the differences between individual marketing stimuli influencing consumer decisions when purchasing healthy and sustainable food products, a Nemenyi post-hoc test was conducted following the Kruskal–Wallis analysis. This non-parametric multiple comparison method allows for the identification of which specific pairs of factors differ significantly in their mean ranks.

The results presented in Table 4 show the ranking of marketing activities based on their impact on consumer behavior. Each activity was assigned to one or more homogeneous groups (A–E), where activities within the same group do not differ significantly from each other, while those in different groups demonstrate statistically significant differences.

Table 4: Nemenyi's method

Sample	Frequency	Sum of ranks	Mean of ranks	Groups				
Social media Ads	300	1386,500	4,622	A				
Influencers	300	1434,000	4,780	A	B			
Product Branding	300	1438,000	4,793	A	B			
Eco-Friendly Packaging	300	1575,500	5,252	A	B	C		
Product and/or Packaging Design	300	1607,500	5,358	A	B	C	D	
Certificates (e.g. organic, fair trade)	300	1669,500	5,565		B	C	D	
Special Offers	300	1676,500	5,588			C	D	
Storytelling	300	1682,500	5,608			C	D	
Product Tastings	300	1815,500	6,052				D	
Advertising	300	2214,500	7,382					E

Source: Own construction

Based on the results of the Nemenyi post-hoc test, statistically significant differences were observed among the examined marketing stimuli in terms of their influence on consumer decision-making when choosing healthy and sustainable foods.

The lowest mean ranks were recorded for social media advertisements and influencers, indicating that these forms of marketing have a weaker impact on consumer decisions compared to other stimuli. Conversely, product tastings and traditional advertising achieved the highest mean ranks, suggesting a stronger influence on consumers.

The grouping (A–E) according to the Nemenyi test shows that some marketing activities do not differ significantly from each other (e.g., influencers and product branding – both in groups A/B), while others (e.g., social media ads – group A vs. advertising – group E) show statistically significant differences.

These findings indicate that consumers tend to respond more positively to direct product experiences (such as tastings) and traditional, credibility-based communication forms (advertising, certificates, design) rather than to digital or influencer-driven marketing stimuli.

4 Discussion

Gomes (2023) highlights that a major challenge in sustainable marketing lies in Generation Z's limited willingness to pay a premium for green products, despite their strong environmental values. The study reveals an evident attitude–behavior gap, where ethical awareness does not always translate into actual purchases. To address this, companies should create value-oriented marketing strategies that emphasize not only sustainability but also quality, transparency, and authenticity, helping justify higher prices and build consumer trust.

Kim (2025) explores how influencer characteristics affect Generation Z's engagement in pro-environmental behavior. The study shows that authenticity and self-disclosure—when influencers share personal values and experiences—significantly enhance followers' trust and motivation to act sustainably. Influencers who are perceived as genuine and value-driven, rather than purely promotional, are more effective in shaping eco-friendly attitudes and purchase intentions. These findings underline the importance of transparent and emotionally resonant communication in digital marketing strategies targeting Generation Z.

Prasana et al (2024) states that, recent reviews and conceptual studies (2024–2025) provide a comprehensive overview of Gen Z consumer behavior, highlighting key characteristics such as digital identity, demand for authenticity, and preference for value-focused brands. These studies suggest that Gen Z does not respond well to traditional marketing tactics; instead, they prefer transparent, purposeful, and interactive communications. Incorporating this insight into marketing strategies can increase engagement, foster trust, and encourage sustainable purchasing decisions. Such findings provide a theoretical basis for designing campaigns that align brand values with the ethical and social expectations of this generation.

5 Conclusion

This paper highlights the significant influence of marketing strategies on the sustainable purchasing behavior of Generation Z, providing insights into the ways in which brands can effectively engage this environmentally and socially conscious demographic. Generation Z distinguishes itself through a strong awareness of environmental, social, and ethical issues, which heavily shape their consumption patterns. Unlike previous generations, for whom decisions were often guided primarily by price, quality, or brand recognition, Generation Z increasingly prioritizes products and services that reflect their personal values, ethical beliefs, and lifestyle preferences. Transparency, authenticity, and ethical communication therefore emerge as essential determinants of trust, loyalty, and positive brand perception.

The study further underscores the critical role of digital media and social networks as instruments for shaping environmental consciousness and sustainable behavior among young consumers. Platforms such as Instagram, TikTok, and YouTube serve not only as sources of entertainment but also as powerful channels for information dissemination, social influence, and behavioral motivation. Through carefully designed influencer collaborations, interactive storytelling, and engaging campaigns, companies can effectively educate and inspire Generation Z to adopt sustainable consumption practices. Integrating educational content with emotional appeals proves especially effective in establishing meaningful connections between consumers and brands, fostering long-term commitment to sustainability.

Importantly, the findings demonstrate that superficial or symbolic environmental claims, such as labeling a product merely as “eco-friendly” or “sustainable,” are insufficient to gain the attention and trust of this generation. Generation Z expects alignment between corporate values, marketing messages, and actual business practices. Therefore, effective marketing strategies must adopt a holistic approach that combines authentic storytelling, transparency in production and supply chain processes, corporate social responsibility initiatives, and active consumer participation. By implementing such a strategy, brands can enhance credibility, strengthen emotional engagement, and contribute to a more ethically aware and sustainable marketplace.

This paper also offers practical guidance for companies and marketing professionals seeking to design strategic and value-driven marketing approaches. Aligning commercial objectives with social and environmental responsibility enables organizations to not only drive sales but also build lasting trust and loyalty among young consumers. Moreover, the findings suggest that businesses have the potential to play a transformative role in shaping consumer attitudes and behaviors toward sustainability, thereby contributing to a broader societal shift toward responsible consumption.

In conclusion, the study provides a comprehensive understanding of the interplay between marketing, sustainability, and Generation Z consumer behavior. It emphasizes that effective marketing for this demographic is no longer solely transactional but must incorporate ethical and environmental considerations into the core brand narrative. By fostering transparency, authenticity, and engagement, brands can position themselves as credible, responsible, and forward-thinking, while simultaneously promoting a sustainable market transformation. These insights lay a foundation for future research in

sustainable marketing, digital communication strategies, and Generation Z consumer behavior, offering valuable implications for academics, marketers, and policymakers alike.

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South Korea – Australia Free Trade Agreement (KAFTA)

Iryna Taliian¹

Abstract: The world economy is a dynamic entity that is constantly changing. Part of these changes has been the process of internationalization, which reflects closer economic connections between individual countries. International ties are thus transforming from exclusively trade exchange to increasingly integrated components. This is a phenomenon that has a multidimensional level and is characterized by the growing complexity of trade exchange. Bilateral trade relations are one of the most widespread forms of cooperation, where integration leads to the harmonization of regulatory frameworks and the strengthening of strategic ties. The aim of the article is to describe the level of cooperation between Australia and South Korea. This research paper will attempt to examine the impact of the KAFTA trade agreement on selected sectors of the economy - meat and sugar, as strategic trade items.

Keywords: KAFTA, bilateral trade, export

JEL: F15

1 Introduction

Bilateral trade agreements are a key pillar of the countries' foreign policy, where the aim is to support economic growth and ensure sustainable progress. Australia and South Korea are allies who promote democratic values with common foreign policy interests. Their allocation in the Pacific has created momentum for mutual economic cooperation and trade liberalization. The Republic of Korea is Australia's fourth largest bilateral trading partner for 2023. Bilateral relations between Australia and South Korea have a long history but were strengthened by Australia's participation in the United Nations Commission on Korea in 1947. Diplomatic relations between the countries were established in 1961.

The South Korea-Australia Free Trade Agreement (hereinafter as the KAFTA) is a comprehensive bilateral trade agreement that aims to liberalize trade in goods and services between the countries. KAFTA entered into force on 12.12. 2014 and is one of three strategic free trade agreements signed by Australia with Asian partners as signatories, supporting and intensifying economic relations in the Asia-Pacific region. KAFTA has led to a significant increase in bilateral trade between the countries. Two-way trade between Australia and South Korea has more than doubled, from around \$33 billion US in 2013 to over \$71 billion US in 2023. The agricultural sector has played a significant role in this growth, with exports increasing from \$2.4 billion US to \$5.6 billion US over the same period.

KAFTA has established that more than 99% of Australian exports to South Korea are subject to preferential tariff treatment or are subject to duty-free treatment, which represents a significant step in trade liberalization. According to the Australian Government the Republic of Korea has committed to immediately eliminating tariffs on selected agricultural commodities, supporting the competitiveness of Australian producers in the Korean market and optimizing supply chains. The source further informs that a schedule for the gradual elimination of tariffs has been set for specific items that have previously been subject to higher tariffs.

2 Methods

The goal of this research paper is to describe the impact of the KAFTA free trade agreement on selected sectors of the South Korean economy. The research paper aims to identify and qualify selected sectoral changes between Australia and South Korea after the implementation of KAFTA, emphasizing exogenous and endogenous factors that influence cooperation in agriculture and energy resources, such as demographic changes in the country.

The methodology of the article is based on a combination of qualitative and quantitative approaches to analyze the impact of KAFTA. The quantitative part will include the analysis of statistical data on exports and imports from official

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sources, such as government statistics and international databases (e.g. UN Comtrade, Australian Bureau of Statistics, Statistics Korea). Using time series, the dynamics of changes in the volume and structure of trade flows before and after the entry into force of KAFTA will be monitored.

The qualitative part of the research will include a content analysis of relevant documents, official reports, and economic studies that address the implementation of the agreement and its macroeconomic impact. The methodology will use a comparative approach that will allow comparing the volume of trade flows in selected sectors between Australia and South Korea, which was influenced by the reduction of trade barriers in the optimization of customs procedures after the introduction of KAFTA.

3 Research results

The Australia-South Korea Free Trade Agreement has become an important instrument of economic integration and trade liberalization, which has promoted the reduction of tariff barriers and streamlined regulatory mechanisms between the two countries. In the area of customs procedures, the KAFTA agreement has laid down an institutional and legal framework for the harmonization and transparency of customs clearance procedures for goods, which serves as an impetus for stimulating and strengthening trade relations.

The KAFTA agreement obliges the customs authorities of Australia and South Korea to issue written advance rulings at the request of importers, exporters or manufacturers. These rulings are binding with respect to the application of customs procedures, including the classification of goods, determination of customs value, and confirmation of preferential origin under the KAFTA rules. The advance rulings mechanism enhances legal certainty by enabling economic actors to ascertain how their goods will be treated by customs authorities prior to importation, thereby increasing legal predictability, reducing business risks and facilitating more efficient import and export processes.

In addition, KAFTA is notable for incorporating a risk management dimension into its customs provisions. The agreement includes provisions to allocate resources primarily to high-risk consignments, while consignments assessed as low-risk are processed through simplified procedures. By way of comparison, Article 4 of the Dominican Republic–Central America Free Trade Agreement (hereinafter the "CAFTA-DR Agreement") also provides for the implementation of a risk management system based on the principle of proportionality, whereby administrative and technical capacities are concentrated on goods presenting higher levels of risk, while low-risk goods benefit from streamlined clearance procedures. This approach reflects one of the core recommendations of the World Customs Organization (hereinafter referred to as the "WCO"), aimed at enhancing the effectiveness of customs controls while avoiding disproportionate administrative burdens.

3.1 Impact on Sheep and Goatmeat

The bilateral trade agreement (KAFTA) has significantly contributed to bilateral trade liberalization between Australia and the South Korea, reducing tariffs on agricultural imports into South Korean market. Certain products, such as wine and wheat (excluding seed wheat), are subject to immediate tariff elimination. Other commodities, including beef, malting barley and unroasted malt, remain covered by agricultural safeguard measures. These measures may be invoked by South Korea if the volume of Australian imports increases at a rate that threatens to cause serious injury to its domestic industry.

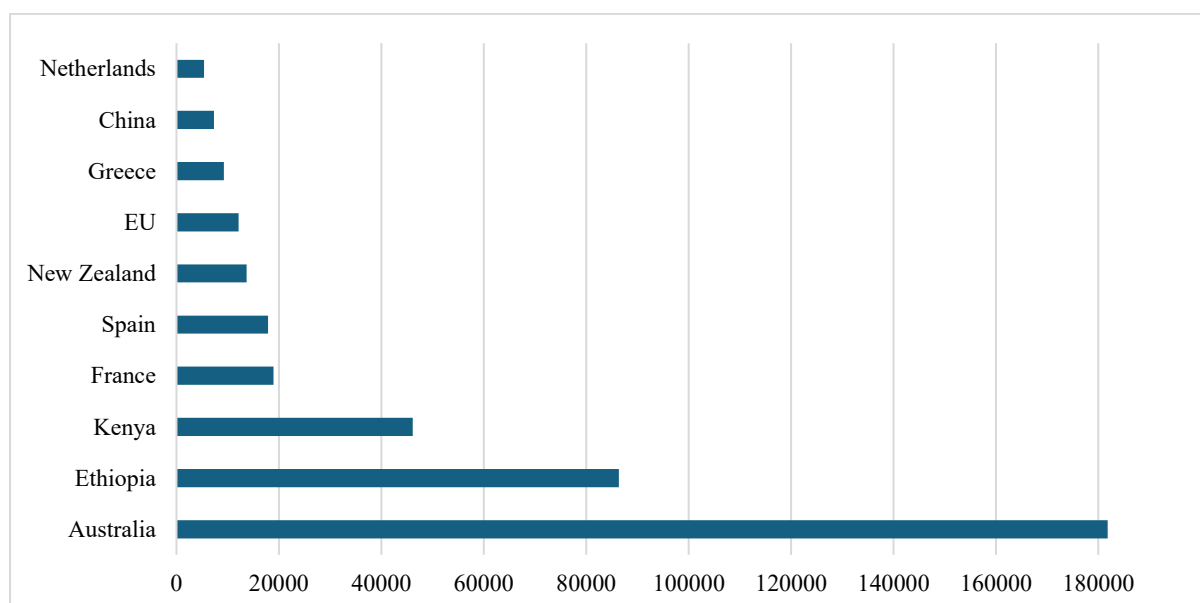
Given the limited scale of Korea's domestic lamb industry, constrained in part by geographical factors, domestic consumption is largely met through imports. This reliance on foreign supply has created opportunities for the expansion and deepening of economic relations with Australia. Beef represents Australia's largest agricultural export to South Korea, with trade valued at over 326 million USD in 2023. As shown in Table 1, exports have risen substantially since the entry into force of KAFTA, a trend closely aligned with the progressive removal of tariff barriers:

Table 1 Australia's meat exports to South Korea

YEARS	Sheep and goat meat exports to Korea	Import tariffs (beef)	Import tariffs (sheep meat)
2010	\$20,317,700 USD	2024 – 10.6%	2024 – 0.0%
2011	\$24,643,100 USD	2028 – 0% under KAFTA	
2012	\$21,697,700 USD		
2013	\$24,613,200 USD		
2014	\$44,726,500 USD		
2015	\$62,482,800 USD		
2016	\$85,280,800 USD		
2017	\$132,476,000 USD		
2018	\$161,545,000 USD		
2019	\$161,666,000 USD		
2020	\$179,018,000 USD		
2021	\$206,346,000 USD		
2022	\$360,805,000 USD		
2023	\$326,955,000 USD		

Source: Own processing

Although Australia is only a modest producer of goat meat (also called chevon), it remains the world's largest exporter, including to South of Korea. Production is predominantly based on semi-wild grazing systems, with limited output from commercial farms, although overall volumes have been expanding. The number of goats in semi-farmed farms is estimated to have increased by 82% between 2015–16 and 2020–21. Australian goat meat exports reached a peak value of 296.7 million Australian dollars in 2021–22. By value, the principal export destinations were the United States (69%), South Korea (13%), Canada (7%) and Taiwan (6%).

Chart 1 Major goat meat exporters by value in 2023, in USD (Fresh, chilled or frozen goat meat exports by country)

Source: Own processing

According to Global Goat Snapshot, the recent growth in goat meat imports into South Korea has been partly driven by the influx of Nepalese and Chinese migrant workers, for whom goat meat is a traditional dietary staple, as well as by rising prices for domestically raised black goats used in medicinal contexts. These factors have increased demand for more affordable imported products and encouraged new entrants into the import market. While goat meat is generally regarded as an important source of protein in South Korea, consumer preferences are often shaped by health-related considerations. Demand tends to peak during the Sambok (summer season), when goat meat is consumed as a substitute for other agri-food commodities.

South Korea provides a dynamic case study of how demographic transformations, urbanization and the evolving consumer behavior interact to reshape the food markets. The sharp increase in the number of one- or two-person households, an aging population and technological adaptation in the food service sector is generating new patterns of demand and transforming the market conditions. These developments have profound implications for bilateral trade relations, especially in the context of the KAFTA. As reported by Meat and Livestock Australia, shifts in the composition of the South Korean population are significantly influencing demand preferences. It is predicted that by 2027, up to 55% of households will consist of one or two people. This trend is driving demand for convenient, portion-controlled, and rapidly available products, such as Home Meal Replacement (hereinafter referred to as "HMR") items. Parallel to this, the uptake of online grocery shopping and delivery services is rising, with over 80% of the population already making use of such platforms. Australian goat meat has established a competitive advantage under KAFTA in online marketplaces such as Gmarket or Auction, demonstrating high market penetration. Some producers have further strengthened this position by tailoring product information to local tastes, highlighting flexibility, quality, and the capacity to adapt quickly to the cultural and gastronomic preferences of South Korean consumers.

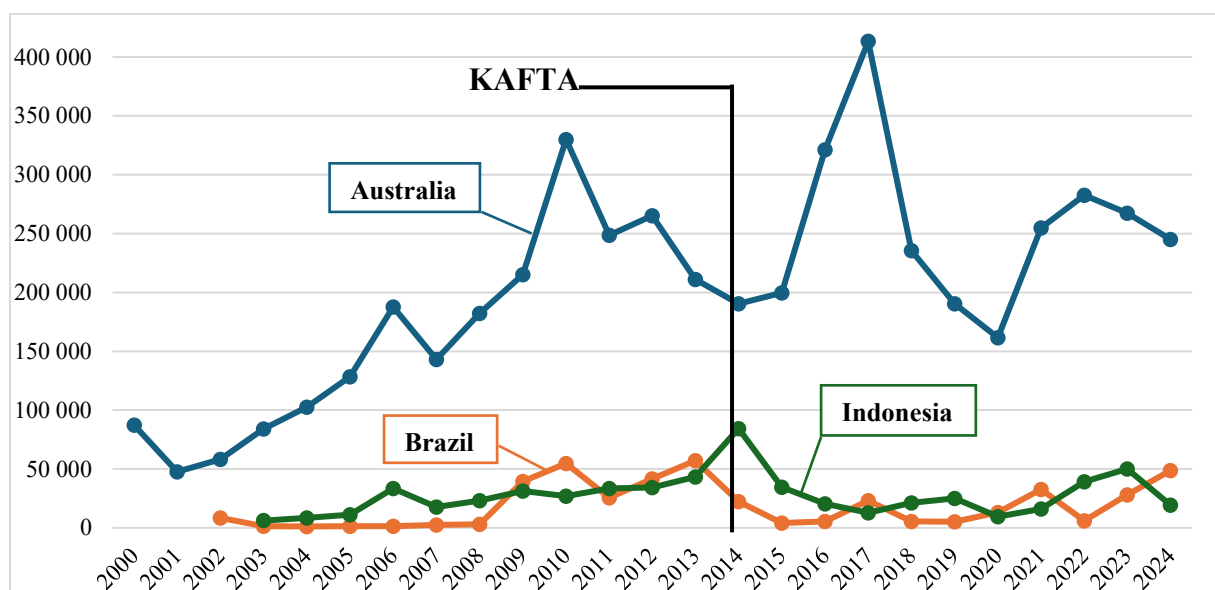
KAFTA represents a significant instrument for trade liberalization between the two countries, with Australian agricultural exports playing an integral role in the South Korean food system. Australia supplies up to 96% of imported sheepmeat and 99% of goatmeat in the South Korean market. This dominant position is underpinned by long-term consumer confidence in the quality, safety, and consistency of the supply of Australian products. Consumers declare that they perceive Australian meat as reliable and high-quality over several decades. Australia's presence in the Korean market is therefore both quantitative and qualitative. Its ability to meet a wide range of product requirements, from processed raw materials to luxury gastronomic specialties, confers an exceptional comparative advantage. Australian meat is successfully positioned across the spectrum, from cheaper minced meat to premium Wagyu.

3.2 Impact on agriculture. Sugar sector

Within the trade dynamics between Australia and South Korea, the sugar sector constitutes a central pillar of bilateral agri-food exports. According to 2020 data, South Korea has established itself as the dominant buyer of Australian sugar, absorbing more than 40% of the total export volume, worth an estimated \$1.2 billion USD. This reflects a broader regional pattern in which approximately 85% of Australia's annual raw sugar production (approximately 4-4.5 million tonnes) is exported to Asian markets, primarily Korea, Japan and Indonesia, where it is subsequently refined into white table sugar.

Rising demand for sugar growing at a rate of 1,8% to 2% per year, places constant pressure on producers to optimize production chains, diversify markets and implement environmental standards. Within this competitive landscape Australia faces strong competition from exporters such as Brazil, Thailand, India, Indonesia, Guatemala and Mexico. Despite these challenges, the Australian sugar sector gains a strategic advantage through the KAFTA Free Trade Agreement, which provides preferential access to the South Korean market with increased legal certainty and tariff concessions. The high quality of raw materials, the reliability of supply and the transparency of regulatory procedures create a competitive framework that is in line with the growing demands of South Korean importers.

Chart 2 Sugar Exports to South Korea from 2000 to 2024



Source: Own processing

Note: Sector: SITC 2: Sugar, sugar preparations and honey. In thousands of USD

The decline in sugar imports from Brazil (yellow line) and Indonesia (green line) in 2014 can be explained by the entry into force of the KAFTA agreement, which helped to remove trade barriers to imports into the South Korean market. The aim of the KAFTA agreement was to eliminate the tariff on raw sugar (3%) from the start of the agreement, as indicated by the significant increase in values on the graph and the decrease in imports from other partner countries, such as Brazil or Indonesia. In addition, the 35% tariff on refined sugar is to be gradually reduced from the start of the agreement and must be completely eliminated by 1.1. 2031.

Sugar, as a raw material plays a key role in the production of a wide range of processed foods and beverages, which are integral to the convenience food segment. This trend supports the constant need for a stable supply of high-quality raw sugar from reliable markets, with Australia fulfilling this role not only as a producer, but also as a partner guaranteeing commercial responsibility.

4 Future of KAFTA

The future of the bilateral trade agreement KAFTA appears to be positive and promising, with the potential to further consolidate trade and economic relations between the two countries. Nevertheless, persistent concerns remain that Australian meat exports to South Korea may face significant competitive pressure from the KORUS (i.e. United States-South Korea) trade agreement, which would lead to a reduction in consumer prices within the South Korean market.

Looking ahead, bilateral ties are likely to deepen, with growing attention directed towards expansion of cooperation in emerging sectors of the economy such as green hydrogen and carbon storage, in line with global efforts to achieve net-zero emissions by 2050. International cooperation on renewable energy projects, including interconnected grids and shared technologies, facilitates the creation of new electricity sources and accelerates the energy transition. This process enhances the energy security and lowers barriers to the adoption of green technologies, supported by promising partnerships among countries including Australia, South Korea, Japan and others. As a result, digitalization and the rapid development of new technologies are on the rise in global trade and the economy, with technology, e-commerce and IT services assuming increasing importance. Consequently, international trade agreements are being revised to incorporate provisions with a focus on digital trade, intellectual property and sustainable development, thereby laying the groundwork for expanding cooperation in technologically demanding areas. Therefore, it can be assumed that this cooperation has a solid foundation that could extend beyond traditional commodity trade towards strategic and technology-intensive industries in the future.

5 Conclusions

The bilateral trade agreement KAFTA, which entered into force in 2014, constitutes an important milestone in the economic relationship between Australia and South Korea. As an institutional framework, KAFTA has played a significant role in advancing trade liberalization between the two countries. The research paper seeks to examine its impact on selected sectors, thereby fulfilling its primary objective.

Empirical evidence demonstrates that Australia holds a dominant position in the South Korean market for selected commodities, particularly sugar and beef. The elimination of tariffs on sheepmeat and the gradual reduction of tariffs on beef have created favorable conditions for the dynamic expansion of bilateral trade in agricultural goods. At the same time, shifts in consumer preferences in South Korea, such as the growth of single-person households, increasing demand for HMR products and the digitalization of distribution channels have significantly reinforced this trend. The long-term complete elimination of tariffs by 2031 underlines the strategic importance of KAFTA for the long-term sustainability of trade relations. A comprehensive analysis thus indicates that KAFTA functions not only as a means of trade liberalization, but also as a driver of economic integration, energy security and adaptation to emerging socio-demographic challenges in the region.

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Subliminal Effects of Music in the Shopping Environment an Empirical Analysis of Consumer Preferences and Behavior

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Adrian Rajtár⁵

Abstract: Music is a significant component of the shopping environment that can affect consumer behavior on both conscious and subconscious levels. The objective of this study is to examine the correlation between musical stimuli and consumer experience in retail food stores. An online questionnaire survey from various age groups and locations in Slovakia forms the foundation of the research.

Two hypotheses were developed based on the existing data. The first looks at how the level of the music and how sensitive a person is to noise affect how likely they are to leave the business early. The second one looks at how the chosen and perceived tempo of music match up and how it affects how much fun shopping is and how annoyed people are. The investigation included regression models that accounted for sociodemographic characteristics, including generation, settlement size, and cultural practices. The anticipated outcomes suggest that consumers with heightened noise sensitivity are more inclined to exit a store when the music volume is excessive. It is also thought that when the preferred and actual tempo of the music are the same, it makes the shopping experience seem better and less irritating.

The study enhances comprehension of the effects of auditory stimulation in a retail context and facilitates practical recommendations in sensory marketing, while also addressing subliminality and consumer variability.

Keywords: music, consumer behavior, sensory marketing, sublimination, shopping experience

JEL Classification: M31, M39

1 Introduction

Music in retail environments fulfils a considerably broader function than merely masking silence. It subtly influences customer's emotional states, movements, and the amount of time they remain in the store. Previous research has shown that auditory stimuli can shape not only people's moods but also their perception of taste and space (Spence & Shankar, 2010). Consequently, music should not be perceived as a decorative or secondary element, but rather as a meaningful component that contributes to consumer experience and behavior.

Both tempo and loudness have been found to significantly affect how customers behave while shopping. Slower music tends to make people move at a calmer pace and spend more time exploring products, whereas faster rhythms can increase the likelihood of impulsive decisions and quicker movements (Eroglu, Machleit, & Chebat, 2005; Verlegh, Krywuczky, & Kocaman, 2025; Sun, Chang, & Xu, 2023). In this sense, music can be used strategically to encourage different shopping patterns depending on the retailer's goals. Gentle, low-volume background music has even been associated with higher sales of healthier food options (Biswas, Lund, & Szócs, 2019). However, the musical style must align with the brand identity of the store, since an unsuitable match may produce discomfort or confusion among customers (Oakes & North, 2008).

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When music complements the brand image, consumers typically evaluate the environment more positively, which appears to be especially important in the fashion industry (Barmpageorgopoulou, 2023).

Nevertheless, auditory elements rarely work in isolation. Their effects become stronger when they are combined with other sensory cues, such as lighting or scent (Soars, 2009; Helme Falk, 2019; Butawski, 2024). Emotional responses also intensify when several senses are stimulated simultaneously (Viegas, 2022). The tonal characteristics of sound play a part as well: lower tones are often perceived as calming, whereas higher tones tend to increase alertness (Sekeroglu, 2025). Many of these effects occur without conscious awareness, meaning that people are often unable to explain why they feel a certain way (Peck & Childers, 2008; Kulkarni & Kolli, 2022). Still, background music quietly shapes the emotional experience of consumers. Adapting music to different times of the day or to specific customer segments can further enhance this connection (Lorre, 2017). Moreover, even in online shopping environments, background sounds have been shown to influence browsing behavior (Lehr, 2023).

Comparable effects can be observed beyond traditional retail settings. Music has been found to improve mood even during small, everyday shopping situations (Hedström, Höggqvist, & Piri, 2015). In service contexts, such as beauty salons, background music can enhance satisfaction and loyalty among clients (Fu, 2025). The most favorable outcomes generally occur when auditory, olfactory, and visual cues are harmonized (Lindblom, 2023). A pleasant sensory environment may also increase the likelihood of impulse purchases (Reza, 2025). On a broader level, thoughtfully designed soundscapes have the potential to reduce stress in crowded public spaces (Cui et al., 2025) and to influence how people perceive cities and public environments more generally (Vicente-Salar, Traveria, & Bueno, 2025).

2Methods

The research was conducted in the form of a quantitative questionnaire survey, the aim of which was to determine customer preferences regarding music volume and noise sensitivity, as well as music tempo during grocery shopping. The aim was to identify the dependencies between musical stimuli and consumer experience in grocery retail stores. The research was based on an online questionnaire survey of respondents of different age groups and locations in the Slovak Republic.

This study used a quantitative online survey conducted on a sample of $N = 2501$ participants (1235 men, which is 49% and 1266 women, which is 51%) from Slovakia. The research was conducted in eight regions: Bratislava, Trnava, Nitra, Trenčín, Banská Bystrica, Žilina, Prešov and Košice in various retail food stores. Data collection took place in January 2025 through the market research agency MN Force s. r. o.

The first investigated variable was the level of perceived sensitivity to loud music, and the second variable was music tempo. Two hypotheses were created from the existing data:

H1a: Higher music volume and increased noise sensitivity increase the likelihood that a consumer will leave the store early.

H1b: Customers who are more bothered by music in the store are more likely to leave the store earlier.

H2: A match between the preferred and perceived tempo of music increases the subjective experience of shopping pleasure and reduces the perception of music as a distraction.

The research included regression models that took into account sociodemographic characteristics including generation, size of residence, and cultural practices.

The following methods were used to analyze the data:

- Kruskal-Wallis test is a non-parametric test based on the order of values – applied to compare responses between several independent groups (noise sensitivity levels, music loudness perception and music interference level during shopping). The test allows to determine whether there is a statistically significant difference between the medians of the groups in the case of non-parametric data. And it was used in testing all three hypotheses.

- T-test with constant was used to compare the mean value of the respondents' responses regarding music loudness perception, noise sensitivity level and music interference level with a reference value of 20%. This test allows to verify whether the mean values of these variables differ statistically significantly from the established reference level and therefore contributed to the verification of hypotheses H1a and H1b.

The graphs and visualizations presented in this article were generated using the RStudio program (version 2023.09.1). All tests were performed with a 95% confidence level ($\alpha = 0.05$) using Microsoft Excel, XLSTAT (v2023.3.0) and the ChatGPT-4o language model for validation and interpretation of results.

The study was guided by the Code of Ethics of the Laboratory of Consumer Studies, FEM SPU in Nitra (2023). The authors' share in the preparation of the questionnaire and the implementation of the survey was as follows: Peter Vaško – 40%; Jakub Berčík – 20%; Patrik Jurčíšin – 15%; Tomáš Krahulec – 10%; Adrián Rajtár – 15%.

3 Research results

Hypothesis H1a was aimed at verifying whether increased music volume in a store and different customer sensitivity to noise affect the probability that a customer will leave the store early. Analysis of the percentage data presented in Table 1 and the graphical representation in Graph 1 shows a clear trend: the more sensitive the customer is to noise, the higher the probability that the music bothers him so much that he considers leaving early.

The highest proportion of respondents who stated that they would leave the store due to disturbing music is found in the “rather sensitive” group (9.00%), followed by the “very sensitive” group (6.96%). These two groups also show the highest values of subjective discomfort caused by music. In the group of respondents with low noise sensitivity (“not very sensitive”), the proportion of customers who would leave early is significantly lower (5.72%). The lowest values were recorded for customers who declared that they were not at all sensitive to noise (3.32%).

These values show that there is a clear connection between noise sensitivity and the tendency to leave the store due to loud or distracting music. As noise sensitivity increases, the proportion of customers who are bothered by music so much that they would leave the store also increases.

This relationship is also confirmed by the results of the Kruskal–Wallis test, which showed statistically significant differences between the groups studied ($H = 65.278$; $p < 0.05$). This means that noise sensitivity significantly influences customers' reactions to music volume and has a direct impact on their decision to stay in the store or leave it sooner.

Based on the analysis, it can therefore be stated that hypothesis H1a was confirmed. The findings clearly show that increased music volume can cause early departure, especially among customers with higher noise sensitivity.

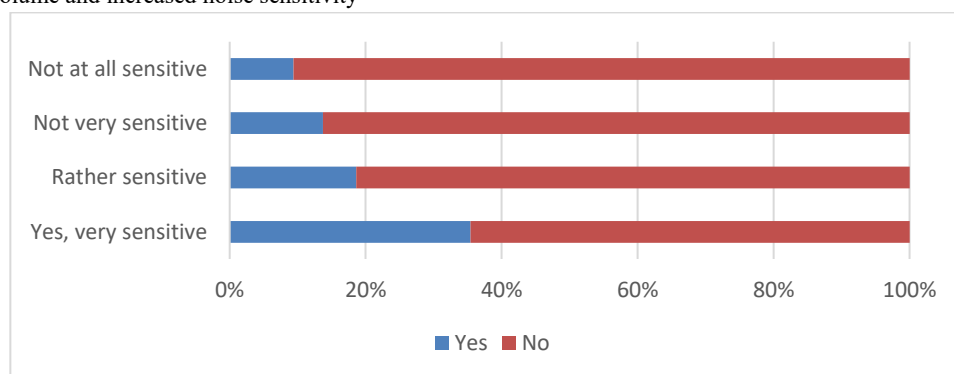
Table 1 Music volume and increased noise sensitivity

	Yes in %	No in %
Yes, very sensitive	6,96	10,67
Rather sensitive	9,00	31,15
Not very sensitive	5,72	23,03
Not at all sensitive	3,32	10,15

Source: Authors

The percentage representation is graphically shown in Figure 1.

Chart 1 Music volume and increased noise sensitivity



Source: Authors

Hypothesis H1b assumed that customers who are bothered by music in a store are more likely to leave the store earlier. Analysis of the data in Table 2 and the graphic representation in Graph 2 confirms that the level of music annoyance significantly affects customer behavior during shopping.

The highest proportion of “yes” answers, i.e. situations in which a customer would leave the store due to distracting music, is found in the groups of respondents who stated that music bothers them “always” (4.24%) or “very often” (5.08%). These groups also show the highest level of negative perception of music and are most prone to leaving early. A similar trend can be observed in the group that stated that music bothers them “often”, where 4.92% of respondents declared that they would leave the store earlier.

Conversely, as the level of distracting music decreases, the probability of leaving also decreases. In the group where music is only “sometimes” a distraction, 7.28% of respondents stated that they would leave early, but the dominant part of this group answered negatively (27.18%). The lowest tendency to leave was confirmed among customers who are “not bothered at all” by music, of whom only 3.56% stated that they would leave early, while as many as 31.02% declared that they did not perceive music as a distracting factor.

The statistical significance of these differences is confirmed by the Kruskal–Wallis test ($H = 303.21$; $p < 0.05$), which showed that there are statistically significant differences in the tendency to end the purchase early between groups of customers with different degrees of music distraction. This result shows that music distraction plays a significant role in the decision to stay in the store.

Based on the analyzed data, it can be stated that hypothesis H1b was confirmed. Customers who are often or always disturbed by music in the store are clearly more likely to leave the store early, while customers who do not perceive music as a distraction show a significantly lower probability of leaving early. These findings emphasize the importance of appropriate music selection in the retail environment and its impact on customer shopping behavior.

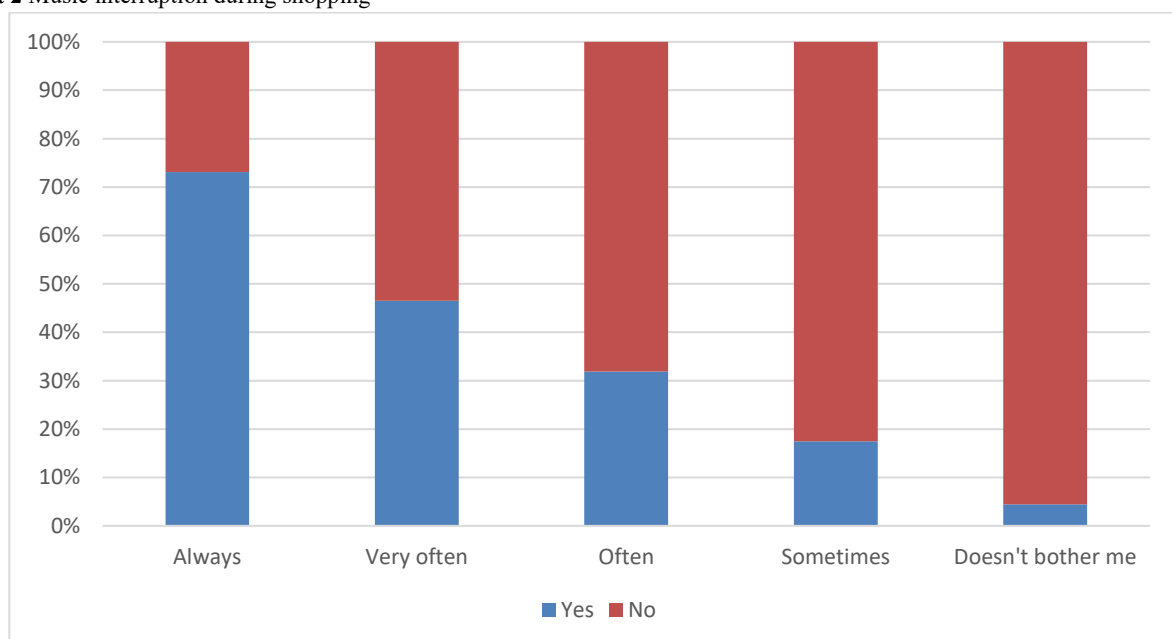
Table 2 Music Interference During Shopping

	Yes in %	No in %
Always	4,24	2,80
Very often	5,08	5,60
Often	4,92	8,32
Sometimes	7,28	27,18
Doesn't bother me	3,56	31,02

Source: Authors

The percentage representation is graphically shown in Chart 2.

Chart 2 Music interruption during shopping



Source: Authors

Hypothesis H2 assumed that the match between the preferred and perceived tempo of music increases the subjective experience of shopping pleasure and at the same time reduces the perception of music as a distracting element. Analysis of the data from Table 3 and the graphical representation in Graph 3 confirms that the tempo of music plays a significant role in how customers evaluate their shopping experience.

The most significant positive effect on shopping pleasure was recorded among respondents who prefer a faster, more energetic tempo of music. In this group, as many as 5.32% of respondents stated that music “always” makes their shopping more pleasant, and 7.60% stated that it makes their shopping more pleasant “sometimes”. These are the highest values among all tempo categories examined. These results indicate that the faster tempo of music is most in line with their preferences for this group of customers, which is reflected in the positive assessment of the shopping atmosphere.

Similarly, in the group of respondents who prefer a slower, calmer pace, there are also positive responses (8.29% “yes, always” and 22.91% “yes, sometimes”), but these values are scattered across different levels of satisfaction. The group with a neutral attitude towards the pace (“I don’t care”) shows a medium level of satisfaction, with 6.53% stating that music always makes shopping more enjoyable, and 20.55% stating that it sometimes makes shopping more enjoyable. This suggests that for this group, the pace does not play a key role, and the subjective experience is therefore more stable and less variable.

Lower values of the positive impact of music can be observed among respondents who prefer shopping without music. In this category, only 0.12% stated that music always makes shopping more enjoyable, and 1.95% that it sometimes makes it more enjoyable. Most respondents in this group perceived music neutrally or negatively, which confirms that for these customers music is more of a distracting element.

The results of the Kruskal–Wallis test ($H = 430.95$; $p < 0.05$) showed statistically significant differences between the studied groups, which confirms that the tempo of music affects the subjective experience of the shopping atmosphere. Customers are sensitive not only to the volume or genre of music, but also to its tempo, which significantly affects their emotional reaction to the store environment.

Based on these findings, it can be stated that hypothesis H2 was confirmed. The match between the preferred and perceived tempo of music increases the subjective experience of shopping pleasure, while the mismatch between the customer's preference and the tempo of music can lead to a neutral or less positive shopping experience. These results point to the importance of targeted musical stimulation in retail environments, which can be an effective tool for improving customer satisfaction and their overall shopping atmosphere.

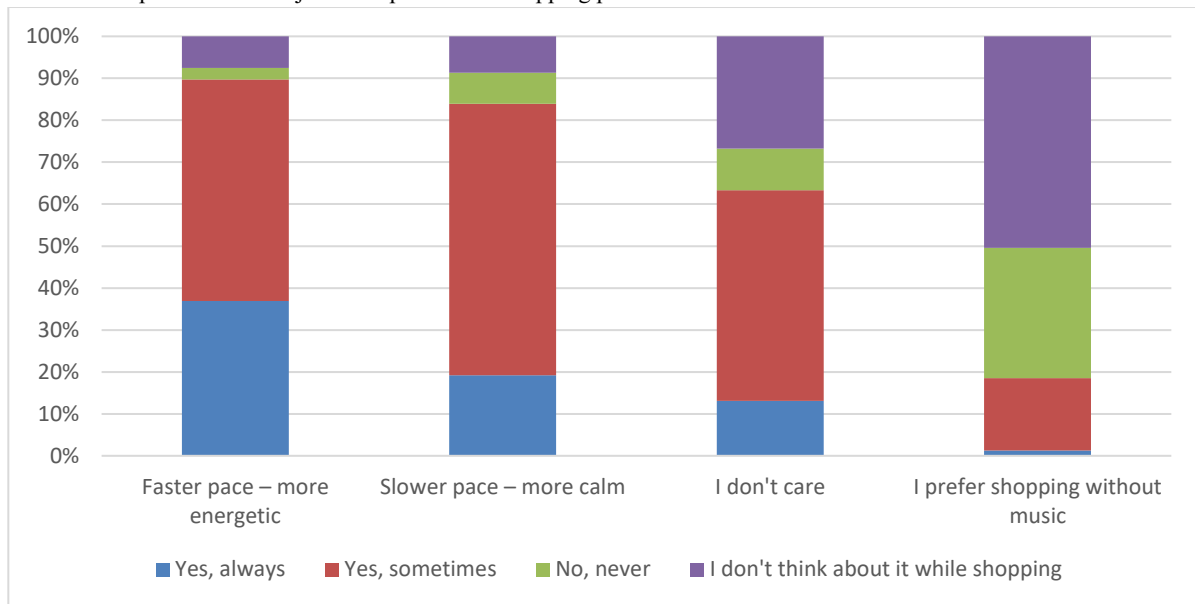
Table 3 Music tempo and subjective experience of shopping pleasure

	Faster tempo – more energetic in %	Slower pace – more peaceful in %	I don't care in %	I prefer shopping without music in %
Yes, always	5,32	8,29	6,53	0,12
Yes, sometimes	7,60	22,91	20,55	1,95
No, never	0,40	2,60	4,97	2,88
I don't think about it while shopping	1,08	3,08	10,96	4,68

Source: Authors

The percentage representation is graphically shown in Graph 3.

Chart 3 Music tempo increases subjective experience of shopping pleasure



Source: Authors

4 Conclusions

The research findings indicated that musical cues in retail settings significantly influence customer behavior and experiences while grocery shopping. Elevated music level and heightened noise sensitivity augment the probability of consumers departing the business prematurely, hence validating hypothesis H1a. Hypothesis H1b was validated, indicating that clients who are upset by music while shopping are more inclined to exit the store prior to finalizing their purchase.

The findings indicate that optimal music volume settings can have a positive impact on customer retention in the store and thus on their purchasing decisions. On the contrary, loud music or inappropriate background music may cause customers to be less satisfied and spend less time in the business. The second hypothesis was likewise validated: the subjective experience of shopping pleasure is increased and the impression of music as a distracting element is decreased when the desired and perceived tempos of the music coincide. This emphasizes the significance of music tempo as a tool for influencing the store's ambiance and fostering a satisfying shopping experience.

Overall, the results highlight the need for targeted and sensitive work with music in the retail environment. The right choice of volume and tempo of music, adapted to customer preferences, can contribute to increasing comfort, satisfaction and also to strengthening consumer loyalty.

The results provide recommendations for store managers who use music to promote sales. The volume of the music should be appropriate for the type of store and the number of customers, as too loud music can lead to customers leaving early. It is advisable to adapt the background music to the age and preferences of customers, as younger people usually tolerate higher volume and faster tempo. Faster tempos are more suitable in the morning, while slower ones are suitable in the afternoon, when customers shop more leisurely. Artificial intelligence can help automatically adapt music to customer behavior in real time. However, music should create a pleasant atmosphere and should not appear manipulative.

The research was confined to participants from the Slovak Republic, hence the findings may not be applicable to other cultural contexts.

The data were acquired by a questionnaire, therefore relying on the subjective reactions of the participants. The survey was conducted within a single time period, which may influence the perception of music across other seasons or contexts. Future research could include other countries, experimental measurements and comparisons of different types of stores.

We are currently conducting research in a Kaufland store, where we track the movement of shopping carts using a positioning system with tags. During shopping, a playlist created by us with a specifically designed genre, tempo and subliminal stimuli is played. The objective is to ascertain the impact of such music on consumer behavior and their impression of the environment. We collect data using a positioning system, questionnaires and EEG readings that capture reactions to musical stimuli. The data will assist us better understand the interaction between music, emotions and consumer behavior in a realistic context.

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Exploring the Role of Community Tourism in Sustainable Destination Development – the Case of Římov

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Abstract: Growing concerns in the tourism industry have brought community tourism to the forefront as a potential solution. Community tourism emerges as one of the possibilities for mitigation of tourism's negative externalities: mitigation of poverty by creating local jobs and income, cultural degradation by enabling communities to preserve and showcase local traditions, environmental damage by placing residents as stewards of their environment, and the economic imbalance of mass tourism by ensuring benefits stay within the community. This approach offers a framework for local communities to take ownership and control of their tourism development. By empowering residents, community-based tourism seeks to ensure that the benefits of tourism remain within the local area. This study includes a preliminary analysis of a small-town community tourism potential based on three semi-structured interviews with community leaders in Římov, followed by a review of existing literature on community tourism to establish a foundation for future research.

Keywords: tourism, community, sustainability, development

JEL Classification: Z32, Z38, R11, L83

1 Introduction

A fundamental shift toward sustainable practices is reshaping tourism. Community-based approaches (CT) are increasingly crucial against overtourism, making bottom-up implementation a pertinent development question for destinations like Římov where tourism is set to rise. This article explores CT potential in the small Czech municipality by employing preliminary exploratory research: qualitative interviews with three local representatives established key themes, which guided a tailored literature review. This process aims to identify critical success factors (CSFs) for future research to assess conceptual foundations and practical feasibility for sustainable, community-driven tourism.

The term Community Tourism (CT) represents a paradigm shift from traditional top-down development toward participatory, locally-driven models. Historically centralised by Murphy (1988), CT initiatives recognise that the tourism product depends on the goodwill and cooperation of host communities. Academic discourse is rooted in equitable, sustainable local development, requiring meaningful local participation where positive community change affects tourism (Dogra et al., 2022). CT is generally recognised for its potential to support local empowerment, build capacity, and improve livelihoods (Butler, 2017; Khan et al., 2020). Despite this, the research body remains fragmented, marked by conceptual ambiguities and political tensions that complicate measurement and success (Giampiccoli & Mtapuri, 2012).

Římov is a small municipality in the south of Bohemia with ca. 3000 resident inhabitants. It is governed by a local municipality and offers a kindergarten and a primary school, two grocery shops, a cultural and tourist information centre, and a restaurant. The tourism in the area is primarily pilgrimage-adjacent, with the main attractions of the recently renovated Passion route, local church with ambits, and local religious cultural works (O obci, 2012). The destination offers scattered and often informal hospitality services, and a handful of community and cultural events per year, mainly adhering to Christian customs and traditions. After the Covid pandemic, the local community was generally unproblematic (as it does not display the externalities of an excluded location-based community) but fragmented. In 2023, a community advisor Ms. Černická from the Via foundation initiated her collaboration with the town. She employed the ABCD method (McKnight & Russell, 2018), where through a series of listening conversations with local prominent personas she assisted in uncovering the local leaders, strengthening community connections and allowing people to explore common interests (Lucie Černická,

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2023). As a result of her advisory, the community worker position has been established, whose wages are uniquely financed by the municipality.ⁱ The ABCD process has seen such success in community cohesiveness that the town and its community is currently being studied by multiple researches and foundations in the field of community work and involvement as one of the most successful case studies.ⁱⁱ At the moment multiple different subject in the destination are in the planning stages of projects that have the potential to develop local tourism and increase the visitor numbers. Considering the community development, both the municipality and the community worker have an interest in developing tourism sustainably, with community tourism principles incorporated, which is where our input begins.

2 Method

This paper examines the conceptual foundations of CT and asks what key themes are essential for assessing the practical feasibility of CT principles in Římov on the basis of initial insights from community leaders and a focused literature review.

The main research question is following: *What is the preliminary potential for sustainable, community-driven tourism development in the municipality of Římov, and what critical success factors are identified through initial local perspectives and a tailored literature review?*

Our work uses a mixed-methods approach, combining preliminary exploratory research to investigate CT potential in Římov with a focused literature review. The initial phase involved three in-depth, semi-structured interviews with prominent local figures. We replaced the traditional linear research model with an iterative, flexible approach. The interviews served as exploration, refining the research agenda before the main data collection phase. Insights guide the literature review, ensuring a tailored document that directly prepares for subsequent research. This approach, like those recommended by Chiappa et al. (2020) and Kuilis-Bosimin and Chan (2020), first uses qualitative research to gain initial insight.

Interviews were conducted in person in October 2025, audio-recorded, transcribed, and analysed qualitatively. Subjects were Father Zentner (pastor), Iva Černá (LAG Pomalší manager), and Pavla Tichá (Římov community coordinator/gallery curator). The guide covered perceptions of the local community, the current state of tourism, associations with 'community tourism', and views on CT implementation potential. The analysis followed a thematic analysis approach, specifically using a mixed deductive and inductive coding strategy to address the core research questions directly and allow for the discovery of unexpected insights. An apriori codes list was generated directly from the main conceptual framework. These were applied to the data first to ensure that all passages related to the study's focus areas were systematically identified and tagged. Following the deductive pass, the data was subjected to an open coding process. Any text segment not adequately captured by the apriori codes, or one offering a new perspective or concept, was assigned a new, emergent code. The final set of codes were grouped into larger categories and overarching themes and a subsequent analysis focused on identifying patterns of consensus, divergence, and correlation across them.

Following this, the literature review will be conducted to present findings relevant to the community's context, identifying key themes, consensus points, and CSFs for assessing CT implementation potential.

3 Results

3.1 Exploratory interviews

The interview with Father Zentner was the first to be conducted. He is a well-regarded figure in the community and has vast knowledge about the nature of local community, as well as about the nature and habits of visiting tourists as they visit the Passion Route in Římov and usually end their pilgrimage in the local, recently renovated church. In the interview, the local community in Římov is characterised as highly diverse, containing open, closed, and eccentric individuals. A defining feature is a strong sense of conservatism and adherence to tradition, which Father Zentner notes is unique compared to other municipalities. While this trait helps to preserve what is good, it can also impede change or development. Father Zentner doesn't observe active sabotage of community initiatives but rather a simple lack of interest from some residents. Personally, he prefers to maintain a degree of professional distance in his interactions, which he associates with a feeling of freedom. When it comes to tourism, Římov primarily attracts a specific type of visitor who seeks out the location, rather than mass tourism (unlike nearby Český Krumlov). Visitors are often pilgrims, devout worshippers, or cultural enthusiasts drawn to the Passion Route and the church's unique services, specifically the older rite mass (partially in Latin). The main experience sought is peace, quiet, and contemplation. Father Zentner is willing to engage with visitors who actively seek contact but insists on respecting the boundary of those who come purely for silence and do not wish to be disturbed, treating the church as a sacred space for quiet reflection. The concept of CT was initially unfamiliar to Father Zentner. Upon being briefed on its definition—focusing on local experience sharing and ensuring economic benefits remain with the community—he acknowledged that the prospect of financial reward would likely increase local engagement and

effectiveness. A concrete example of this model already in planning is the renovation of the local rectory into a "Pilgrim's House." This initiative directly aligns with CT principles by having a local institution provide much-needed accommodation services to its specific niche market.

A second interview was conducted with Ms. Černá, an employee of the LAG (Local Action Group) Pomalší based in Římov. In the interview, the local community in Římov is described as open and highly willing to invest time and resources in communal activities, a characteristic noted as being more pronounced here than in other municipalities. This cohesive environment is actively supported by key local institutions, including the school, a gallery, and the cultural commission, as well as the municipality, which is very supportive of resident-led initiatives. While the community is open to outside participation, as it consists of several partially "competing cells," it currently does not actively run campaigns to invite non-residents to join their activities. Current visitation in Římov is often highly purposeful. Visitors, particularly those using the Passion Route typically arrive for a specific artistic or religious experience, knowing exactly where they are headed. While Ms. Černá noted limited direct interaction with tourists, it is observed that tourists are first welcomed by staff at the local community information centre with coffee. A key physical asset is the unique and inviting town square, which is regularly decorated through community initiatives, creating a "living room" atmosphere that enhances the visitor experience alongside existing features like the local pub, the school, and the gallery. Ms. Černá associates the term 'community tourism' with the idea that the local population, or specific parts of it, create and define the attractions they wish to share. Crucially, this model includes the community's right to self-define the boundaries of tourism—determining the desired volume of visitors, the intensity of activities, and what constitutes their private space. This self-definition is vital for sustainable implementation, especially given the challenges of limited, scattered accommodation capacity and the risk of local resentment toward tourists. A promising development is the planned renovation of the rectory to offer lodging and a community space.

The third interview was conducted with Ms. MgA. Tichá, who manages the local gallery and information centre in Římov and simultaneously acts as a local community worker and coordinator appointed and financed by the municipality, a concept ultimately unique to Římov. Ms. Tichá marks that the local community in Římov is evolving, having transitioned from perceived disparate "sectors" (parish, municipal) into a single, broader, and increasingly interconnected community over the past eighteen months (since she has been appointed as a community coordinator). This positive shift was catalysed by opening up physical spaces like the gallery without overly formal organisation, which prompted residents to spontaneously bring forth their own ideas and initiatives. This open, sharing environment is contrasted with a segment of "old settlers" who are closed, non-sharing, and adhere rigidly to tradition—a group humorously described as the "South Bohemian sourdough starter". Ms. Tichá's motivation for community work stems from cultivating genuine relationships, engaging in creative collaboration, and finding a sense of charitable purpose, rather than seeking personal credit. Římov's tourist visitor base is highly specific and segmented. The main groups are pilgrims, who are typically slow-paced, deeply contemplative, and seek meaningful engagement with the site's spiritual atmosphere and the Passion Route. In contrast, tourists are often driven by external factors such as marketing, social media, or simply seeking mementos like postcards and stamps (referred to as stamp collectors). Key attractions include the main pilgrimage complex, the unique sense of "tranquillity", and smaller cultural sites like the Model Train Museum. Local engagement with visitors is managed by Ms. Tichá with a focus on distinguishing between the deep spiritual interest of the pilgrims and the more superficial interests of the casual tourist. Successful implementation of community tourism faces obstacles, notably a severe lack of basic infrastructure (access to toilets is described as a "catastrophe") and limited water access for visitors. Accommodation is currently scattered across a few small guesthouses and a dilapidated summer campground. The concept of 'community tourism' is welcomed by Ms. Tichá to expand the local awareness of the community's own hidden resources and businesses—such as local bakers, flower businesses or hidden guesthouses—ensuring the economic benefit of any tourism is distributed internally. However, she warns that this very "tourism buzz" is the greatest risk, as it can cause frustration, noise complaints, or neighbourly envy among local business owners.

The interview analysis uncovered several topics that would need further exploration for the purposes of effective planning and management of potential CT in Římov. Sustainable implementation relies heavily on local stakeholders' ability to self-define its boundaries—the crucial factor for preventing resentment towards "outsiders." The successful CT model must use a managed interaction approach, catering separately to the core audience of pilgrims/worshippers (respecting the atmosphere of peace and reflection) and cultural tourists. This approach utilises existing strengths, specifically authenticity and strong institutional support (school, gallery, municipality). Local cooperation also seems to depend on clearly articulating the economic return, as financial motivation is key to resident participation.

Immediate attention is required for both infrastructural and social challenges. Deficits in basic infrastructure, like public toilets and water access, must be addressed promptly as they undermine the visitor experience. Addressing the

accommodation gap is paramount; the rectory renovation into a "Pilgrim's House" is the most aligned lodging project. Social strategies must mitigate local envy and competition from business successes and manage the disruptive tourism "buzz" through spatial and activity planning. Finally, focusing on the internal market—making locals aware of their own hidden resources—will internally increase service supply and ensure economic benefits are shared, preventing burnout or unfair perceptions among active members.

The subsequent literature review must focus on CT models intersecting with pilgrimage and spiritual tourism, specifically maintaining core values while pursuing economic goals. Key themes must include strategies for capacity control and boundary definition, the critical role of local governance, and mechanisms for equitable distribution of financial benefits to drive participation and mitigate social friction. The review is required to identify CSFs related to sustainable CT at heritage sites, specifically focusing on infrastructure development and internal resource mobilisation to secure Řimov's self-defined, long-term viability.

3.2 Literature review

The most frequently studied themes in the CT literature highlight the human and organisational dimensions of tourism, specifically focusing on how local communities interact with and are affected by the industry.

The body of literature (N=102 articles) demonstrates a growing field centred on five complementary themes. The most frequent areas of investigation pertain to the political dimensions of participation and governance (19 articles), the psychological mechanisms driving resident support (16 articles), the measurable outcomes related to sustainability and economic viability (26), the conceptualization and critique of CT models (12); and contextual and niche CT applications (53 with common considerable overlap with other themes).

The academic study of CT features several recurring subthemes. Economic focus areas include poverty alleviation, reducing economic leakage, determining CSFs, and examining sustainability indicators (social, economic, environmental), resilience, and profitability (e.g. Ndivo & Cantoni, 2016; Choi & Sirakaya, 2006; Aquino et al., 2018; Lee & Jan, 2019; and Giampiccoli et al., 2020). Organisational and social research concentrates on community involvement, effective planning models and management structures, governance constraints, the role of social capital, and complexities in power relations and leadership behaviours (e.g. Tosun, 2006; Chen et al., 2017; Sutawa, 2012; Kannapa Pongponrat, 2012; Marsuki et al., 2025; and Ntow-Gyan et al., 2025). Psychological impacts are explored through themes like Quality of Life, emotions, perceived impacts, emotional solidarity, and prosocial/proenvironmental behaviours (Jordan et al., 2019; Moghavvemi et al., 2017; Kim et al., 2013). Theoretical work involves defining, critical analysis of CT failings, and the conception of theoretical models (e.g. Jamal & Dredge, 2014; Zielinski et al., 2020; and Amerta, 2017). Finally, contextual studies cover diverse applications such as rural/agricultural synergy, indigenous tourism, cultural heritage awareness, the role of technology, and post-disaster recovery (e.g. Shrestha et al., 2025); Gascón & Cañada, 2025; and Nuanmeesri, 2022).

The literature employs a diverse array of scientific methods, ranging from conceptual critiques and bibliometric analyses to rigorous quantitative modelling and localised qualitative case studies.

Recent research

The examination of articles published from 2023 onward (N=21) indicates a distinct progression towards highly specialised behavioural modelling, a pivotal decolonial perspective, and an escalating emphasis on institutional resilience. Between 2017 and 2023, mainly research on Community-Based Rural Tourism grew significantly. This shows that the sub-field is growing up and increasingly relevant (Cordova-Buiza et al., 2025). The analysis of recent scholarly works reveals that CT scholarship has began transitioning from descriptive case studies and conceptual debates to complex empirical testing of interconnected social and psychological mechanisms. The core definition of success in academic literature is shifting significantly from focusing narrowly on purely economic benefits to prioritising the measurement of socio-psychological well-being, Quality of Life, and deep-seated local identity (Guan et al., 2025; Ramkissoon et al., 2025). The persistent failure of CT initiatives has notably been regarded as a governance failure, rooted less in a flaw in the conceptual model and more in chronic poor management of internal power dynamics (Reed, 1997) and currently is increasingly the inability to overcome external institutional and structural obstacles (Marsuki et al., 2025). The obviously significant trend in most current research indicates a decisive movement toward regenerative goals and a demand for decolonial methodologies. This trajectory necessitates research that integrates native voices, confronts systemic inequalities (gender, socioeconomic), and aims for active restoration of social, cultural, and environmental riches, rather than merely sustaining the status quo (Shrestha et al., 2025; Hernández-González & Espeso-Molinero, 2025; Tariq, 2025).

Site-specific points for literature review

The theoretical viability of community-centric planning frequently relies on the presumption that the community unit is cohesive and homogeneous. Analyses show this construct is fundamentally flawed due to heterogeneity and preexisting power dynamics (Dredge & Jamal, 2014). Scholarly critiques assert that CT literature often fails by viewing the host community as a single entity and ignoring basic structural limitations that obstruct local control (Blackstock, 2005). Spiritual and pilgrimage sites are specialised heritage forms whose resource (sacred integrity) is non-renewable and highly vulnerable to damage from poorly planned tourism (Kamamba, 2003). Successful management via a CT framework relies on recognising that the primary value is cultural significance and spiritual authenticity, not commercial attraction (Kamamba, 2003). Local culture is a vital resource for development, not merely an attraction (Giampiccoli & Kalis, 2012). Models like the *Guthi* mechanism in Nepal show how traditional institutions can reinforce cultural identity outside of purely commercial interests (Shrestha et al., 2025). Management structures must be empowered to halt any development that threatens the site's sacral integrity (Kamamba, 2003).

Maintaining core community values while ensuring economic benefits is a major challenge with the risk of commodification (Lee & Jan, 2019; Andereck et al., 2005). The balance requires integrating environmental, social, and economic sustainability (Dogra et al., 2022) through a holistic capital accounting framework that measures trade-offs across six sustainability dimensions (Stone & Nyaupane, 2018). Genuine, empowered participation is the primary mechanism for safeguarding values against commercial pressures, as the direction of change in community capitals (accumulation vs. depletion) is determined by the nature of participation (Stone & Nyaupane, 2018). Furthermore, the poverty alleviation potential is routinely undermined by economic leakages and weak engagement, leading to elite capture (Ndivo & Cantoni, 2016). A social justice strategy with redistributive goals is essential to ensure commitment and defend cultural values (Saayman & Giampiccoli, n.d.).

The need for capacity control is paramount, as exceeding capacity leads to common problems like crowding and increased social issues (Andereck et al., 2005; Lee & Jan, 2019). For sustainable CT, capacity must be viewed dynamically, encompassing the socio-political and psychological dimensions of the community, as impacts are linked to resident stress and Quality of Life (Jordan, Spencer, & Prayag, 2019). Capacity is not static but evolves with the destination's maturity (TALC), meaning perceptions of sustainability vary significantly across developmental stages (Lee & Jan, 2019). Effective planning necessitates defining boundaries and integrating concepts of scale, change, and resilience to manage shocks (Lew, 2014; Tosun, 2006). Comprehensive planning frameworks, such as the 125 sustainability indicators across six dimensions (political, social, ecological, etc.), serve as models for defining the scope and rules of activity (Choi & Sirakaya, 2006).

Critical success factors

Considering the specific variables at play when planning for and establishing community tourism in a specific destination, we must review the existing case studies and additional literature to uncover which success factors have been identified in similar situations. The CSFs can be understood as the elements or activities required for a project to achieve its objectives and be successful (Lucchetti & Font, 2013).

Research into long-term viability identifies CSFs across three strategic areas: commercial viability, institutional capacity (internal affairs), and external linkages (interaction with the outside world). These factors relate broadly to market viability, governance, and socio-psychological support. Commercial success requires meticulous business planning, focusing on profitability and developing attractive products (Lucchetti & Font, 2013). However, success is often undermined by economic leakages, which divert gains to elites and external parties (Ndivo & Cantoni, 2016). Sustainable strategies must actively reduce these leakages to boost local economic development (LED) (Mtapuri et al., 2022). Financial returns are necessary because residents prioritize economic benefits as the most significant outcome of rural tourism (Liu, Chiang, & Ko, 2023; Turčinović et al., 2025), a factor critical since many initiatives require substantial subsidies to operate (Goodwin & Santilli, 2009). Long-term viability rests on strong institutional structures, strong leadership (Ntow-Gyan et al., 2025), and effective management of social capital (Auliah et al., 2024; Grybovyč & Hafermann, 2010). Organisational structures, like the "Langde Mode's" work point system, successfully manage participation and resolve the "free rider" problem (Chen, Li, & Li, 2017). However, implementation is often hampered by institutional obstacles, leading to inequalities (Marsuki et al., 2025). While genuine self-mobilisation fosters sustainability, superficial "interactive participation" can be detrimental to development outcomes (Tabatabaei et al., 2025). Managing external relationships is critical for market access and resilience. Commercial efficacy relies on market proximity and strong private sector links (Lucchetti & Font, 2013). Initiatives also benefit from cross-sectoral synergy, such as tourism driving agricultural activity (Gascón & Cañada, 2025). External factors, including NGO involvement, are crucial for industry revitalisation following shocks (Robinson & Jarvie, 2008). The structure of external power dynamics critically impacts the scope of local participation (Jordan et al., 2013).

Communities must therefore actively seek involvement in external policy processes to manage stakeholder assimilation and ensure local needs are met (Thetsane, 2019; Zielinski et al., 2020).

4 Discussion

The relationship between the identified CSFs from the wider literature and Římov's unique local characteristics confirms that the municipality's assets generally align with established prerequisites for successful CT.

Commercial success relies fundamentally on converting cultural assets into profitable returns by actively reducing economic leakage, a primary strategy for converting passive community acceptance into active CT involvement (Ndivo & Cantoni, 2016; Mtapuri et al., 2022). The local willingness to participate is explicitly reliant on articulating the economic return (Liu, Chiang, & Ko, 2023; Turčinović et al., 2025). Římov appeals to a specific, non-mass market: pilgrims seeking peace and contemplation. Success requires profitable management of this niche through aligned projects like the proposed rectory renovation, rather than pursuing broad commercial appeal (Lucchetti & Font, 2013). Focusing on mobilising locals' "hidden resources" ensures internal benefit distribution (Goodwin & Santilli, 2009).

The long-term viability of the project must leverage Římov's existing institutional capacity. Strong institutional support and social cohesion (Auliah et al., 2024; Grybovyč & Hafermann, 2010) form a strong, pre-existing CSF, critical for managing the municipality's diverse community segments and overcoming internal inequalities (Marsuki et al., 2025). The demand for self-defined boundaries is essential for capacity control, preventing resentment among conservative residents and protecting the core product of tranquillity (Tabatabaei et al., 2025). The model must incorporate participation mechanisms capable of managing the divided community and overcoming the "free rider" problem (Chen, Li, & Li, 2017).

Managing external linkages is crucial for market access and resilience. The severe lack of basic infrastructure (public toilets, water access) is an immediate operational failure, making external funding and municipal coordination paramount (Choi & Sirakaya, 2006). Strategy must strengthen external connections to religious and heritage networks to reach the highly purposeful pilgrim audience, rather than general market proximity (Lucchetti & Font, 2013), thereby preserving the site's spiritual authenticity (Kamamba, 2003). Initiatives should also aim to benefit from cross-sectoral synergy, such as tourism driving local agricultural activity (Gascón & Cañada, 2025). Finally, attracting external resources (e.g., LAG involvement) strengthens community resilience against external shocks, a key requirement for long-term development (Zielinski et al., 2025; Robinson & Jarvie, 2008).

5 Conclusion

This exploratory study confirms that the small municipality of Římov presents a promising case for adopting CT, grounded not only in its cultural assets but also in its level of institutional capacity achieved through recent community development work.

The main theoretical premise of this research lies in its reinforcement and specification of the role of social capital in CT development theory. Our findings imply that high social capital and strong institutional capacity (such as established community worker position and post-ABCD cohesion) should be viewed not merely as one of the CSFs but as structural preconditions that lower risk and enhance resilience. Our findings moreover provide theoretical guidance for applying CT principles to niche, low-volume religious destinations. Success in these contexts is not dependent on broad market appeal or proximity to mass tourism hubs. Instead, our research suggest that it relies on preserving spiritual authenticity by managing external linkages to religious and heritage networks to reach a highly purposeful audience.

The practical implications for the planned projects in Římov are immediate and actionable. The strong social cohesion and leadership identified via the exploratory interviews and the ABCD method (e.g. McKnight, & Russell, 2018) represent a powerful pre-existing CSF, as suggested by research that champions strong social capital and effective internal governance (Auliah et al., 2024; Chen, Li, & Li, 2017). Management must leverage the established community worker position and participatory structures to ensure that new tourism projects prioritise local control (Ndivo & Cantoni, 2016; Mtapuri et al., 2022). Considering the predominantly pilgrimage-adjacent nature of existing tourism, strategy should focus on strengthening external linkages to religious and heritage networks to build robust market connections (Lucchetti & Font, 2013).

Římov acts as an interesting case for testing whether successfully pre-developed social capital and strong leadership can overcome typical institutional and participative obstacles that frequently derail CT initiatives (Marsuki et al., 2025; Ntow-Gyan et al., 2025). The research underscores that genuine empowerment is the necessary structural precondition for translating community cohesion into sustainable economic benefit (Sutawa, 2012). For future research in Římov, the next

phase should ideally comprise multiple steps, such as creating a locally relevant framework of sustainability indicators (Choi & Sirakaya, 2006) that specifically measure the social, cultural, and environmental impacts unique to a small, religion-based destination, and conducting a large-scale quantitative survey to test the causal relationships between the locally prioritised factors (identified through the interviews) and resident support, perceived quality of life, and intention to participate (Kim, Uysal, & Sirgy, 2013).

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ⁱ Where in similar towns and on similar positions the costs are usually covered by multiple grants that must be periodically renewed or reapplied to, which significantly reduces the stability and ability to plan long-term.

ⁱⁱ This information is based on multiple informal interviews with Ms. Lucie Černická who was the initiator of the ABCD method in Římov and the representatives of local municipality.

Session:
Management of Change and Innovation

Digitalization of Process Mapping as an Integral Part of Business Process Management

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Abstract: An important driver of success, according to several scientists, is Business Process Management (BPM), which represents a structured holistic management discipline focused on improving the performance of enterprises through the management of their business processes. BPM includes various methods, techniques and tools to support the identification, design, mapping, modelling, implementation and optimization of processes in order to support business goals. Business process mapping, as an integral and primary part of BPM, plays a fundamental role in the identification, analysis and design of processes. The digitalization of business process mapping supported by BPM software tools and standards fundamentally changes the means of documenting and managing processes. The scientific article includes: theoretical definition of basic concepts in the field of BPM, analysis and development of business process mapping and management also in the context of digitalization, synthesis of findings from expert sources and surveys, identification of barriers to implementing BPM, overview of BPM software tools and formulation of recommendations for enterprises in the field of BPM, including the digitalization of business process mapping. The main findings indicate that companies have low levels of digitized processes, 70% of companies use at least one BPM tool, only 3% of companies do not model or map processes at all, and up to 82% of companies use paper or manual process mapping. These findings are critical in the context of Industry 4.0, where the current emphasis is on digital innovation and thus on a high level of automation of business processes.

Keywords: process management, digital technologies, business process management, digitalization, BPM

JEL Classification: M11, M15, O31, O33

1 Introduction

The dynamically changing business environment and current economic challenges, including Industry 4.0, force companies to be efficient, competitive, innovative and digitally transformed, which also requires proper management and optimization of business processes. For this reason, business process management itself is becoming a key pillar of success in companies. Szelagowski (2019) also points out the importance of processes in companies and that all organizations hoping to prosper in the 21st century must be process oriented. Business process mapping is a necessity for organizations that focus on sustainable growth (Rosita, 2022).

Albrecht, Lösner & Röglinger (2024) argue that in order to maintain their competitiveness, companies must embrace the dynamics of the ever-changing business environment, radically change the way work is done and thus implement business process management (BPM). The importance of business process management and the implementation of BPM has also been pointed out in recent years by other researchers such as: Helbin & Van Looy (2021); Gabryelczyk, Sipior & Biernikowicz (2022); Tellez-Risco (2022); Özkan et al. (2023); Mößlang et al. (2024); Handriani & Mahendrawathi (2024) and Kozma et al. (2024). According to Mößlang et al. (2024), business process management is essential for companies to adapt to changing requirements and remain relevant in the market. Business process is defined by Sołtysik-Piorunkiewicz & Morawiec (2021) as a series or network of value-added activities, performed by their relevant roles or collaborators, to purposefully achieve the common business goal. Senkus et al. (2021) state that business process is a complex work that brings value to customers. Process management has been around for over 100 years (Koch et al., 2022) and represents the systematised application of relevant concepts, methods and tools of influence at the stages of identification, modelling, controlling, implementation and improvement of processes (Wąchol, 2020).

Business process management (BPM) according to Albrecht, Lösner & Röglinger (2024) is a holistic management discipline that offers mature methods and end-to-end management activities. BPM according to Al-Fedaghi & Mohamad (2019) refers to the execution of processes using tools (for workflow management, tools for enterprise application

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integration and web services, which also includes process automation technologies) and also according to scientists it is an approach to change in an enterprise through the use of various tools, which include business process mapping. Stojanović et al. (2020) provide a definition according to Harmon (2005), and BPM is defined as a management discipline focused on improving corporate performance by managing a company's business processes. According to Reijers (2021) BPM embodies a management philosophy that is supported by a range of methods, techniques and tools. Fahrenkrog-Petersen (2024) state that BPM is widely used for discovering, modelling, analysing and optimizing organizational processes. BPM is defined as the discipline that involves any combination of modelling, automation, execution, control, measurement, and optimization of business activity flows in applicable combination to support enterprise goals within and beyond the enterprise boundaries (Von Rosing, von Scheel, & Scheer, 2014; Saidane, Hassani & Ghannouchi, 2024). According to Putra & Mahendrawathi (2024), BPM is an approach that aims to improve the performance and flexibility of an organization through business process management.

BPM is an important discipline that drives the success of a company (Vom Brocke & Mendling, 2018; Vom Brocke et al., 2021). According to Reijers (2021), the development of the BPM discipline over the years is characterized by: BPM systems, process modelling, process design, coordination and interoperability, model management, process mining and new technologies. According to Karmoker & Golam Rabiul (2025), BPM is part of modern organizations that helps them analyse and redesign business processes. BPM has its roots in business process reengineering (Niehaves & Hense, 2011), enables continuous improvement of business processes (Dunzer et al., 2024) and includes, according to Koch et al. (2022), the design, implementation and optimization of processes. According to Ubaid & Dweiri (2020), BPM also includes process mapping. BPM focuses on business processes using analytical techniques that assume a clearly defined beginning and end (Fahrenkrog-Petersen, 2024).

The BPM process according to Tellez-Risco (2022) includes activities such as:

- Planning and alignment: knowledge of available documentation.
- Process analysis: use of matrices (e.g. SWOT and VAA) to know the efficiency of the process.
- Process design: know the hardware and software requirements to improve the process.
- Process implementation and monitoring: there will be a matrix of KPIs to be able to verify that the implementation is giving the expected results.
- Process refinement: verification of fulfilment of KPIs, and if not, analyse what went wrong and readjust the process.

BPM models include: flowchart, BPMN (Business Process Model and Notation), EPC (Event-Driven Process Chain), UML (Unified Modelling Language), which are modelled in (Nizioł et al., 2021).

An element and integral part of BPM is also process mapping (PM), which according to Templar & Mena (2010) is generally defined as the activity of identifying and recording relevant tasks. Bedel (2003) defines PM as a thorough analysis of organizational processes in order to understand how tasks are performed using tools such as flowcharts and process diagrams. PM is a key link in the enterprise, which significantly improves business processes and economic results (Hunt, 1996). Process mapping is a common practice for documenting existing and newly designed processes, it is a best practice and one of the four most commonly used tools in business process improvement (Kettinger, Teng & Guha, 1997; Dolan, 2003; Siha & Saad, 2008; Bowles & Gardiner, 2018). According to Al-Fedaghi & Mohamad (2019), PM is a schematic representation of processes. PM is found in several BPM activities and can be classified as one of the initial phases of BPM: identification, modelling and design of business processes. The phases characterizing the process of process mapping according to Antonacci et al. (2021) are: preparation, planning and process identification; data and information gathering; map generation; process analysis, and further fulfilment /take it forward. The output of PM are process maps or process maps, which, according to Goodman, Kuniavsky & Moed (2012), are the result of applying the task analysis approach to the entire business or organization.

Since its inception, BPM has traditionally been combined with information technology (IT) to fully exploit the potential of BPM for process redesign, improvement and management (Gabryelczyk, Sipior & Biernikowicz, 2022). BPM is a multidisciplinary process, most business processes are supported by IT (Harmon, 2010; Sidorova & Isik, 2010; Niehaves, Plattfaut & Becker, 2012), and therefore the functioning of BPM should also be supported by software tools and digital technologies of Industry 4.0, as currently pointed out by several researchers such as: Ubaid & Dweiri (2020); Brkić, Tomićić Pupek & Bosilj Vukšić (2020); Zuhaira & Ahmad (2021); Moreira & Dallavalle (2024); Szelągowski & Berniak-Woźny (2024); Vu et al. (2025) and others.

Digitalization of process mapping represents a change from an analogy approach to the use of information technologies for collecting information about business processes, their modelling, visualization and optimization. Initially, business processes were recorded on paper - so-called paper mapping and were not formally managed at all. The turning point came in the 1980s, when textual digitization of processes documented in Microsoft office software tools began. Later, in the 1990s and until the beginning of the 21st century, the first specific software tools designed for process modelling began to emerge, such as: Microsoft Visio, Aris Toolset and IBM WebSphere Business Modeler. The standardization of BPM and the emergence of BPMN 1.0, cloud tools, BPMN 2.0, the advent of Industry 4.0 and the use of digital technologies represented further development phases of BPM and the digitization of process mapping itself, which is its integral part.

BPM provides several advantages in business, as scientists Aidara, Diaw & Cisse (2024) emphasize that BPM increases the efficiency of business processes, reduces costs and increases profits in companies. De Luzi et al. (2025) state that in recent years, scientific and industrial interest in BPM approaches and methods has increased. The interest of companies is also significant due to the increasing rate of digitalization in companies and, consequently, the continuous optimization of business processes.

2 Methods

The main objective of the scientific article is to analyze the digitalization of business process mapping and management in enterprises, to evaluate the current state of the techniques and tools used, and to provide recommendations for effective and digital mapping and management of business processes.

The achievement of the main objective required the fulfillment of the following partial objectives, namely:

- to examine the theoretical foundations in the field of business process management (BPM) and business process mapping in general and subsequently with a focus on digitalization;
- to evaluate the significance of BPM digitalization in the context of Industry 4.0;
- to map the current state of use of BPM tools in business practice based on available statistical reviews and conducted studies;
- to identify software tools for the digitalization of business process mapping;
- to formulate recommendations for business practice aimed at the effective digitalization of business process mapping through BPM tools.

The subject of this scientific article is the digitalization of business process mapping and management in business practice.

The object of the study is business entities involved in statistical and empirical surveys in the field of BPM, which represented enterprises of various sizes and operated in various sectors of the economy.

The collection and selection of literary sources took place in scientific databases with an emphasis on the Web of Science and Google Scholar databases, where sources were searched for in the period from 2020 to 2025 (older sources were included for referencing in relevant scientific publications). The search for literary sources was carried out using keywords. The keywords for the initial search were: "industry 4.0", "process management", "Business process management", "process mapping", "business process mapping", "digitalization of business process mapping" and the abbreviation "BPM", which were used separately and in combination. Given that the databases in some cases contained hundreds of thousands of documents, we focused on peer-reviewed and freely available sources when processing the literature review. The data presented in the analytical part came from secondary statistical surveys and expert analytical reports that were published on expert portals in 2024 and 2025. The results and discussion part contained sources about companies that have implemented and used BPM solutions in practice and use software tools for mapping business processes and BPM in general. The analytical part also identified specific software tools used in process mapping, which were subsequently evaluated according to the frequency of occurrence in expert sources, mainly of technology companies.

Several scientific methods were used in the preparation of the scientific article, namely:

- abstraction - in generalizing findings and making recommendations for business practice;
- analysis - in dividing the researched issue of BPM and its digitalization into individual researchable parts;
- deduction - in verifying general principles in specific BPM applications in business practice and also in formulating general recommendations from individual cases and vice versa;

- induction – when drawing general conclusions from individual case observations;
- comparison – when comparing the development of BPM and the use of tools between different periods;
- synthesis – when integrating knowledge from different studies into a coherent concept of effective process management, and thus also connecting knowledge into coherent conclusions.

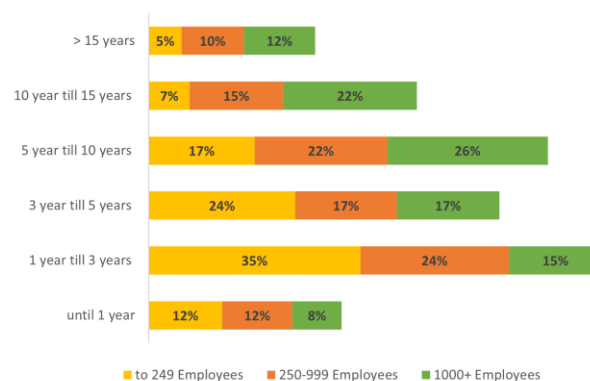
3 Research results

The size of the global BPM market according to Fortune Business Insights (2025) was valued at 17.78 billion USD in 2024. Comidor (2024) estimates the value of the BPM market in 2024 at 15.4 billion USD and states that the need for organizational excellence and reduction of operational costs is the driving force behind the growing BPM market, which is also influenced by the evolving business environment and the need to thrive in the digital sphere. Quixy (2025) states that the global BPM market will be worth 26.18 billion USD in 2028. Fortune Business Insights (2025) also predicts the future growth of the BPM market, namely that it is expected to grow from 21.51 billion USD in 2025 to 70.93 billion USD by 2032 at a CAGR of 18.6%.

3.1 Comparison of statistical studies of BPM and business process mapping in corporate practice

Gerussi (2025) reports the duration of BPM practice in companies (figure 1), which shows that it is significantly influenced by the size of the company. Larger companies have many years of experience with BPM, but smaller companies do not have as much experience and have increasingly started using BPM only recently. The reasons may be that larger companies have more available resources (financial, personnel and technological), technologies are implemented there earlier, and they have a higher pressure on digitalization and business efficiency.

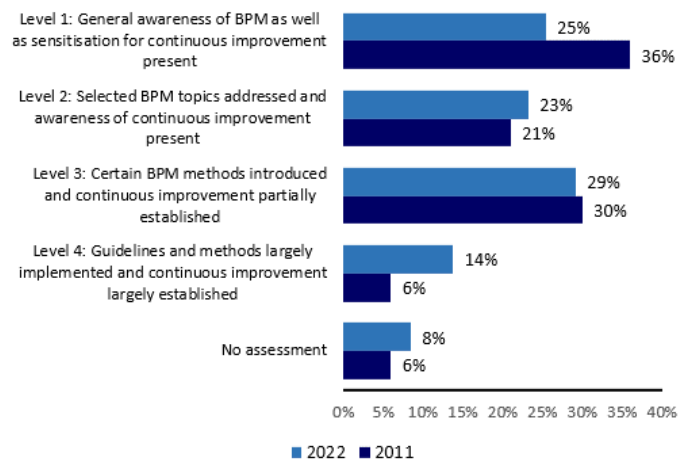
Figure 1 Length of time BPM has been practiced in businesses by size



Source: Gerussi (2025)

The maturity level (figure 2) shows a visible shift towards systematic and embedded BPM from general awareness (level 1) to fully implemented BPM (level 4). The largest increase was recorded at level 4, where companies are continuously engaged in the management and overall improvement of business processes. Despite the fact that BPM is growing, most companies remain at intermediate levels (levels 2 and 3), which indicates room for further improvement, especially in the area of digitalization and process optimization. Level 1 fell by 11 percentage points, indicating that fewer and fewer companies remain in the early stages of BPM without concrete activities.

Figure 2 BPM development stages and maturity levels in 2011 and 2022



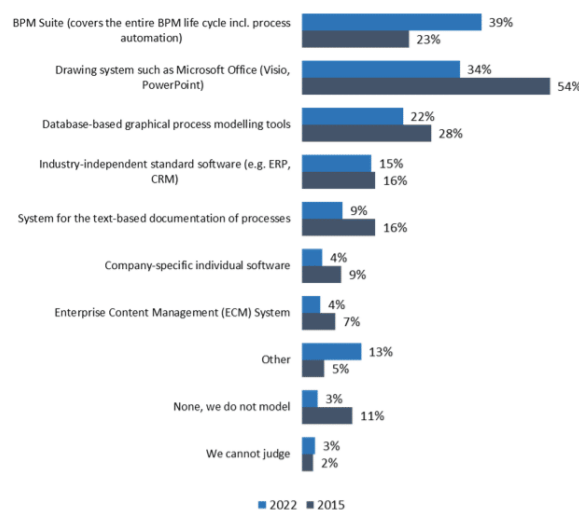
Source: Gerussi (2025)

Figure 3 illustrates the growth in BPM tool usage between 2015 and 2022, showing the transformation from simple/ad hoc tools to integrated, comprehensive BPM solutions. The graph shows:

- a significant decline in companies that do not model processes at all, from 11% to just 3% of companies;
- an increase in the use of BPM Suite tools from 23% to 39%;
- a decline in traditional office and text documentation tools for mapping business processes.

These changes mean that robust solutions are being replaced by traditional tools, companies are increasingly preferring integrated tools that support the entire BPM lifecycle - from identification, mapping, modelling to automation and monitoring, and the importance of automation and workflow orchestration within BPM is increasing.

Figure 3 Tools used in the field of BPM in 2015 and 2022



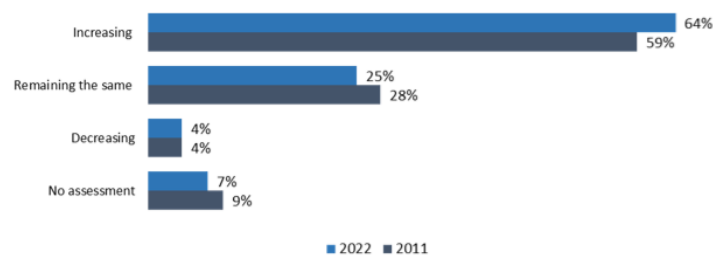
Source: Gerussi (2025)

The digitalization trend in process mapping is evident in Figure 3, as it captures the shift from analog process mapping to the use of intelligent BPM tools.

Despite previous findings that full BPM integration remains a challenge for many companies, the trend in the importance of BPM has been consistent over the years. The research results clearly point to the important importance of BPM in companies, especially in terms of the use of software tools for BPM – the so-called BPM tools (Figure 4). Between 2011 and 2022, there was an increase in companies that expect the growing importance of the tools, from 59% to 64%. At the

same time, only 4% of companies expect the importance of BPM software to decrease, which has remained constant over the years. The number of companies that cannot assess the future development of BPM software tools has slightly decreased. Overall, up to 89% of companies consider BPM tools to be increasingly important and at least as important as in the past. Changes in the use of BPM tools reflect a broader push to increase efficiency, automation, and agility in businesses, resulting from the digital transformation of businesses and the emergence of the Industry 4.0 paradigm.

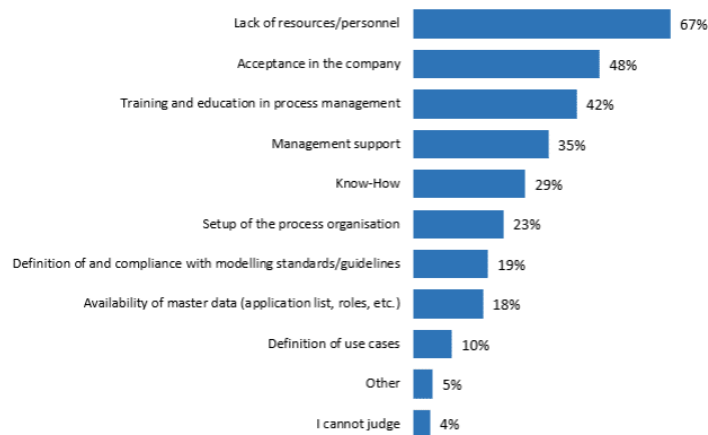
Figure 4 The future importance of BPM tools in enterprises in 2011 and 2022



Source: Gerussi (2025)

BPM implementation in enterprises faces several obstacles related to human capacity, as well as operational and technical factors. The main barriers in the field of BPM (figure 5) are the lack of personnel in 67% of enterprises, which represents a lack of professional capacities and competencies. Other significant obstacles are: poor adoption in 48% of enterprises, insufficient training and education in process management in 42% of enterprises, low management support in 35% of enterprises and lack of know-how in 29% of enterprises. In addition to these main obstacles, companies also face structural and methodological challenges, such as: unclearly defined or insufficiently developed process organizational structure in 23% of companies, absence and non-compliance with modelling standards in 19% of companies, unavailability of relevant master data (e.g. application lists, roles, process owners) in 18% of companies, as well as poor identification and formulation of specific use cases for BPM initiatives in 10% of companies.

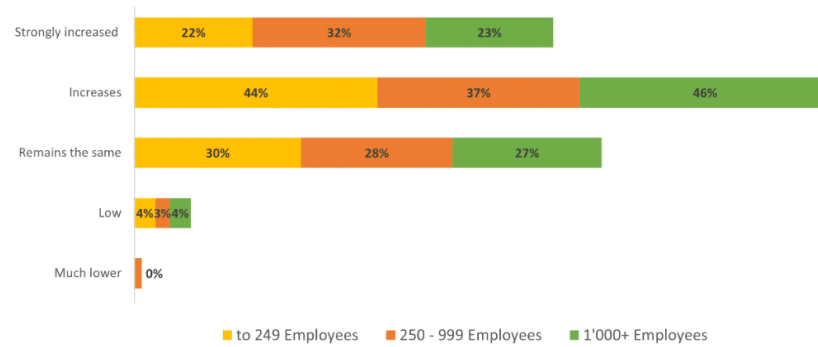
Figure 5 Barriers in BPM



Source: Gerussi (2025)

The future of BPM in terms of enterprise size (figure 6) indicates the growing strategic importance of BPM. The results of the survey according to Genussi (2025) show a high level of consensus in the assumptions of the growing importance of BPM, where up to 68% of enterprises expect that the importance of BPM will grow normally or significantly in the coming years, while the majority of enterprises expect at least to maintain the current level.

Figure 6 Expectations for the future of BPM by company size



Source: Gerussi (2025)

The results confirm that BPM is no longer just a trend in large enterprises, but is also becoming an essential management practice in small and medium-sized enterprises. The main reasons are: the use of digital technologies and the digital transformation of Industry 4.0, a dynamic business environment, various economic challenges and global problems, the increasing complexity of business activities and processes, and especially the greater availability of BPM tools.

Condor (2024) points to the growing use in business practice in 2024, when businesses believe that it will help them manage tasks and increase efficiency. Given this, there has been a sharp increase in interest in BPM and at least 74% of businesses have shown an increased interest in implementing BPM. It is further stated that: 70% of businesses already use at least one BPM application and 63% of businesses use two or more BPM tools; 38% of businesses have formalized BPM programs; businesses with BPM implemented have seen a reduction in workload and 40% of businesses have seen a reduction in errors and the implementation of more accurate decisions.

Lordan (2025) states that 26% of companies are implementing BPM, 28% of companies are mapping processes or modelling processes, and there are also a large number of companies that manage business processes through Excel. One company reports that it uses 10,000 Excel documents for BPM throughout the company. Forrester and Lordan (2025) point out that up to 82% of companies still use paper and manual process mapping.

In addition, Condor (2024) also points out that companies rely on manual processes or processes recorded on paper, which means inefficient systems, which leads to losses and financial impact on the business. According to statistics, companies have lost at least \$ 1.3 million due to inefficient processes (Condor, 2024).

Bennett (2025) states that only 2.76% of companies monitor and manage their processes; 21% of companies use process optimization techniques; BPM software is used by less than 50% of enterprises and the rest do not use it because they think it is too expensive; 29% of enterprises want to deploy business process management software; 48% of enterprises are trying to use business process automation tools to automate the management of manual processes; 54% of enterprises say that mapping complex processes is their biggest obstacle to automating operations.

In terms of segments, according to Condor (2024), the highest BPM implementation rate was in the banking, financial services and retail sectors (35%), followed by the healthcare and retail segments with the next highest adoption.

3.2 Software tools for digitizing business process mapping

Given the findings in the previous theoretical and analytical base, it follows that companies are increasingly aware of the importance of BPM and process mapping, so their implementation is limited by a lack of professional and technological resources. In this context, software tools play an important role.

Specific software tools for digitizing business process mapping and BPM in general are listed in the following table 1.

Table 1 Software tools for digitizing business process mapping

Business process mapping tool	SAP (2025)	IBM (2025)	Dreher (2025)	Microsoft (2025)	Gupta (2025)	Gartner (2025)	Miro (2025)	Covel (2025)	Occurrence
Adonis			X			X			2
Apromore			X						1
Aris			X			X			2
BIC Platform						X			1
Bizagi Modeler								X	1
Cacoo					X				1
Camunda			X						1
Celonis			X						1
Creately					X			X	2
EdrawMax					X				1
GitMind					X				1
IBM Blueworks Live		X				X			2
iGrafx			X			X			2
Lana			X						1
Lucidchart					X			X	2
Microsoft Visio			X	X	X	X		X	5
Miro					X		X	X	3
SAP Signavio Process Manager	X		X			X			3
Trisotech			X						1

Source: own processing

The analysis of tools illustrates that the BPM software tools market is fragmented and provides solutions ranging from traditional to complex BPM Suite solutions. Individual software tools differ in the degree of extensions, integration, functionalities, deployment models, level of support for business process mapping in enterprises and other parameters. A comparative analysis of the mentioned software tools for the digitalization of business process mapping and for BPM in general shows that the most frequently mentioned BPM tools are: Microsoft Visio, SAP Signavio Process Manager and Miro. Microsoft Visio has a dominant position, providing a comprehensive solution and having an intuitive user interface, integration with the MS Office package, high availability and compatibility with the BPMN standard. SAP Signavio Process Manager is a highly robust cloud system for advanced analysis and integration with ERP solutions, supports BPMN 2.0 and is mainly used in large enterprise architectures. Miro represents a modern collaborative tool for visual facilitation of processes, thereby supporting distributed environments and agile teams in enterprises. Other less common software BPM tools represent established BPM solutions or tools with specialized functionalities.

4 Conclusions

Business Process Management (BPM) is a holistic management discipline focused on improving the performance of companies through the management of their business processes. BPM includes various methods, techniques and tools to support the identification, design, mapping, modelling, implementation and optimization of processes in order to support business goals. In the context of a dynamic business environment, economic challenges, Industry 4.0, BPM is profiled as a strategic tool enabling the optimization of business activities, thereby also ensuring the support of decision-making in the company. Business process mapping as an integral and primary part of BPM plays a fundamental role in the identification, analysis and design of processes. The digitalization of business process mapping supported by BPM software tools and standards fundamentally changes the means of documenting and managing processes. The importance of BPM is also confirmed by the growing scientific and industrial interest in this area, while BPM is positioned as a driving force for increasing efficiency in companies and achieving sustainable business growth.

Not only from the theoretical basis, but also from the analysis of the state in business practice, we have found that BPM is gaining increasing strategic importance in companies, across various size categories of companies. Its importance is increasing especially in the context of Industry 4.0 and the emphasis on the digital transformation of companies, where digitalization and the use of digital technologies play an important role. The historical development of business process mapping also points out in the analytical part a fundamental transformation from an analog format to a digital format. The transformation of process mapping occurred from traditional, informal and ad hoc approaches, where business processes were carried out intuitively, were not managed at all and were without a systematic understanding. Subsequently, paper-based mapping began to be used, in which processes were recorded manually in the form of text descriptions and informal diagrams. The development towards digitalization occurred with the emergence of office software, when processes were already recorded digitally in text form. Gradually, not only the classic description of the algorithm of activities was used, but also flowcharts. In the 1990s, a fundamental shift in digitalization occurred, when specialized software tools were created that enabled standardized process modelling, including process mapping, advanced analysis, automation, optimization, and integration with other information systems in enterprises.

Based on the analysed statistical data from various research studies, it can be stated and highlighted that there is significant growth, diversification, and digitalization shift in BPM indicators. The main findings show that: the market value in 2024 is estimated to reach between 15.4 and 17.8 billion USD, with forecasts predicting an increase to 70.93 billion USD by 2032 with an annual CAGR of 18.6%; larger enterprises have longer implementation and use of BPM; BPM maturity is increasing; There is a visible shift from traditional, paper and office methods to digital tools in business process mapping and BPM, with 39% of companies using them; 70% of companies use at least one BPM tool; 82% of companies use paper or manual process mapping (mainly Excel); only less than 3% of companies do not model processes at all and up to 89% of companies perceive that BPM software tools, including tools for process mapping, are important. The main obstacles are: lack of BPM experts, low acceptance in the company, lack of training and education, and low support from company management.

Digital tools in process mapping and in BPM in general represent the main pillar of BPM and we recommend that companies, for better efficiency and digitalization of process mapping:

- ensure full support from the company's management in BPM;
- implement and use BPM in business;
- introduce BPM software tools and thereby replace the original manual and office tools;
- focus on cloud solutions for software tools and the use of digital Industry 4.0 technologies in them;
- provide experts in the field of BPM and process mapping;
- provide employee education in the field of BPM, including training courses;
- assign an owner/responsible person to each process, who will ensure their updates and continuous improvement;
- evaluate process performance through KPIs;
- ensure the integration of BPM tools with other information systems in the company (e.g. ERP, CRM, SCM and others);
- regularly optimize business processes, including updating process maps.

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The Future of Work in the Age of Artificial Intelligence

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Abstract: The research investigates how artificial intelligence (AI) reshapes labour markets, focusing on job composition, evolving skill demands, and changes in HR practices. The analysis reveals that AI can simultaneously promote efficiency and the creation of new high-skill positions while exacerbating labour market polarization and eroding stable employment forms. The scope and intensity of these effects vary significantly across sectors, occupational categories, and institutional environments. The results highlight that techno-logical progress is not inherently inclusive; rather, its impact depends on how technology is integrated into organisational and social frameworks. Employee involvement, training and retraining systems, and effective social dialogue emerge as key determinants of equitable adaptation. The study concludes that the governance of technological change, rather than technology itself, will shape the future configuration of labour markets.

Keywords: labour market, artificial intelligence, future of work

JEL Classification: E24 · E32 · J24 · L86 · O15 · O29

1 Introduction

Artificial intelligence (AI) has become a catalyst of structural transformation in the labour market, influencing not only productivity but also the very nature of employment relations. While its early diffusion was concentrated among large IT corporations, smaller and younger firms are increasingly adopting AI tools, expanding innovation capacity across diverse sectors such as services, research, and business (Damioli et al., 2024). The IT industry remains the most dynamic environment for observing these changes, where automation, algorithmic management, and outsourcing reshape work organisation and job stability (Doellgast, 2023). At the same time, AI's capacity for data-driven insight, for instance in predicting employee turnover through advanced models like LightGBM and logistic regression, illustrates its potential to enhance workforce planning and retention (Lazzari et al., 2022). However, the transformation extends beyond mere automation. The emergence of advanced and general AI enables convergence between previously separate fields—such as healthcare and data science—resulting in new professional domains that prioritise interdisciplinary expertise, creativity, and adaptive thinking (Giacomoni, 2022). Thus, AI operates simultaneously as a driver of efficiency and as an “enabling technology” that redefines qualifications, competences, and the structure of work itself.

2 Methods

This study employs a systematic qualitative literature review combined with thematic analysis to examine how artificial intelligence (AI) affects labour markets, employment structures, skill requirements, and human resource management practices. The objective is not merely to summarise existing research but to identify recurring patterns, dominant narratives, and points of divergence across empirical and conceptual studies. The methodological approach follows the principles of structured literature reviews and is informed by the PRISMA 2020 guidelines to ensure transparency and reproducibility.

The literature search was conducted using the Web of Science Core Collection database, which was selected due to its rigorous indexing standards and broad coverage of high-quality peer-reviewed journals in economics, management, and social sciences. The review focuses on articles published between 2020 and 2025, reflecting the period of accelerated AI diffusion and its increasing relevance for labour market research. Only publications written in English were considered.

The search strategy was designed to capture studies addressing both technological and socio-economic dimensions of AI. Boolean operators were used to combine keywords related to artificial intelligence and labour market outcomes. The core search query included combinations of the following terms:

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- “artificial intelligence”, “AI”, “machine learning”, “natural language processing”, “algorithmic management”, “digital transformation”,
- AND
- “labour market”, “employment”, “future of work”, “human resource management”, “skills”, “labour market dynamics”.

The search was conducted across titles, abstracts, and author keywords to ensure comprehensive coverage. Initial searches yielded more than 3,000 publications.

To ensure relevance and methodological quality, explicit inclusion and exclusion criteria were applied. Studies were included if they:

- Explicitly addressed the impact of AI or related technologies on employment, skills, working conditions, or HR practices,
- Were empirical studies, systematic literature reviews, or theoretically grounded conceptual papers,
- Were published in peer-reviewed academic journals.

Studies were excluded if they:

- Focused exclusively on technical or engineering aspects of AI without socio-economic implications,
- Were conference proceedings, editorials, commentaries, or non-peer-reviewed publications,
- Did not meet basic quality standards in terms of methodological clarity and scholarly contribution.

The selection process followed a multi-stage screening procedure consistent with the PRISMA framework. After removing duplicates, titles and abstracts were screened for relevance. The remaining articles were subjected to full-text review, during which the inclusion and exclusion criteria were applied more rigorously. This process resulted in a final sample of 39 studies, which formed the analytical basis of the review.

The selected studies were analysed using qualitative thematic analysis. Each article was systematically coded, and recurring themes were identified and grouped into higher-order analytical categories. Five core dimensions emerged from the analysis:

- Employment effects (job creation, displacement, and polarisation),
- Skill transformation and changing qualification requirements,
- Applications of AI in human resource management and workplace organisation,
- Sectoral and occupational heterogeneity of AI impacts,
- Institutional, regulatory, and governance factors shaping outcomes.

The analysis focused on identifying cross-study patterns, areas of convergence and divergence, and contextual factors influencing AI’s labour market effects. Rather than evaluating individual studies in isolation, the synthesis emphasises how findings collectively contribute to understanding the future of work in the age of artificial intelligence.

3 Research results

3.1 Artificial Intelligence Applications

Machine learning (ML) represents one of the core pillars of artificial intelligence and has become an indispensable tool for analysing complex data structures and predicting dynamic processes. Beyond traditional supervised and unsupervised learning, recent progress in reinforcement learning and particularly deep reinforcement learning, has enabled adaptive decision-making even under uncertain or incomplete data conditions (Shi et al., 2023). ML techniques are widely applied across domains (from healthcare and genomics to business intelligence), supporting prediction, classification, and causal inference. Meaningful integration of these methods requires a solid methodological framework encompassing data preprocessing, model tuning, and validation, while ensuring transparency, replicability, and ethical integrity (Cho et al., 2024). Another rapidly advancing field is Natural Language Processing (NLP), which focuses on enabling machines to

understand and generate human language. With the advent of deep learning and large-scale pre-trained models such as BERT and GPT, NLP systems have achieved remarkable progress in translation, sentiment analysis, and automated reasoning (Lauriola et al., 2022). In parallel, recommender systems have become an essential AI application in enterprise and HR information systems, where algorithms personalise recommendations for products, learning content, or career development based on user similarity or hybrid data-driven approaches (Yassine et al., 2021). Together, these technologies demonstrate how AI is not only automating routine processes but also expanding decision-making and analytical capabilities across organisational and social contexts.

3.2 AI in the Workplace

AI-driven automation is perceived differently across organisational hierarchies. Management emphasizes efficiency gains and strategic renewal, whereas employees more often associate it with job insecurity, stress, and upskilling pressure (Gómez Gandía et al., 2025). This asymmetry signals that digital transformation is not merely a technical upgrade but a socio-organisational process that reshapes worker–firm relations. Sustainable adaptation depends on participatory introduction, competence development, and transparent communication about technological change (Gómez Gandía et al., 2025). Human capabilities remain central. Social skills, domain know-how, and experience, combined with technical and cognitive skills, create complementary profiles that are difficult to decompose or fully automate, preserving the value of human interaction and adaptability even in AI-rich settings (Das, 2021). In HR, AI tools (ML, predictive analytics, chatbots) now support workforce planning, talent management, performance appraisal, and learning, shifting HR from an administrative burden to a strategic partner (Benabou & Touhami, 2025). Chatbots streamline recruiting and internal communications but still struggle with complex queries and require maintenance (Majumder & Mondal, 2021). Despite productivity improvements and faster decisions, full substitution of human labour is constrained by data quality, technical limits, and market conditions. The extent to which AI replaces or complements HR activities depends largely on market conditions and organisational strategy. In highly standardised markets, AI tends to substitute routine human tasks, whereas in more complex or innovation-driven environments, it often complements human expertise and supports hybrid collaboration models. Industry demand, strategic priorities, and available resources ultimately determine which of these approaches prevails (Das, 2021). Ethical and distributional issues accompany these gains. Automation of routine tasks can displace workers and create reskilling needs while opening new roles in AI oversight and strategic decision-making (Benabou & Touhami, 2025).

At the micro level, AI can raise engagement and performance by offloading routine work; at the firm level, it tends to lower costs and improve competitiveness but may also heighten uncertainty, stress, and perceived substitution risks, calling for robust change management and socio-technical interventions (Budhwar et al., 2022). At the macro level, digital transformation is positively associated with economic growth, labour productivity, and overall employment, particularly among women. However, its impact on vulnerable forms of employment remains limited unless supported by adequate social and legal protection measures (Aly, 2022).

AI adoption remains uneven across the economy. In 2017, only 5.8% of U.S. firms reported using AI, but the employee-weighted rate reached 18.2%, showing that adoption is concentrated in large enterprises and fast-growing startups capable of turning AI into process innovation. This unequal diffusion risks widening productivity and wage gaps between digital leaders and lagging firms. Adoption intensity also differs by sector. Information technology, healthcare, and manufacturing are at the forefront, while retail, transport, construction, and agriculture remain behind, making the effects on employment, skills, and inequality highly sector-dependent (McElheran et al., 2024). The impact of digital technologies varies by type. Exposure to robotics and traditional software is often linked to poorer working conditions, whereas AI adoption tends to improve job prospects by shifting focus from manual substitution to support for high-skilled tasks. However, deep participation in global value chains is still associated with weaker labour conditions and persistent gender disparities, particularly disadvantaging women and younger workers (Parteka et al., 2024); Serrano, 2025).

Current research indicates that augmentation, rather than full automation, dominates in knowledge-intensive sectors. AI primarily complements human labour (especially in research and development) by enhancing creativity, innovation, and decision-making, while complete automation remains concentrated in manufacturing. Job roles are being redefined rather than eliminated, increasing the value of adaptability and human–AI collaboration (Johnson et al., 2022). The balance between substitution and complementarity depends on economic and social conditions. Rising demand can strengthen complementarity, leading to higher wages and job creation (Das, 2021). The demand for AI-related skills has surged across industries, particularly in high-value, innovation-driven firms, which reward these competencies with wage premiums, whereas routine service roles are more prone to automation (Aleksieva et al., 2021).

Human resource management is undergoing a major transformation as AI reshapes recruitment, learning, and employee engagement. Hiring increasingly relies on AI-driven sourcing and screening, training shifts toward micro-learning, and engagement uses gamification (Kraus et al., 2023). Current AI technologies fall into the category of “weak AI,” meaning they execute specialised functions based on predefined algorithms without autonomous reasoning or general understanding. “Strong AI,” envisioned as human-level intelligence capable of independent learning, remains theoretical. Consequently, AI adoption currently leads to partial automation of routine activities while stimulating demand for highly skilled professionals able to design, manage, and collaborate with such systems (Zhang, 2023). Tools such as AR and VR can support workforce adaptation by enhancing training and real-time learning (Harborth & Kümpers, 2022). However, digitalization also raises concerns about privacy, oversight, and motivation (Shahid et al., 2025). Persistent labour costs following AI adoption suggest a complementary human–technology dynamic that heightens the demand for skills and continuous organisational learning (Wang & Qiu, 2023).

3.3 Towards an Inclusive Future of Work

The digital transformation of work is redefining skill requirements. In the early stages, demand centres on technical competencies, but as AI systems become more complex, domain expertise, interdisciplinary collaboration, and decision-making skills gain importance (Theben et al., 2023). Employers increasingly prioritise practical “hard skills” such as Python, SQL, and machine learning over formal qualifications, while traditional analytical roles decline due to automation (Liu et al., 2024). However, adoption remains uneven across the workforce. Highly educated employees adapt more easily to AI-driven change, whereas low-skilled positions face greater risks of substitution, deepening wage disparities (Zhang, 2023). To ensure inclusive adaptation, labour market policies must focus on targeted support, adaptive skill development, and continuous reskilling for vulnerable groups (Carbonero et al., 2023).

Evidence from China’s SMEs indicates stable overall labour demand, with low-skilled positions being replaced by automation while demand for AI-skilled professionals rises, reflecting simultaneous job displacement and creation (Xu et al., 2024). AI competencies carry a wage premium of around 21%, highlighting their growing market value (Stephany & Teutloff, 2024). To ensure inclusive growth, policy efforts should focus on expanding digital infrastructure, strengthening education and lifelong learning, and fostering collaboration between industry and training institutions (Shen, 2024; Badulescu et al., 2025; Theben et al., 2023). At a broader scale, AI’s employment effects vary by institutional and innovation capacity. In the EU, job growth linked to AI is concentrated in advanced innovation economies, while less-developed regions see weaker benefits (Guarascio & Reljic, 2025). These asymmetries confirm that AI outcomes are shaped by political, economic, and organisational factors rather than technological determinism. In developing economies, digitalisation supports productivity and female employment but has limited influence on vulnerable work without complementary social protections (Howcroft & Taylor, 2023).

Effective AI diffusion depends on economic coordination and governance. Rather than taxing automation, targeted subsidies and coordinated state support can promote balanced adoption adapted to each country’s technological maturity (Ünveren et al., 2023). Maintaining human oversight in AI-driven decision-making ensures that efficiency is balanced with ethical and contextual judgment, while education systems and employers must foster adaptability, agility, and lifelong learning to manage technological change (Ashta & Herrmann, 2021). Broader policy initiatives such as basic income, retraining programs, and automation taxes reflect concerns about preserving autonomy, accountability, and decent work in algorithmic management (Santoni de Sio, 2024).

The functioning of labour markets remains closely tied to education and skill formation: employment outcomes improve with digital and communication competencies, highlighting the need for curricula aligned with the digital economy (Crețu et al., 2025). In recruitment, AI reduces costs and bias, but talent shortages persist; low labour supply elasticity underscores the importance of internal reskilling and strong education–industry partnerships as key strategies for sustainable workforce development ((Black & van Esch, 2020); (Duch-Brown et al., 2022); (Theben et al., 2023)).

4 Conclusions

This paper set out to analyse how artificial intelligence reshapes labour markets by synthesising evidence from 39 peer-reviewed studies published between 2020 and 2025. Rather than treating AI as a uniform technological force, the analysis reveals a highly differentiated set of impacts shaped by sectoral conditions, organisational strategies, skill structures, and institutional environments.

Across the reviewed literature, a consistent pattern emerges that artificial intelligence predominantly augments human labour in knowledge-intensive and innovation-driven sectors, while substitution effects are concentrated in routine, standardized, and low-skilled tasks. The analysed studies do not support a narrative of widespread technological unemployment. Instead, they point to job transformation and task reconfiguration as the dominant outcome, with employment effects varying significantly across occupations and industries.

A second robust finding concerns skill transformation. The reviewed studies converge on the conclusion that AI adoption increases demand for advanced technical competencies while simultaneously elevating the importance of complementary human skills such as problem-solving, creativity, domain expertise, and social interaction. At the same time, the literature highlights a growing risk of labour market polarisation, as highly educated workers adapt more easily to AI-driven change, whereas low-skilled workers face higher displacement risks unless supported by reskilling and lifelong learning systems.

In the domain of human resource management, the analysis shows that AI primarily functions as a supportive and enabling tool rather than a full substitute for human decision-making. AI applications in recruitment, performance management, and learning systems improve efficiency and data-driven insight but remain constrained by ethical concerns, data quality, and contextual judgment requirements. The reviewed studies consistently emphasize that the effectiveness of AI in HR depends on organisational governance, transparency, and employee involvement.

At the macro level, the literature analysed in this review indicates that AI adoption is generally associated with productivity growth and, in some contexts, net employment gains. However, these positive effects are unevenly distributed, benefiting primarily advanced innovation economies and large firms with sufficient absorptive capacity. Without complementary institutional frameworks such as active labour market policies, education reform, and social protection mechanisms, AI diffusion risks reinforcing existing inequalities rather than mitigating them.

Overall, the findings of this review confirm that technology itself is not the decisive factor shaping labour market outcomes. Instead, outcomes are mediated by governance structures, organisational choices, and the capacity of societies to invest in human capital and institutional adaptation. The future of work in the age of artificial intelligence will therefore depend less on the pace of technological innovation and more on how effectively economic actors manage its integration into social and organisational systems.

By systematically synthesising recent empirical and conceptual research, this study contributes to a more nuanced understanding of AI's labour market effects and highlights the need to move beyond deterministic narratives. Future research should focus on comparative empirical analyses across sectors and regions, as well as longitudinal studies capturing the long-term consequences of AI-driven transformation for employment quality, inequality, and work organisation.

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Artificial Intelligence in Compliance and Corporate Governance – Risk or Opportunity?

Corinna Elisabeth Frommelt¹, Christian Toros²

Abstract: The exploitation of artificial intelligence (AI) seems to be limitless and has therefore increasingly become a top trend topic in research and practice. This article deals with AI in the field of compliance and corporate governance. Since the topic of AI and compliance has hardly been addressed in the literature to date, the authors approach the subject by examining AI and corporate governance, another sensitive business management topic. Using the Gioia methodology, this article analyzes the current state of AI in corporate governance literature. While the possibilities and advantages of AI are often highlighted, there are also a number of open questions, risks associated with AI and, consequently, essential conditions that must be met for the successful use of AI. The results indicate that the risks and concerns of AI applications currently appear to predominate, which is why it must be the task of research and practice to find ways to address the doubts to exploit the full potential of AI also in sensitive business areas such as corporate governance.

Keywords: artificial intelligence, AI, compliance, corporate governance, Gioia methodology

JEL Classification: K20, L20, O33

1 Introduction

Several studies advocate the view that the emergence of a business world in which the comprehensive application of artificial intelligence (AI) is virtually ubiquitous represents one of the key developments currently influencing corporate practice (Haefner et al., 2023, p. 2). However, there are currently still many question marks surrounding the concept of AI. It therefore comes as no surprise that there is still no generally acknowledged understanding of the term (Stewart et al., 2020, p. 135). An additional complication is that various approaches are taken in academia to explain AI, which can vary slightly, particularly depending on the scientific discipline and the respective perspective on AI (Sobrinho-García, 2021, p. 14). A common view of AI from an economic perspective interprets it as a structural concept respectively process with the capacity to acquire new knowledge and execute thought processes in order to accomplish challenges that would otherwise require the intelligence of people (Malin et al., 2023, p. 2). Another reason why AI is so difficult to capture and describe is that it is not just one technology, but rather a range of different technologies that are grouped together under the overarching label of AI (Aaltonen & Kurvinen, 2025, p. 3). In the study of Banh and Strobel (2023, p. 63), a hierarchical structure of AI is clearly visualized. It shows that machine learning, deep learning, and generative AI are integral elements of AI. However, in order to better understand this structure, it is first necessary to take a closer look at the structural composition of AI. While machine learning is considered a minor category of AI (Herrmann, 2022, p. 5), deep learning forms an under-level group of machine learning (Banh & Strobel, 2023, p. 3), whereas generative AI is regarded as a component of deep learning (A. Kumar et al., 2025, p. 1). Machine learning can be applied to generate forecasts with regard to the allocation of information into meaningful groups, which is achieved with the support of a large number of calculation methods (Stewart et al., 2020, p. 138). The technological operating mode of deep learning, by contrast, utilizes so-called neural networks and can be useful for examining extensive amounts of information for meaningful interconnections (Banh & Strobel, 2023, p. 3). Generative AI can be used to create different types of materials as a result of previously imported information. These new materials can, for example, take the form of written documents or be designed as illustrations (Akanfe et al., 2025, Section “2.2.1 Generative AI and Financial Inclusion”). Particular importance is attached to generative AI, which is considered a major development of our time (Pedota et al., 2025, p. 1).

Innovations in the field of AI are challenging our existing knowledge and current approaches in business and management. AI is even changing the nature of competitive advantage and people need to acquire new capabilities (Krakowski et al., 2023, p. 1427). Many advantages are seen in literature by using AI. By processing large data volumes rapidly, AI can improve decision-making in companies (Hickman & Petrin, 2021, p. 619), can be used in methods of fault detection and diagnosis (Zhao et al., 2019), and benefits many different industries such as health care in multiple ways, e.g. AI-based supply chain management (Damoah et al., 2021) or customer relationship management (P. Kumar et al., 2023).

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AI can be used in different branches and disciplines such as human resource management (Nawaz et al., 2024; Rodgers et al., 2023; Vrontis et al., 2022), service industries (Mariani & Borghi, 2024), hospitality and tourism branch (Dwivedi et al., 2024), hotel industry (Nam et al., 2021) or manufacturing (Zeba et al., 2021). AI and other Industry 4.0 technologies such as big data or blockchain can also improve corporate governance as well as risk management and therefore innovation and global collaboration activities are required to exploit their full potential (Meiryani et al., 2023, p. 76). This enthusiasm in literature gives the impression that there are no limits to the use of AI, AI technologies and the resulting opportunities. At the same time, literature also emphasizes concerns and possible threats of using AI in corporations, such as discriminatory and fraudulent aspects, violations of data protection and privacy (Hickman & Petrin, 2021, pp. 619–620). Even if the use of AI is accompanied by a large number of improvements, there are hardly any regulations on AI available (Hickman & Petrin, 2021, p. 594). Next to the realization of AI technologies' potential, companies and governments need to address how standards can be established to ensure the use of AI is safe and ethical (Albalawee & Fahoum, 2024, pp. 8–9), to mention just one open issue. All in all, considering the areas of application for AI described above, it becomes apparent that AI is being discussed from different perspectives in almost all business areas.

However, science and practice do only pay little attention to AI in sensitive business areas such as compliance or corporate governance. Since AI opens up so many possibilities, it should be examined what opportunities, efficiency increases, and quality improvements are possible in this special discipline to foster efficient corporate governance and to avoid compliance violations. There is great potential that AI can advance and foster compliance and corporate governance, which is worth analyzing this topic in depth. At the same time, we do not yet know what organizations can do to fully exploit the potential of AI, what challenges need to be addressed and what outstanding issues need to be clarified. Findings are highly relevant from a theoretical perspective but also have practical implications for compliance management in organizations and can provide insights into the future of AI.

The purpose of this article is to provide an overview of AI in compliance and corporate governance, taking into account current issues in literature. Since there is hardly any literature on how AI can be used in a compliance context, this article focuses merely on the equally sensitive area of corporate governance. As compliance is an important aspect of corporate governance, the findings can be applied to both areas. By following the Gioia methodology (D. A. Gioia et al., 2013), the authors are contributing to a better theoretical understanding of the current literature on AI in compliance and corporate governance. The main findings suggest that the use of AI in corporate governance offers many different benefits and improvements, but concerns currently (still) outweigh these, compounded by unresolved issues and non-trivial conditions that must be met for the successful use of AI in corporate governance.

2 Methods

The intention of qualitative research is to simplify complex phenomena by employing theoretical models (D. Gioia et al., 2022, p. 236). The Gioia methodology is increasingly being used as a new qualitative approach in various areas (e.g. Magnani & Gioia, 2023; Sankaran et al., 2024; Suleiman & Othman, 2021). The special characteristic of the Gioia methodology is that concepts are formed inductively, although the rigor required in qualitative research is also considered (D. A. Gioia et al., 2013). The Gioia methodology refers to the qualitative analysis of interviews (D. A. Gioia et al., 2013, p. 19), but it is also used for article analysis, e.g. in the field of business intelligence and business analytics to provide a comprehensive reflection of the current state of research (Jiménez-Partearroyo et al., 2024, p. 2295).

As previously described, there is hardly any literature dealing with AI and compliance, which is why the focus is set on literature concerning AI and corporate governance. Even though the topics are not directly interchangeable, rule-compliant behavior in line with corporate compliance is an essential component of corporate governance. In order to comprehensively explore the topic of AI and corporate governance in current literature, this paper follows a qualitative approach, using the Gioia methodology (D. A. Gioia et al., 2013). The Gioia methodology starts with specific research, such as literature articles, and ends up with findings that are theoretical and abstract (Jiménez-Partearroyo et al., 2024, p. 2294). The authors apply the Gioia methodology (D. A. Gioia et al., 2013) through the following steps, based on Jiménez-Partearroyo et al. (2024, pp. 2294–2295).

1. Data Collection:

By using the keyword search in literature database Scopus, articles which address AI or AI applications in the area of corporate governance are identified. Those articles contribute to a better understanding of the phenomena of interest. In the subsequent selection of articles, it was important that the focus was not on the question of how AI can be used compliantly, but on how AI itself can be used in the area of corporate governance.

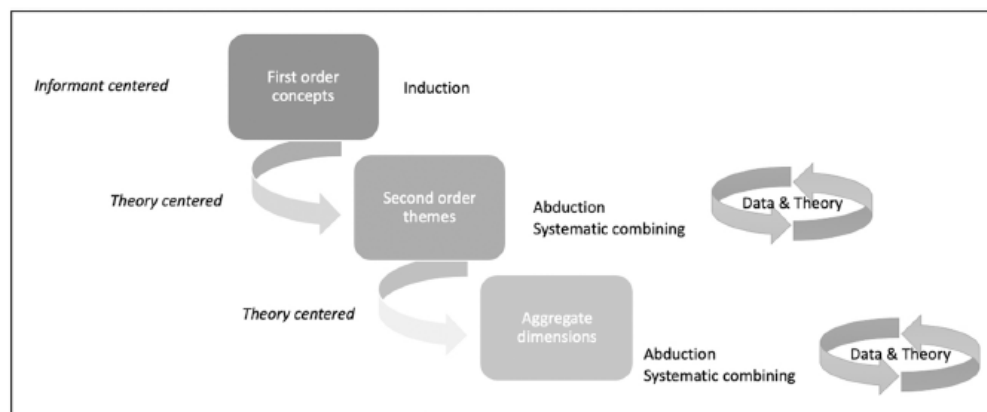
2. Data Analysis:

The data from the selected articles were evaluated using the Gioia methodology, whereby a first order analysis is carried out first, in which initial efforts are made to form categories, closely following the terminology of the data source (D. A. Gioia et al., 2013, p. 20). In this step, a large number of first order categories can be identified in the data material (D. A. Gioia et al., 2013, p. 20). In a second step, the first order categories are reduced by identifying similarities and differences in order to describe these categories more abstractly, whereby an attempt is made to recognize a deeper structure by simultaneously considering numerous first order and rather theoretical second order categories (D. A. Gioia et al., 2013, p. 20). The extent to which the second order themes can be further aggregated to dimensions is examined in a last step (D. A. Gioia et al., 2013, p. 20).

3. Conceptual Framework Development/Data Structure

With the help of a data structure, one can not only present the view of informants (or in this case the experience of the authors of the articles), but also introduce a further theoretical view by highlighting key aspects and their connections (Magnani & Gioia, 2023, p. 2). Using the analyzed first order concepts, second order themes and aggregate dimensions, a data structure can be visualized that shows the analysis process (D. A. Gioia et al., 2013, pp. 20–21). The process of finding a data structure is illustrated in figure 1.

Figure 1 The inferential process in developing a data structure



Source: Magnani and Gioia (2023, p. 4)

4. Theory Generation:

The aim is to develop a comprehensive model, based on data, considering the relationships among the central aspects of the subject in a dynamic way, which also shows the transition from data to theory (D. A. Gioia et al., 2013, p. 22). Following this approach, the authors therefore contribute to theoretical insights about AI and corporate governance.

3 Research results

In the following section the authors present the descriptive results as well as the results of the content analysis of conducting the Gioia methodology (D. A. Gioia et al., 2013).

3.1 Descriptive results

To perform the analysis, the authors first searched for relevant literature in the Scopus literature database using appropriate search and filter functions. The following specific query string was used to identify articles in journals that deal with AI and corporate governance:

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(TITLE("Artificial Intelligence" OR "AI") AND TITLE("corporate governance")) AND ( LIMIT-TO ( EXACTKEYWORD,"Corporate Governance" ) OR LIMIT-TO ( EXACTKEYWORD,"Artificial Intelligence" ) OR LIMIT-TO ( EXACTKEYWORD,"Ai" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) ) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )
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At the time of evaluation, there were 23 contributions. In a second step, papers were chosen that deal with AI and corporate governance in general, i.e. without thematizing a specific AI application. The correct context also has to be addressed, which is why articles that focus on the corporate governance of AI were excluded. Articles that performed bibliometric analyses were also excluded, as the Gioia methodology (D. A. Gioia et al., 2013) is hardly applicable to this

type of article, since concrete content is to be analyzed. The articles presented in table 1 were selected for conducting the analysis according to the Gioia methodology (D. A. Gioia et al., 2013).

Table 1 Overview of selected papers

Author(s)	Year	Titel	Journal
Bello y Villarino, J-M. & Bronitt, S.	2024	AI-driven corporate governance: a regulatory perspective	Griffith Law Review
Hilb, M.	2020	Toward artificial governance? The role of artificial intelligence in shaping the future of corporate governance	Journal of Management & Governance
Kalkan, G	2024	The impact of artificial intelligence on corporate governance	Journal of Corporate Finance Research
Ustahaliloğlu, M. K.	2025	Artificial intelligence in corporate governance	Corporate Law & Governance Review

Source: Table created by the authors.

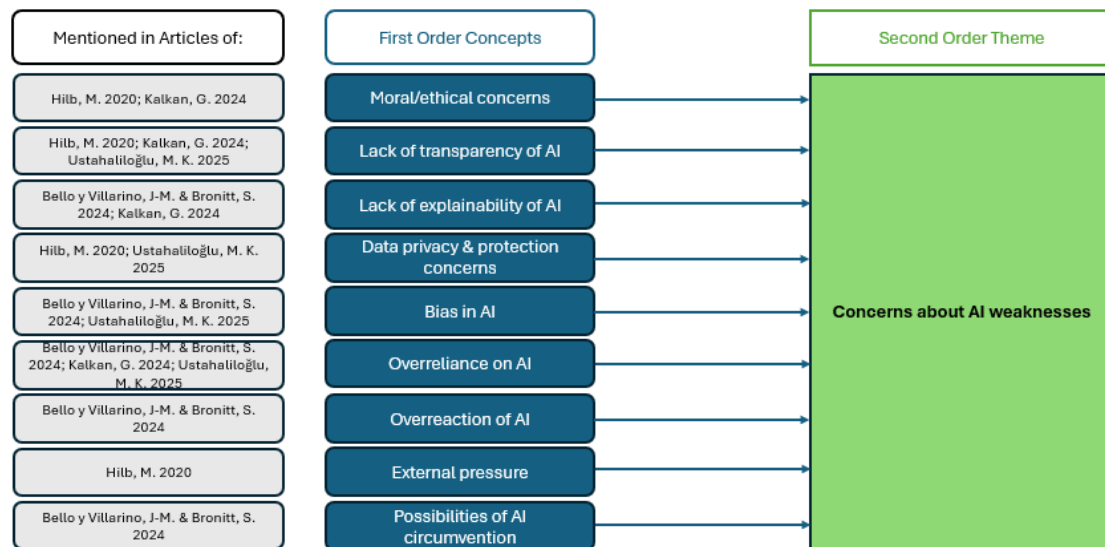
With the exception of the article of Hilb (2020), these are very recent contributions, whereby Hilb is of course most frequently cited, taking into account the publication date. The journals are related to both law and business or management.

3.2 Content analysis

By applying the Gioia methodology (D. A. Gioia et al., 2013), several first order concepts were identified in literature, resulting in more abstract second order themes and finally two major aggregate dimensions. The data structure is presented in detail in the following section.

The first second order theme, “concerns about AI weaknesses”, was easily identified in the selected literature, as there are several aspects that raise doubts about the use of AI in corporate governance. One first order concept addresses the moral and ethical concerns regarding the use of AI in the context of corporate governance, Hilb (2020, p. 860) refers to a “central concern” and highlights that decisions require a moral foundation and corresponding principles that also reflect the values of a company. The lack of transparency can also be attributed to this second order theme, as transparency is not only crucial for successful corporate governance itself, but also poses a major difficulty when integrating AI into companies (Kalkan, 2024, p. 18). A similar aspect concerns the lack of explainability of AI decisions. For example, when an operation is identified as suspicious by automated compliance management systems (ACMS), it must not be subject to the black box effect in order to maintain trust in these AI applications (Bello y Villarino & Bronitt, 2024, p. 366). In addition, the processing of large amounts of data, especially sensitive data, by AI algorithms raises serious concerns regarding data security and data privacy (Ustahaliloğlu, 2025, p. 130). Another important aspect to consider are biases in AI applications, which can be caused by already existing biases in the training data sets (Bello y Villarino & Bronitt, 2024, pp. 366–367), which can potentially result in discrimination (Ustahaliloğlu, 2025, p. 129). Furthermore, the use of AI in the field of corporate governance carries the risk of overreliance, leading to a fatal reduction in necessary human engagement (Bello y Villarino & Bronitt, 2024, p. 368; Ustahaliloğlu, 2025, p. 129). Bello y Villarino and Bronitt (2024) have also identified two further weaknesses of AI in the area of corporate governance. There is a possibility that fraudulent companies could circumvent AI applications, such as ACMS, or that ACMS overreact, for example due to abrupt new circumstances resulting in indicating plenty of “suspicious” operations (Bello y Villarino & Bronitt, 2024, pp. 367–368). In particular, the circumvention or manipulation of AI applications can be critical in the areas of corporate governance and compliance. AI can be used by companies as window dressing, i.e. companies give the impression of being particularly compliant, because this is supposedly achieved through the use of AI. Another interesting aspect, which can also be attributed to this second theme is the external pressure from economy to implement AI-based corporate governance to benefit from its advantages (Hilb, 2020, p. 867). Due to this external pressure, it is possible that immature AI solutions will be implemented or that companies will use AI applications without having acquired the skills they need to handle AI-driven corporate governance. An overview of the different first order concepts, assigned to the second order theme “concerns about AI weaknesses” is provided in figure 2.

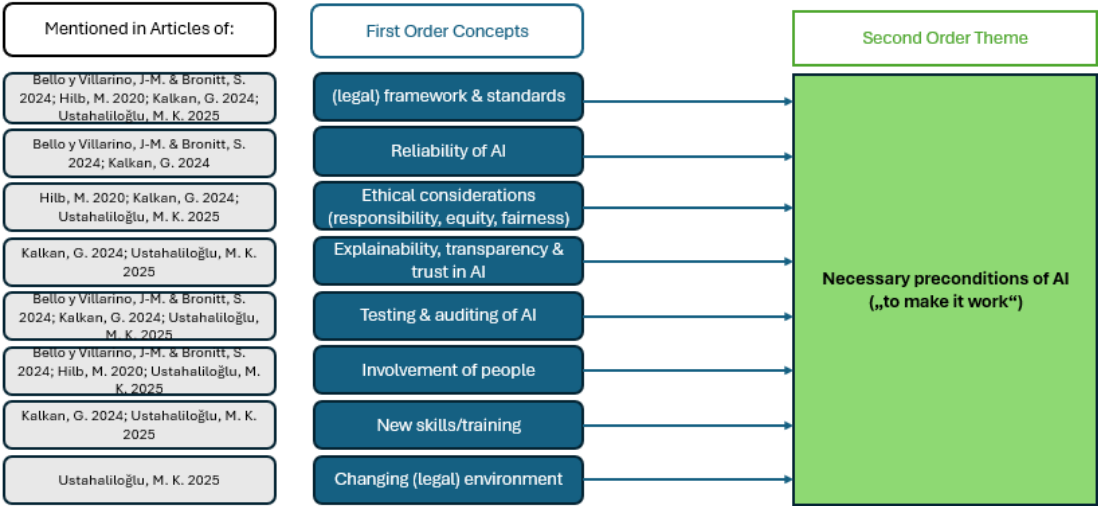
Figure 2 Second order theme “concerns about AI weaknesses” obtained using the Gioia methodology (D. A. Gioia et al., 2013)



Source: Authors' compilation from selected articles.

Logically, in addition to the concerns, there are equally many aspects that must be fulfilled to successfully use AI in the area of corporate governance, which already relate to some of the concerns mentioned above. These first order concepts can be summarized under the second order theme “necessary preconditions of AI”. According to Hilb (2020, p. 858), the discussion about a solid legal basis is not yet complete. However, it seems necessary to define regulatory standards regarding AI usage (Bello y Villarino & Bronitt, 2024, p. 370; Ustahaliloğlu, 2025, p. 130), while AI related frameworks are intended to serve ethical aspects in particular (Kalkan, 2024, p. 23; Ustahaliloğlu, 2025, p. 125). Emphasizing aspects such as “fairness” and “accountability”, organizations can introduce procedures to ensure unbiased AI algorithms (Ustahaliloğlu, 2025, p. 125). One of the main purposes of the standards is to define the reliability of AI applications such as ACMS (Bello y Villarino & Bronitt, 2024, p. 370), which is why the reliability of AI applications is another important condition for the successful use of AI. Further ethical considerations such “equity and fairness in AI algorithms” (Ustahaliloğlu, 2025, p. 124) represent fundamental preconditions to be fulfilled in the development and usage of AI, as well as the responsibility that comes with the use of AI (Hilb, 2020, p. 867), especially with regard to preventing misuse (Hilb, 2020, p. 860). The lack of transparency and explainability were significant concerns, which is why it seems understandable that fulfilling these aspects contributes significantly to the success of AI use in corporate governance. According to Kalkan (2024, p. 21), the academic literature calls for “transparency by design” and “meaningful explainability” in particular. In this context, building trust in AI is of paramount importance and a key task, which ultimately could be achieved through strong explainability (Kalkan, 2024, p. 23). Regular testing (Bello y Villarino & Bronitt, 2024, p. 368), regular auditing of AI systems (Ustahaliloğlu, 2025, p. 131) and especially ethical auditing (Kalkan, 2024, p. 23) serve to ensure that AI systems function correctly and ethically. The use of AI in corporate governance also requires the acquisition of new management skills (Kalkan, 2024, p. 19) and requires further training of the workforce of a company to address ethical aspects (Ustahaliloğlu, 2025, p. 131). It also seems important that many relevant stakeholders are involved in the development and implementation of AI applications (Bello y Villarino & Bronitt, 2024, p. 371), company management in particular can make a significant contribution (Hilb, 2020, p. 867). In addition, it is necessary to stay up to date and adapt to legal changes in the context of AI (Ustahaliloğlu, 2025, p. 127). An overview of the different first order concepts, assigned to the second order theme “necessary preconditions of AI” is provided in figure 3.

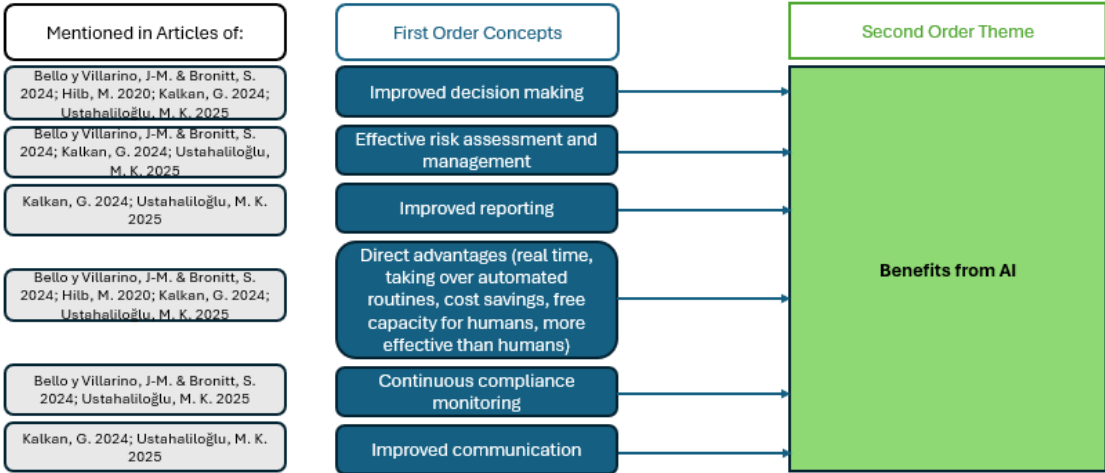
Figure 3 Second order theme “necessary preconditions of AI” obtained using the Gioia methodology (D. A. Gioia et al., 2013)



Source: Authors’ compilation from selected articles.

The multitude of concerns and preconditions are contrasted by just as many advantages offered by AI, such as improved decision making. AI-driven decision making is not only a reliable approach (Hilb, 2020, p. 866), but also fast and effective (Ustahaliloğlu, 2025, p. 130). Companies also benefit economically from improved risk management, since AI enables risks to be countered at an early stage (Ustahaliloğlu, 2025, p. 128), including the risk of non-compliance (Bello y Villarino & Bronitt, 2024, p. 360). Improvements through AI are also evident in other business disciplines, such as enhanced company communication (i.e. with shareholders) (Ustahaliloğlu, 2025, p. 125), continuous compliance monitoring (Bello y Villarino & Bronitt, 2024, p. 370; Ustahaliloğlu, 2025, p. 129) and optimized reporting considering diverse requirements (Ustahaliloğlu, 2025, p. 129). AI will improve the ability of organizations to steer themselves compared to human capabilities (Hilb, 2020, p. 867). The obvious, direct advantages resulting from the superior performance of AI in corporate governance, compared to human capabilities are outlined, such as the cost effectiveness (Bello y Villarino & Bronitt, 2024, p. 362) and cost savings (Ustahaliloğlu, 2025, p. 124), time or speed advantages (Bello y Villarino & Bronitt, 2024, p. 362; Ustahaliloğlu, 2025, p. 129) and the automation of routine activities, which results in free capacity of employees otherwise employable in more strategic areas (Ustahaliloğlu, 2025, p. 124). An overview of the different first order concepts, assigned to the second order theme “benefits from AI” is provided in figure 4.

Figure 4 Second order theme “benefits from AI” obtained using the Gioia methodology (D. A. Gioia et al., 2013)

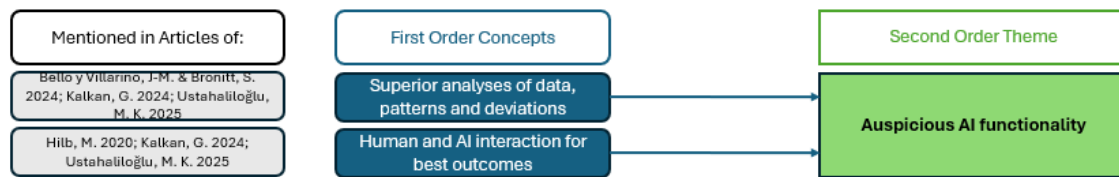


Source: Authors’ compilation from selected articles.

The promising functionality of AI is also discussed and represents another second order theme. Its superior functionality enables the above-mentioned benefits of AI. In detail, reference is made to the various data sources and the large amounts of data that can be processed by AI to identify patterns and compliance deviations (Ustahaliloğlu, 2025, pp. 128–129). Another aspect concerning the functionality of AI relates to interaction with humans, which seems to be crucial, as the greatest intelligence effectiveness can be achieved with the “synergic” approach (Hilb, 2020, pp. 861–862). An overview

of the different first order concepts, assigned to the second order theme “auspicious AI functionality” is provided in figure 5.

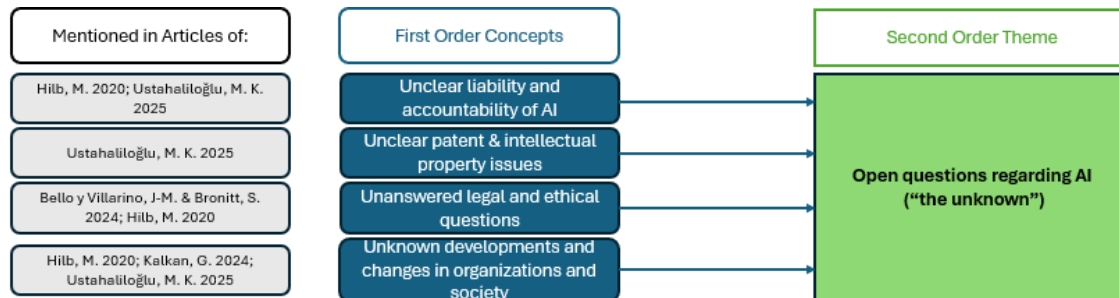
Figure 5 Second order theme “auspicious AI functionality” obtained using the Gioia methodology (D. A. Gioia et al., 2013)



Source: Authors’ compilation from selected articles.

It is evident that AI as a new subject also raises open questions, which are addressed in the selected literature and represent another second order theme of primary importance. There is the important legal question of liability (Hilb, 2020, p. 866; Ustahaliloğlu, 2025, p. 126) and accountability (Ustahaliloğlu, 2025, p. 126) of AI applications. Another unclear legal aspect relates to the question of who is the originator of AI-based innovations (Ustahaliloğlu, 2025, p. 130). In general, AI results in a multitude of legal and ethical issues that need to be discussed, e.g. concerning human will (Hilb, 2020, p. 867). The need for a new legal system is also being addressed (Bello y Villarino & Bronitt, 2024, p. 364). In addition, there is general uncertainty, e.g. about the maturity of AI (Ustahaliloğlu, 2025, p. 123), but also about the general development of AI and society’s response to it (Hilb, 2020, p. 867). An overview of the different first order concepts, assigned to the second order theme “open questions regarding AI” is provided in figure 6.

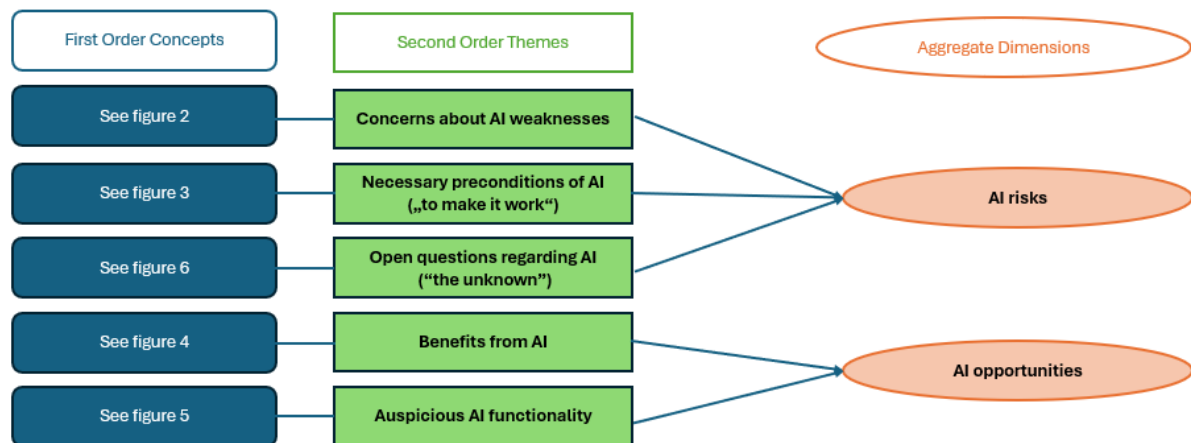
Figure 6 Second order theme “open questions regarding AI” obtained using the Gioia methodology (D. A. Gioia et al., 2013)



Source: Authors’ compilation from selected articles.

A large number of interesting first order concepts were identified in the literature and have already been assigned to five different second order themes. Looking at the second order themes, two aggregate dimensions can be formed from the data. This results in the dimension of AI risks, which arises not only from concerns about AI itself, but also from the necessary conditions that, if not met, pose a significant risk for the successful use of AI. Unanswered questions and unknown developments also contribute significantly to the risks posed by the use of AI. There is also the dimension of AI opportunities, summarizing the great potential offered by AI. This category includes the benefits of AI and its promising, outstanding functionality. An overview of the resulting data structure is provided in figure 7.

Figure 7 Data structure for AI in corporate governance obtained using the Gioia methodology (D. A. Gioia et al., 2013)



Source: Authors' compilation from selected articles.

4 Conclusions

By using the Gioia methodology (D. A. Gioia et al., 2013), the authors were able to shed light on the topic of AI in the sensitive topics of compliance and corporate governance. It is striking that research on AI in corporate compliance is still in its early stages. Corporate compliance is an essential component of corporate governance, which is why the focus of the analysis was placed on relevant literature that examines AI in corporate governance. The results show that AI in corporate governance is a highly controversial issue, with significant risks and challenges on the one hand and immense potential on the other. This has practical implications for compliance officers and company management. Companies should actively leverage and apply the advantages of AI in the areas of compliance and corporate governance, but it seems crucial to be aware of the risks described above and to address them responsibly. It also requires a joint effort by researchers, practitioners and governments to answer open questions and define a common framework for the future use of AI technologies.

Compliance and corporate governance are linked by the importance of adhering to rules and laws, which is why the results could apply to both areas. However, it is important to keep in mind that the two topics are not synonymous. It is therefore recommended to analyze AI in a purely compliance context in future research. The aim of this paper is to capture the big picture of AI in corporate governance, i.e. to abstract and summarize the topic, which is why not all aspects mentioned in the selected literature could be covered in detail. Another limitation is that the selected literature considers corporate governance from different perspectives, e.g. with a stronger regulatory perspective or stronger focus on compliance. Occasionally, AI also appears to be considered in isolation without a focus on corporate governance or compliance. In general, the topic of AI in compliance and corporate governance does not yet seem to have been sufficiently addressed. Further research should therefore focus on the identified first order concepts, in particular to determine precise ways in which preconditions for successful AI use can be fulfilled and, of course, to answer open questions and dispel concerns related to AI. Similarly, the potential and functionalities of AI seem far from exhausted and hold further groundbreaking insights especially with regard to compliance and corporate governance. Finally, the full potential of AI use in companies can only be fully exploited once ways have been found to meet the challenges posed by AI (Ustahaliloğlu, 2025, p. 131). This is also relevant for sensitive areas such as compliance and corporate governance, although it may be even more difficult to achieve.

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Measurement Approaches for Evaluating the Technological and Organizational Factors of Artificial Intelligence Implementation in Businesses

Róbert Hanák¹, Dávid Rybjanský²

Abstract: The empirical literature has identified dozens of specific factors, such as organizational and technical readiness and many others, which positively influence the implementation of artificial intelligence (AI) in innovative businesses. The aim of this article was to compile a theoretical review of measurement instruments for these factors and to discuss their qualities, strengths, and weaknesses. Using a systematic literature review approach, we identified dozens of articles describing the factors in question, within which we analyzed specific measurement instruments and compiled a systematic overview of them. We found that the methods of measurement, the instruments, and the indicators used to describe and assess the status and level of these factors differ in nature and design and vary in their explanatory value and measurement validity. Self-report questionnaires and subjective expert assessments are combined with objective financial indicators. A systematic and comprehensive overview of measurement tools will provide managers with a practical aid in the process of implementing AI, thereby increasing the likelihood of successful AI implementation. At the same time, it will enable researchers to improve the existing framework and help create better, more informative measurement instruments.

Keywords: AI implementation, AI implementation factors, measurement tools

JEL Classification: O32, M15, M21

1 Introduction

In recent years, artificial intelligence has achieved exceptional performance across a variety of cognitive and practical tasks, which has contributed to its widespread adoption among individual users (Inkpen et al., 2024). At the same time, its implementation in enterprise solutions has, in practice, lagged behind individual use. There are multiple reasons for this; among the most frequently cited are difficulties integrating it into business processes (Haefner et al., 2023). This lag at the organizational level has spurred intensive scholarly efforts to examine and uncover the factors influencing the adoption of artificial intelligence. The empirical literature has identified dozens of distinct factors that affect AI adoption, either positively or negatively (Kar, Kushwaha, 2023; Khanfar, et al. 2025). These factors operate at the level of the initial decision, the implementation processes, and overall success. These factors and barriers are diverse and can be categorized into several groups. In this article, we focus on two broad groups that Khanfar and colleagues (2025), in a systematic review, refer to as organizational factors and technical factors.

However, if we aim to successfully implement artificial intelligence in a specific enterprise, it is essential to examine the organization's level of readiness, more precisely, the level and status of those factors that have been shown to affect the success of AI implementation. These factors are, however, often described in fairly general terms, such as organizational readiness, which raises a practical question for management: how can this organizational readiness be meaningfully measured?

Empirical studies examining these factors usually report the specific measurement instruments by which they were operationalized. A review of this literature reveals considerable variability and diversity in the instruments employed. Some studies rely on self-report questionnaires (Agarwal, 2022; Tjebane et al., 2022), others on structured interviews (Campion et al., 2022; Neumann et al., 2024), expert assessments (Wang K. et al., 2021), or approaches that gauge readiness using objective financial indicators or other methods. These instruments also differ in measurement quality, specifically in terms of validity, reliability, objectivity, and sensitivity. They likewise vary in the demands they place on data collection and administration with respect to time, staffing, and the organization of data collection. From both a scholarly and managerial

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standpoint, it is important to know which measurement instruments have been used empirically to assess the level of implementation factors and an enterprise's readiness with respect to the specific factor under study. Accordingly, the aim of this article was to compile a theoretical review of measurement instruments for these factors and to discuss their qualities, strengths, and limitations.

2 Methods

In the first step, we conducted a systematic literature review to identify empirical articles that describe factors related to the implementation of artificial intelligence in enterprises and that report explicit measurement instruments used to operationalize these factors. The search targeted instruments used to assess organizational factors (for example organizational readiness) and technological factors (for example technological readiness), including questionnaires, interview protocols, expert elicitation matrices, and secondary data indicators. We searched the following bibliographic databases: Scopus, Web of Science, ProQuest. The search covered the period from 2020 to 2025. The database searches retrieved 524 records. After deduplication, 144 duplicates were removed, and 380 unique records remained. Title and abstract screening excluded 323 records as clearly irrelevant to AI implementation in organizational settings or without any operationalized organizational or technological factors. We assessed 57 full text articles for eligibility. Of these, 41 were excluded because they did not report an explicit measurement instrument or operationalization, were not empirical, or did not focus on organizational or technological determinants of AI implementation. An additional 6 studies were identified through backward and forward citation searching and supplementary searches conducted by the second reviewer. In total, 22 studies were included in the synthesis and instrument comparison.

We included peer reviewed empirical studies that examined AI adoption or implementation in organizational settings that reported at least one technological or organizational factor relevant to implementation and specified the measurement instrument or operationalization used for that factor. We excluded review articles (systematic reviews and meta-analysis), purely conceptual or theoretical papers, editorials, and studies that discussed factors without describing how they were measured. Furthermore, the review process involved two independent reviewers at all critical stages, including study selection and data extraction.

Records were deduplicated prior to screening. Titles and abstracts were screened against the eligibility criteria, followed by full text assessment of potentially relevant articles. Disagreements were resolved through discussion.

We conducted quality appraisal at two levels. At the study level, we assessed methodological quality using a design appropriate checklist, and used the appraisal to interpret the strength of evidence rather than to exclude studies. At the instrument level, we evaluated measurement approaches using a structured rubric with five criteria: construct clarity, evidence of measurement quality, transparency and reproducibility, practical burden of administration and scoring, and decision usefulness for managers. In addition, a formal quality assessment of the included studies has been incorporated using predefined and theoretically grounded criteria appropriate to the study designs identified.

3 Research results

In the following two tables, we provide an overview of the individual factors and measurement instruments used by the authors of empirical studies to assess the level and state of each factor influencing the adoption of artificial intelligence. The tables indicate the type of research conducted, whether qualitative or quantitative, followed by the specific measurement instrument employed and the sample on which it was applied. The "Aim of the study" column describes the objective of each study, while the final column lists the theories and theoretical foundations on which the respective article was based.

Table 1 Overview of measurement instruments for the organizational readiness factor, competence

Study	Qualitative or Quantitative methodology	Measurement tool	Sample	Aim of the study	Theoretical background
Agarwal (2022)	Quantitative	4-item organizational preparedness scale, 5-point Likert scale	210 human resource management employees	analyze AI adoption antecedents, examining how organizational readiness, perceived benefits, and technical expertise collectively influence AI adoption	Task-Organization-Environment (TOE) Framework and Task-Technology Fit (TTF) Model

Campion et al. (2022)	Qualitative case study approach	in-depth, semi-structured interviews	24 individuals top-level leadership, middle managers, bottom-level analysts	understanding the challenges faced by inter-organizational collaborations in adopting AI tools and implementing organizational routines to overcome these challenges	Interorganizational Collaboration Theory/Organizational Routines Theory
Hradecky et al. (2022)	Qualitative, exploratory approach	A battery of questions for interviews Semi-structured Interviews	seventeen senior managerial representatives from exhibition organizations across nine Western European countries	comprehensive understanding of the factors influencing AI adoption readiness in the exhibition sector, offering insights into both organizational and individual perspectives on new technology adoption	Technology-Organization-Environment (TOE) Framework combined with Technology Readiness Index (TRI)
Neumann et al. (2022)	Qualitative	Semi-structured interviews	17 individuals involved in AI projects across eight Swiss public organizations	comprehensive, adapted theoretical framework and a maturity model, operationalized through qualitative interviews to measure organizational readiness and AI adoption stages	AI-adapted Technology-Organization-Environment (TOE) framework, complemented by a five-level AI maturity model
Tjebane et al. (2022)	Quantitative	Questionnaire	150 construction professionals/ South Africa	identify existing organizational factors influencing AI adoption in the construction and allied industries	Not specified/ systematic literature review
Chatterjee, Rana, et al. (2021)	Quantitative	Questionnaire	340 top/middle-level professionals from manufacturing & production firms (India); small/medium/large organizations	Identify antecedents of AI adoption, assess readiness, and test leadership support as a moderator	Integrated TAM–TOE model (TAM + TOE)
Jöhnk et al. (2021)	Qualitative	Semi-structured interviews; triangulation with literature/practitioner sources; focus-group card-sorting for validation.	25 AI experts (users & providers) across industries and firm sizes; purposive sampling.	Conceptualize organizational AI readiness and derive factors/indicators to guide AI adoption decisions.	Innovation/technology adoption (DOI, TOE, TAM/TRA/TPB) + organizational readiness for change / digital readiness.
Hogan et al. (2020)	Quantitative	Questionnaire	hospital pharmacy staff (pharmacists, interns, support); 64 at implementation	explore factors influencing acceptance of a pharmacy robotic dispensing system during implementation and over time	Extended Technology Acceptance Model (TAM/TAM2)

Neumann et al. (2024)	Qualitative, comparative multi-case	Semi-structured interviews	17 interviewees (internal/external project & programme leads, experts) across state-owned enterprises, ministries, regional agencies, and municipalities	Identify TOE factors that facilitate/hinder AI adoption across maturity stages in public organizations	AI-adapted TOE framework + AI maturity levels (time dimension)
Uren et al. (2023)	Qualitative	Semi-structured interviews	5 AI experts (business, development, research) across 14 interviews	Explain the AI adoption journey and propose a PPTD-with-TRL model to surface readiness factors for moving to operational AI	PPT/PPTD socio-technical lens
Saeed et al. (2024)	Qualitative	Interviews using a TOE+TRI-based guide; reflexive thematic analysis	27 senior representatives: 17 library managers + 10 registrars across Pakistani universities	Assess organizational readiness for AI in university libraries; surface factors to guide adoption.	Integrated TOE + TRI readiness lens
Polisetty et al. (2023)	Quantitative	Questionnaire (5-point Likert); includes 3-item AI readiness and scales for TOE, AI ethics, competitive advantage	866 manager-level employees from Indian SMEs (manufacturing-focused)	Identify TOE antecedents of AI adoption/readiness and test links to competitive advantage with readiness (med.) and AI ethics (mod.)	TOE with AI readiness (mediator) and AI ethics (moderator)
Mathagu (2024)	Quantitative	Questionnaire (5-point Likert);	CEOs/founders/managers/IT professionals	Identify & test critical factors influencing AI adoption in SMEs (UK) via SEM	TOE framework
Lada et al. (2023)	Quantitative	Questionnaire (7-point Likert); includes 4-item Organizational Readiness	196 SME owners/managers (Sabah, Malaysia), multi-sector; judgemental sampling	AI adoption in SMEs	Prior AI-adoption literature; internal/external (TOE-inspired) framing; not an explicit named-theory test

Source: Own processing

In the following table, we present an overview of measurement instruments for the technical/technological Readiness factor, competence.

Table 2 Overview of measurement instruments for the technical/technological readiness factor: competence

Study	Qualitative or Quantitative research	Measurement tool	Sample	Aim of the study	Theoretical background
Dora et al. (2021)	Mixed/decision-analytic case study; expert elicitation	Expert interviews to define CSFs; expert-rating poll (matrix)	15 experts (senior GMs, SC/logistics managers, IT officers, finance)	Identify & prioritize CSFs for AI adoption in food supply chains	TOEH (Technology–Organization–Environment–Human) integrating TOE/HOT
Chen et al. (2021)	Quantitative	Questionnaire (7-point Likert)	289 managers & IT engineers at major Chinese telecom operators	Identify/test success factors driving AI adoption in telecom using SEM	Integrated TOE–DOI framework
Pillai et al. (2020)	Quantitative	Structured questionnaire (5-point Likert); includes 4-item HR readiness scale	562 HR/TA managers & executives from IT/ITeS firms (Mumbai & Pune, India)	Identify predictors of AI adoption & actual usage for talent acquisition in IT/ITeS	Integrated TOE–TTF
Tang et al. (2020)	Qualitative	Open-ended interviews; narrative analysis	7 management-education academics (Instructor–Assoc. Prof.), purposive sample	Explore opportunities & challenges of using educational robotics across curriculum/pedagogy/technology	Vygotskian social constructivism; teachers’ perceptions as adoption determinants
Wang Y. et al. (2021)	Qualitative	Semi-structured interviews + case documents/field visits; triangulated secondary data	3 heavy-manufacturing firms (China); 9 interviewees (technicians, product manager/director, AI team, partners)	Identify TOE-based drivers of AI adoption for digital transformation and propose an AI business model	TOE framework (with DOI/TAM family as background)
Wang K. et al. (2021)	Quantitative	expert-rating DEMATEL matrix (0–4 pairwise influence)	10 experts (industry, government, university; China)	Identify and model challenges to AI/IoT adoption in smart cities and their cause–effect relationships	methodology-driven (DEMATEL)
Arroyabe et al. (2024)	Quantitative	Digital capabilities index from Flash Eurobarometer	12 108 SMEs across 27 EU countries (CATI; stratified by size/sector)	Test how digital (technical) & innovation capabilities and business environment affect AI adoption (regression + ANN/tree models)	Dynamic Capabilities + Resource Dependency theories (integrated)
Rahman et al. (2023)	Quantitative	6-item B2BTR scale (7-point Likert)	217 employees/managers from South African B2B industrial manufacturers	Examine effects of technology readiness → ICT → AI-CRM, and links to relationship & social sustainability;	Dynamic Capability View (DCV) (RBV-based); ICT as mediator, industry dynamism as moderator

Source: Own processing

Across the included studies, the measurement approaches summarized in Tables 1 and 2 can be grouped into a small number of recurring instrument families. These families differ not only in format, but also in the type of evidence they produce, the biases they are exposed to, and their usefulness for managerial decision making.

Instruments most applicable in the practice and their limitations

First, short self report readiness scales use Likert type items to capture perceived preparedness, skills, or perceived ease of adoption. They are inexpensive and repeatable, but they are sensitive to social desirability, overconfidence, and common method bias. Second, extended survey batteries operationalize readiness as a multidimensional construct, often aligned with TOE derived dimensions. They improve construct coverage and analytical detail, but increase respondent burden and often

vary in dimensional definitions across studies, which limits comparability. Third, qualitative diagnostics, such as semi structured interviews, multi case studies, and maturity models, elicit process detail and help identify bottlenecks and sequencing needs. Their outputs are highly actionable, but depend on interviewer skill and are harder to benchmark across firms. Fourth, expert elicitation and decision analytic matrices, including DEMATEL style approaches, are useful for prioritizing interdependent barriers and enablers, but their credibility depends on transparent expert selection and elicitation protocols. Fifth, secondary data indices approximate capabilities using externally collected indicators, enabling benchmarking, but often remain too coarse for firm level implementation planning.

Table 3 Interpretive comparison of instrument families and practical applicability and main limitations

Instrument family	Best practical use and typical outputs	Main limitations and requirements
Short self report readiness scales (Likert)	Rapid baseline and periodic tracking of perceived readiness or competence	Self report biases (social desirability, overconfidence) and common method bias; requires careful survey design
Extended survey batteries (multidimensional questionnaires)	Richer diagnostic survey for medium and large firms; outputs multiple readiness dimensions for benchmarking and modeling	Higher respondent burden; construct definitions vary across studies; requires statistical competence for interpretation
Qualitative diagnostics (interviews, case studies, maturity models)	Implementation planning and transformation programs; outputs bottlenecks, governance gaps, and sequencing guidance	Time intensive; depends on facilitator skill; lower comparability across organizations
Expert elicitation and decision analytic matrices (for example DEMATEL)	Prioritizing interventions when barriers interact; outputs ranked factors and influence structure	Credibility depends on expert selection and transparent elicitation; requires decision analytics capability
Secondary data indices and objective indicators	Benchmarking across sectors or countries; triangulation with internal assessments	Often too coarse for firm level planning; constrained by data availability and indicator validity

Source: Own processing

Table 3 summarizes how the instrument families differ in decision usefulness and feasibility. Questionnaire based approaches scale well, qualitative diagnostics offer higher depth for implementation planning, expert based matrices support prioritization under interdependencies, and secondary data indices are primarily useful for benchmarking.

4 Conclusions

The aim of our research was to produce a theoretical review of measurement instruments for implementation factors. Our review identified a diverse set of instruments. Quantitative tools in the form of questionnaires and qualitative tools, predominantly various forms of structured interviews are represented in roughly equal measure. Other forms of measurement are rare, for example an expert-rating DEMATEL matrix (Wang K. et al., 2021).

As for the scientific theories used to explain the adoption of artificial intelligence, we observe a progressive, gradual approach. In this approach, researchers first attempt to account for AI adoption using older models originally applied to the uptake of various technologies. The Technology Acceptance Model (TAM) is among the most fundamental and widely used. Its now insufficient and rather shallow capacity to explain the adoption of a new, complex technology such as AI has been addressed through continual refinement and extension. Newer and improved versions of the original TAM, such as the extended Technology Acceptance Model (TAM/TAM2), have also been used (Hogan et al. 2020). A similar pattern appears with other legacy models and theories employed to explain AI adoption, such as the Technology–Organization–Environment (TOE) framework (Mathagu 2024), supplemented by newer models like TOEH (Technology–Organization–Environment–Human), used by Dora et al. (2021). Our review also found active combinations of different theoretical approaches and models in an effort to explain AI adoption more effectively. For example, an integrated TAM–TOE model (TAM + TOE) (Chatterjee, Rana, et al., 2021). Likewise, we can identify combinations of TAM, TOE, and the Diffusion of Innovation (DOI) model (Wang Y. et al., 2021).

If managers are to succeed in implementing and deploying artificial intelligence within their organizations, it is essential that they have measurement instruments that help determine the level of readiness with respect to each specific factor. Our research revealed a fairly diverse range of tools currently available. Instrument choice should be driven by the decision context, time horizon, and internal analytical capacity. For rapid baseline assessment in firms with limited analytical resources, short self report readiness scales and compact questionnaires are typically the most feasible and most applicable in the practice because they minimize burden and can be repeated over time. For organizations planning multi month

implementation programs, semi structured interview-based diagnostics and maturity models tend to be more actionable because they surface bottlenecks in governance, data, skills, and process integration. When prioritization among many interdependent barriers is required, expert elicitation and decision analytic matrices are useful, but only when expert selection and elicitation procedures are reported transparently. Secondary data indices are most appropriate for benchmarking across countries or sectors and for triangulation, but they should not be treated as sufficient for firm level readiness decisions.

Accordingly, a practical selection rule is to start with a low burden questionnaire to establish a baseline, follow with qualitative diagnostics in areas where the baseline indicates weaknesses or strategic uncertainty, and use expert-based prioritization methods when decision makers need to rank interventions under complex interdependencies.

Limitations of our study

Our review could be constrained by the scope and quality of the primary studies included, meaning that any biases, methodological weaknesses, or inconsistencies in the original research are transferred into the synthesized findings. Despite the use of predefined standard scientific search strategies, relevant studies may have been omitted due to database coverage limitations or the exclusion of grey literature. Another limitation of our research and thus of our results is publication bias, which remains a persistent concern, as studies reporting statistically significant or positive results are more likely to be published and thus included in the review. We also report, as a limitation, our own subjective judgment in study selection, data extraction, and quality appraisal, although guided by standardized protocols, which may introduce reviewer bias despite our best efforts.

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Use of Digital Twins in Healthcare and Cost Monitoring: A Scoping Review

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Abstract: Digital twins (DTs) are an emerging technological innovation in healthcare, enabling real-time simulation and optimization of clinical and operational processes through the integration of AI, IoT, and data-driven modeling. While initially adopted for clinical prediction and treatment planning, their broader economic implications for healthcare management remain underexplored. This paper presents a scoping review of recent research (2023–2025) examining the cost-effectiveness and economic value of digital twins in healthcare. The review synthesizes evidence from fifteen international studies indexed in the Web of Science database, focusing on both implementation costs and potential financial benefits for healthcare providers and systems. Findings show that DTs are most cost-effective in operational and infrastructural applications such as hospital logistics, energy management, and digital hospital ecosystems where cost reductions are directly measurable through improved resource utilization and process efficiency. In contrast, clinical and population-level twins demonstrate mainly conceptual or long-term economic potential, constrained by limited empirical data and methodological heterogeneity.

Overall, the review identifies digital infrastructure maturity, interoperability, and workflow integration as key enablers of financial sustainability. It also highlights the lack of standardized economic evaluation methods, underscoring the need for consistent reporting frameworks to inform evidence-based investment decisions in healthcare digitalization.

Keywords: digital twin, healthcare management, cost-effectiveness, economic evaluation, innovation economics

JEL Classification: I23, M15, O33

1 Introduction

The contemporary healthcare landscape is undergoing a profound technological transformation, driven by the convergence of advanced computing, artificial intelligence (AI), and pervasive sensing technologies (Fries, 2023). Within this context, the concept of the Digital Twin (DT) has emerged as a rapidly evolving innovation. A Digital Twin is defined as a dynamic, high-fidelity virtual model of a physical asset, process, or system in healthcare, this ranges from individual patient physiology (the 'Virtual Human') to intricate hospital operational flow (Chen & Zhang, 2024). These models integrate real-time clinical, imaging, and sensor data to allow clinicians and administrators to simulate interventions, predict clinical outcomes, and optimize systemic efficiency in a safe, controlled digital environment.

Initial enthusiasm for DTs has correctly focused on their clinical potential, such as simulating personalized drug responses or optimizing surgical planning. However, the widespread adoption and integration of this technology into established healthcare systems are fundamentally constrained by economic feasibility. The healthcare sector operates under stringent financial mandates, demanding clear, quantifiable evidence of value and sustainability for any major capital investment.

Existing research confirms the significant market projections for the digital twin sector, forecasting growth to exceed \$20 billion by 2034 (Global Tech, 2023). Furthermore, initial economic analyses consistently identify the theoretical cost-saving potential, particularly in reducing diagnostic error and optimizing resource allocation. Despite this promise, a critical synthesis gap persists there is no unified evidence integrates about use, efficiency and impact of this area of digitalization in healthcare. Therefore, this paper aims to map healthcare uses of DTs and classify cost-effectiveness outcomes (positive/negative/inconclusive); synthesize drivers of success/failure and future directions.

RQ1: In which healthcare use cases are DTs cost-effective?

RQ2: Where do DTs fail to be cost-effective and why?

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RQ3: What contextual factors (data quality, scale, workflow fit) explain differences?

RQ4: What economic evaluation methods are used and with what rigor?

2. Theoretical Framework

A Digital Twin in healthcare is more than a mere simulation; it is an integrated, dynamic ecosystem (Fries, 2023). From an economic perspective, the DT functions as a continuous feedback loop that reduces information asymmetry and systemic entropy. The high-fidelity nature of the twin mitigates uncertainty in clinical decision-making, which is a major source of cost in current models (Chen & Zhang, 2024). A Digital Twin in healthcare is defined as a dynamic, high-fidelity virtual replica of a physical entity such as a patient's organ, a medical device, or an entire hospital system. These twins continuously integrate real-time data from the Internet of Medical Things (IoMT) and clinical records, allowing the model to mirror the corresponding physical system's state and behavior. DTs are primarily used to run simulations for personalized medicine, predicting the efficacy of drug treatments or optimizing surgical planning in a risk-free environment. Ultimately, the goal is to enhance clinical and operational decision-making by providing predictive insights into patient outcomes and systemic efficiencies.

Economic evaluation provides a structured framework for assessing the value of health technologies such as digital twins (DTs). Classical approaches include cost-effectiveness analysis (CEA), which compares incremental costs and outcomes typically expressed as the cost per quality-adjusted life year (QALY) gained offering a standardized measure of value for money (Drummond et al., 2015; Neumann et al., 2016). Cost-utility analysis (CUA) refines this approach by explicitly incorporating patient preferences and quality-of-life metrics, while cost-benefit analysis (CBA) translates both costs and benefits into monetary terms to determine net societal gain or loss (Sanders et al., 2016). Complementary to these frameworks, return-on-investment (ROI) calculations offer a pragmatic financial perspective that is often favored by healthcare managers when assessing digital innovations (Gravelle & Smith, 2021). Budget impact analysis (BIA) further examines the affordability of an intervention within a specific payer or institutional context over a defined period, focusing on short-term financial feasibility rather than long-term efficiency (Sullivan et al., 2020). Importantly, economic evaluations must distinguish between direct costs such as staff time, equipment, and consumables and indirect costs, including productivity losses, training, or infrastructure overheads, depending on whether the analysis adopts a provider, payer, or societal perspective (Hollingsworth & Wildman, 2020).

When evaluating digital twins in healthcare, identifying mechanisms through which they influence costs is essential. Digital twins can enhance throughput by optimizing clinical workflows and resource utilization, thereby reducing waiting times and distributing fixed costs over more patient episodes (Mustafee & Katsaliaki, 2022). They can also reduce adverse events by allowing predictive monitoring and early detection of complications, lowering the cost burden of preventable incidents (Ma & Thimm, 2022). Improvements in process efficiency may shorten hospital length of stay, which represents one of the most significant cost drivers in inpatient care (Eckert et al., 2023). Further mechanisms include preventive maintenance of critical medical equipment reducing downtime and repair expenses and personalized dosing or treatment optimization, which minimize waste and adverse drug events (Tao et al., 2019; Fuller et al., 2020). In some cases, the deployment of a digital twin enables the avoidance of unnecessary diagnostic or therapeutic procedures, leading directly to cost savings. However, when data quality, interoperability, or clinician engagement are lacking, these mechanisms may fail to generate financial benefits, sometimes increasing costs due to implementation and maintenance burdens (Karan & Shepherd, 2024).

To interpret these mixed economic outcomes, scholars have increasingly adopted a Context–Mechanism–Outcome (CMO) framework originating in realist evaluation (Pawson & Tilley, 1997; Currie & Seddon, 2014). In this framework, context including digital infrastructure maturity, data governance, workforce readiness, and regulatory alignment determines whether the intended mechanisms of a digital twin, such as process optimization or predictive prevention, can function as expected (Greenhalgh et al., 2019). The resulting outcomes in this case, cost savings or overruns depend on the interaction between context and mechanism rather than on the technology alone. For example, in hospitals with advanced data integration and strong clinical engagement, DTs can effectively reduce length of stay and readmissions, yielding measurable cost benefits. Conversely, in low-resource environments lacking reliable data flows, the same tools may underperform, leading to negative ROI or budget strain. Understanding these CMO interactions is thus essential to explain why digital twins are cost-effective in some settings but not in others, and to guide the design of future implementations that align technological capabilities with organizational context.

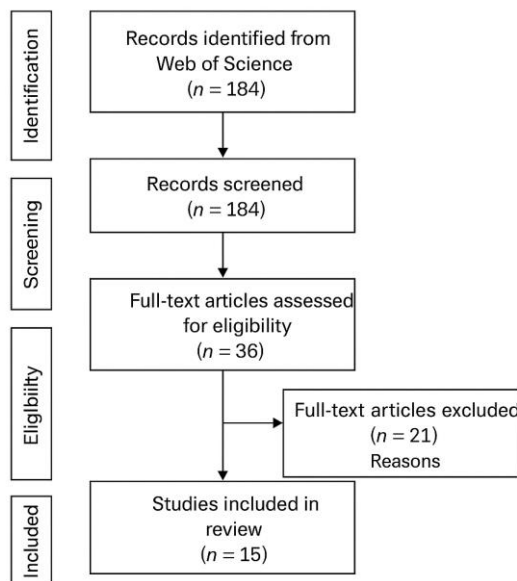
3. Methodology

This study employs a rigorous scoping review methodology, aligned with established scientific reporting guidelines. This scoping review was conducted in accordance with the PRISMA guidelines. Database Web of Science was used. The searches string combined terms reflecting the digital-twin concept (“digital twin*” OR “virtual twin*”), the healthcare context (“healthcare” OR “hospital” OR “clinic” OR “patient*”), and economic/cost dimension (“cost*” OR “economic*” OR “ROI” OR “budget impact” OR “value”). Searches were limited to articles published in English in last three years from 2023 to 2025 in area business and economics or bioengineering. The aim is to find and summarize newest information from this fast-developing area.

Inclusion criteria required peer-reviewed journal articles that describe a digital twin applied in a healthcare (or hospital operational) setting and report some cost or economic metric (whether measured or modelled). Exclusion criteria comprised conference-only papers without full text, papers purely technical without healthcare setting or cost dimension, and non-English publications. For each included study we extracted bibliographic details (author, year, country, journal), healthcare domain (e.g., ICU, surgery, hospital logistics), digital twin type (patient-twin / process-twin / device-twin / facility-twin), comparator scenario (usual care or baseline), cost or economic metric (e.g., cost per patient, ROI, budget impact, ICER), time horizon, perspective (provider/payer/societal), and cost-effectiveness direction (positive: cost-saving or favorable ratio; negative: cost-increasing; inconclusive). We also extracted reported enablers and barriers that influenced economic outcomes (e.g., data maturity, clinician adoption, scale).

For language and stylistic refinement, the assistance of ChatGPT was employed. The tool was used exclusively for grammatical and stylistic editing, without altering the scientific content or interpretation of results. This approach ensured compliance with academic integrity and the preservation of authorship rights.

Figure 1 PRISMA diagram



4. Results

Fifteen peer-reviewed international journal articles published between 2023 and 2025 were included in this scoping review. They represent a diverse set of applications of digital twin (DT) technologies in healthcare, ranging from clinical systems and hospital operations to infrastructure optimization and strategic policy planning. The included studies cover Europe, Asia, and Oceania, reflecting the growing global interest in digital twinning as a mechanism for improving both healthcare quality and economic efficiency (Table 1).

Among these, eight studies (53%) reported positive cost-effectiveness outcomes, five (33%) were inconclusive, and two (13%) indicated mixed or negative economic results. Positive results were found primarily in operational and infrastructural domains such as energy management (Yang et al., 2025; Sun et al., 2025), hospital logistics (Moretti et al., 2025), and digital hospital investments (Nguyen et al., 2024) where measurable cost reductions were achieved through improved

process throughput, energy efficiency, or maintenance scheduling. In contrast, conceptual and review papers (El-Warrak & Miceli de Farias, 2025; Turab & Jamil, 2023; Vallée, 2023) often confirmed theoretical potential for savings but lacked empirical cost data, resulting in inconclusive classification.

Only four studies (Nguyen et al., 2024; Yang et al., 2025; Sun et al., 2025; Moretti et al., 2025) employed formal economic evaluation frameworks such as cost–benefit analysis (CBA) or return-on-investment (ROI) estimation. Most others used proxy indicators (e.g., resource utilization, reduced downtime, shortened length of stay) as indirect measures of cost efficiency. Explicit reporting of economic perspective (provider, payer, or societal) was rare, indicating methodological gaps (RQ4). Nonetheless, positive trends consistently corresponded to quantifiable operational benefits, including 7–9 % reductions in energy costs (Yang et al., 2025) or increased capacity utilization through spatial optimization (Moretti et al., 2025). Table 1 Overview of digitl twin use in healthcare and related economic evaluation

Author (Year)	Domain / Use Case	Type of DT	Cost Metric / Economic Focus	Cost-Effectiveness Outcome	Key Drivers / Barriers	Economic Method
El-Warrak & Miceli de Farias (2025)	Population health management & predictive analytics	Patient/system twin	Theoretical discussion of ROI and resource allocation	Inconclusive	Limited real-world data; promising for preventive care if scaled	Narrative review
Vallée (2023)	Healthcare systems & hospital process modeling	System twin	Qualitative cost-benefit implications across subsystems	Positive (conceptual)	Integration with EHRs, interoperability	Conceptual synthesis
Ghatti et al. (2023)	Survey across medical DT applications	Mixed (patient/device/processes)	Overview of cost-saving claims in literature	Inconclusive	Data immaturity ; limited validation	Descriptive survey
Quazi et al. (2024)	Clinical and operational DT applications	Mixed	Discussion of implementation costs vs. operational efficiency	Mixed	Scalability, staff readiness	Qualitative synthesis
Turab & Jamil (2023)	DTs & Metaverse integration	System twin	Potential for cost reduction in virtual hospitals	Inconclusive	Regulatory and privacy barriers	Narrative review
Moretti et al. (2025)	Hospital logistics & space-aware optimization	Process twin	Reduced idle time → operational cost efficiency	Positive	Real-time data integration, spatial analytics	Simulation + performance analysis
Huang, Ng & Li (2023)	Hospital operations management	Process twin	Adoption determinants influencing cost-benefit	Mixed	Management support, workflow alignment	Quantitative adoption model

Oulefki, Amira & Foufou (2025)	Decision-making & system optimization	System twin	General economic and innovation efficiency	Positive (conceptual)	Data-driven culture, AI integration	Conceptual framework
Nguyen et al. (2024)	Digital hospitals	Process twin	Explicit cost–benefit analysis (CBA); ROI framework	Positive	Structured CBA model, scale effects	Formal CBA
Yang et al. (2025)	Hospital HVAC & energy systems	Infrastructure twin	7–9 % reduction in energy cost (OPEX)	Positive	Predictive control, digital calibration	Empirical ROI estimation
Sun, Wang & Zhou (2025)	HVAC load optimization	Infrastructure twin	Cost-optimal model predictive control	Positive	Semantic data modeling, energy-price optimization	Optimization modeling
Moretti, Zhang & Cheng (2025)	Hospital operations (duplicate study, extended version)	Process twin	Operational efficiency as proxy for cost	Positive	Spatial awareness, scheduling algorithms	Simulation-based CEA
El-Warrak & Miceli (2025)	Population-level policy planning	System twin	Long-term public health savings potential	Inconclusive	Requires national data integration	Conceptual framework
Vallée (2023)	Cross-domain synthesis	System twin	Implementation cost considerations	Mixed	Data interoperability; policy frameworks	Narrative analysis
Nguyen et al. (2024)	Digital hospital investment analysis	Process twin	ROI and full cost–benefit framework	Positive	Clear evaluation model, scalability	Formal economic modeling

In the context of RQ1: In which healthcare use cases are digital twins cost-effective? The review reveals that digital twins (DTs) demonstrate the strongest cost-effectiveness in operational and infrastructural applications rather than in direct clinical decision-making. Studies focusing on hospital logistics, energy management, and resource scheduling consistently reported positive economic outcomes. For instance, Moretti et al. (2025) and Sun et al. (2025) showed that process-oriented twins in hospital operations and HVAC systems reduced idle time, improved space utilization, and achieved measurable energy savings between 7 % and 9 %, translating into lower operational expenditures. Similarly, Nguyen et al. (2024) provided a structured cost–benefit framework for digital hospitals, confirming favorable ROI when DT deployment was integrated with existing IT infrastructure and scaled across departments. These use cases share a common feature: a clear link between simulation outputs and measurable resource efficiency, enabling financial gains to be directly quantified. In

contrast, conceptual or early-phase studies on patient-level or population health twins (e.g., Vallée, 2023; El-Warrak & Miceli de Farias, 2025) describe potential long-term savings through personalized treatment or preventive interventions but lack robust empirical data. While promising, these areas remain economically unproven due to the absence of validated metrics for patient outcomes and longtime horizons required to realize cost benefits.

For RQ2: Where do digital twins fail to be cost-effective, and why? Digital twin implementations tend to fail economically when development and maintenance costs outweigh operational benefits or when integration with existing systems is poor. Several studies (Turab & Jamil, 2023; Huang et al., 2023) identified high initial capital expenditures (CAPEX) including sensor networks, data storage, and modeling expertise as the main barrier to financial justification. Moreover, projects limited to pilot or prototype phases often suffer from insufficient scale, meaning that cost savings do not offset fixed investment costs. Failures were also linked to data fragmentation and lack of interoperability between clinical and operational data sources. Without continuous real-time data, DTs cannot deliver accurate predictions or adaptive control, thereby undermining expected efficiency gains (Ghatti et al., 2023). In some cases, the technology generated additional workload for clinicians or IT staff due to duplicated data-entry processes, further eroding economic benefit (El-Warrak & Miceli de Farias, 2025). These findings suggest that economic failure rarely stems from the concept of DTs itself but rather from implementation immaturity and inadequate system alignment.

Regarding RQ3: What contextual factors explain differences in cost-effectiveness? A strong pattern emerges linking contextual maturity to economic success. Studies reporting positive outcomes (e.g., Nguyen et al., 2024; Moretti et al., 2025; Sun et al., 2025) were characterized by advanced data infrastructure, robust interoperability standards, and organizational readiness. When DTs were embedded in digital hospitals with integrated EHRs and IoT systems, data flows supported real-time feedback loops that generated tangible cost reductions. Conversely, in institutions with fragmented data ecosystems, limited digital literacy, or resistance from clinical staff, expected cost savings were not realized. Workflow misalignment where twin-generated insights were not actionable within existing clinical or managerial processes proved to be a consistent barrier (Huang et al., 2023). Scale was another key factor: small pilot projects rarely achieved economies of scale, while enterprise-level deployments showed cumulative ROI gains as costs were distributed across multiple departments. Thus, data quality, scalability, and workflow integration jointly determine whether DT implementation transitions from experimental to economically sustainable.

Finally, for RQ4: What economic evaluation methods are used, and with what rigor? Methodological rigor across the reviewed studies was generally limited. Only four studies applied formal economic frameworks, such as cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), or explicit ROI estimation (Nguyen et al., 2024; Yang et al., 2025; Sun et al., 2025; Moretti et al., 2025). Most others relied on proxy measures of efficiency like reductions in waiting times, improved resource utilization, or simulated performance improvements without translating these effects into standardized cost metrics. Few studies clearly stated the evaluation perspective (provider vs. payer), the time horizon, or performed sensitivity analyses, all of which are essential elements in economic evaluation according to established health-economic standards (Drummond et al., 2015). The lack of standardized reporting hampers cross-study comparison and limits the ability to aggregate evidence on DT cost-effectiveness. Future research should adopt transparent, reproducible methods aligned with PRISMA-ScR and ISPOR guidelines to establish credible economic evidence for regulators and healthcare investors. A unified reporting framework covering both supply-side investments (CAPEX) and demand-side savings (OPEX) would also strengthen the financial sustainability argument for digital twin deployment.

Taken together, the results indicate that cost-effectiveness of digital twins in healthcare is context-dependent, domain-specific, and methodologically under-evidenced. Digital twins are economically viable when applied to resource-intensive operational domains with measurable outputs and when embedded within mature data infrastructures. Conversely, underdeveloped contexts, fragmented data ecosystems, and limited methodological rigor led to inconclusive or negative economic results. Addressing these gaps through standardized evaluation, real-world data collection, and cross-disciplinary collaboration will be critical for transforming digital twins from a promising innovation into a demonstrably cost-effective tool for healthcare systems worldwide.

5. Discussion

This review highlights that the economic performance of digital twins (DTs) in healthcare is highly context dependent. Overall, DTs show clear cost-effectiveness in operational and infrastructural domains, while evidence from clinical or population-level applications remains limited and mostly conceptual.

Operational and facility-oriented digital twins such as those for hospital logistics, predictive maintenance, or energy management consistently deliver measurable economic benefits. Studies by Yang et al. (2025), Sun et al. (2025), and

Moretti et al. (2025) demonstrate tangible savings of 7–9 % in energy use or reduced idle time in hospital operations. These outcomes arise from improved resource utilization, automation, and process optimization that directly translate into lower operational expenditures. Such use cases provide short-term, quantifiable returns and therefore offer strong justification for investment.

In contrast, patient-level or population-based DTs are still in an exploratory phase. Although several works (e.g., Vallée, 2023; El-Warrak & Miceli de Farias, 2025) emphasize long-term potential through preventive care and personalization, these benefits remain hypothetical due to the absence of longitudinal cost data and standardized evaluation metrics.

The review also confirms that contextual maturity particularly data quality, interoperability, and workflow integration is decisive for economic success. Projects embedded in digital hospitals with advanced EHR and IoT infrastructures (Nguyen et al., 2024) achieved measurable ROI, while those in fragmented data environments often failed to offset high initial investment costs. Implementation scale and clinician engagement further influenced outcomes; pilot projects without integration across departments rarely achieved cost recovery.

Methodologically, most studies relied on indirect efficiency indicators rather than formal economic models. Only a few applied structured approaches such as cost–benefit or ROI analysis. This lack of methodological consistency limits comparability and the robustness of conclusions. Future assessments should therefore adopt recognized economic evaluation standards to ensure credible evidence for policy and managerial decision-making.

In summary, digital twins are economically viable primarily in operational and infrastructure contexts, where financial outcomes can be directly quantified. Their broader economic potential in clinical and public health domains will depend on data integration, scalability, and adoption of rigorous economic evaluation frameworks.

6. Conclusions and Implications

This scoping review systematically examined the current evidence on the cost-effectiveness of digital twin (DT) applications in healthcare, with a focus on identifying when and why these technologies deliver measurable economic value. The synthesis of fifteen international studies published between 2023 and 2025 demonstrates that DTs are most cost-effective when deployed in operational and infrastructural domains such as hospital logistics, building management, and digital hospital ecosystems where cost savings are directly linked to process efficiency, resource utilization, and predictive maintenance. In these contexts, cost benefits were quantifiable, immediate, and reproducible, providing strong justification for investment.

Conversely, clinical and population-level DTs remain at an exploratory stage. Although they promise long-term savings through preventive and personalized medicine, evidence of economic viability is still limited due to methodological inconsistency and the absence of longitudinal cost data. The review also highlights that economic failure does not stem from the technology itself, but from contextual shortcomings fragmented data infrastructures, low digital maturity, and weak alignment between DT outputs and clinical workflows.

Methodologically, the analysis revealed significant variation in how economic outcomes are assessed. Only a minority of studies employed formal frameworks such as cost–benefit analysis or ROI estimation, and even fewer reported perspective, time horizon, or sensitivity testing. This lack of standardization prevents comparability across studies and hinders policy-level decision-making.

From these findings, the paper proposes a dual-lens framework for financial sustainability:

1. Operational ROI, capturing short-term efficiency gains and direct cost savings (e.g., reduced energy consumption, improved scheduling, shorter length of stay).
2. Strategic Value Assessment, encompassing long-term system-wide benefits, regulatory readiness, and collaborative cost-sharing models.

For healthcare providers, this framework supports evidence-based decisions on when DT investments are financially justified. For researchers and policymakers, it establishes priorities for future evaluation: standardized cost metrics, multi-site validation, and full life-cycle costing.

Ultimately, the financial sustainability of digital twins in healthcare will depend not only on technological sophistication but also on the maturity of data ecosystems, integration with existing workflows, and adoption of rigorous economic evaluation practices. Bridging these dimensions will be essential for transforming digital twins from innovative prototypes into scalable, economically viable tools for next-generation healthcare systems.

The findings have several practical implications. Healthcare managers should prioritize DT deployment in operational areas where financial benefits are immediate and measurable. Policymakers can use these insights to guide funding strategies and digital infrastructure investments. Standardized evaluation frameworks will help align technological innovation with health system efficiency goals. Finally, collaboration between economists, clinicians, and data engineers is crucial to ensure that DT implementations achieve both economic and clinical value.

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Artificial Intelligence in Small and Medium-Sized Companies – Comparative Analysis of V4 Region

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Abstract: The main aim of this paper is to examine the application of artificial intelligence in small and medium-sized enterprises and to investigate whether the adoption of AI in enterprises across the V4 countries varies not only by country but also by enterprise size. The analysis is based on the latest available Eurostat data and combines descriptive statistics with chi-square tests: (i) a goodness-of-fit test to assess whether AI adoption rates differ across countries, and (ii) an independence test to verify the relationship between company size and AI adoption. The results show statistically significant differences across V4 countries and size categories: larger enterprises show higher adoption than SMEs, and there are significant disparities between countries, with some lagging behind. The findings confirm that structural factors (company size, national context) play a key role in AI deployment. The study provides practical recommendations for policymakers and SME managers: to develop competencies and infrastructure in a targeted manner, to focus support on overcoming identified barriers to adoption, and to monitor the effect of company size on the return on AI implementation.

Keywords: Artificial intelligence, Industry 4.0, small and medium-sized enterprises, V4

JEL Classification: M10, M15, O30.

1 Introduction

The issue of continuous development in the technological environment is one of the most important for businesses. Development is constantly accelerating, and new opportunities continually emerge for organizations. In general, these changes can be called Industry 4.0 – a concept encompassing a range of technologies that seek to connect production with people, processes, and services in real time (Nayernia et al., 2022). These technologies include artificial intelligence (AI), the Internet of Things (IoT), big data, cyber-physical systems, cloud computing, robotics, and one of the most talked-about applications of Industry 4.0: digital twins (Reaidy et al., 2024; Yao et al., 2023). A digital twin enables a digital representation of production operations, communication flows, and material movement (Javaid et al., 2023). Modern technologies bring several advantages, the most important of which include increased product quality and safety, reduced operating and maintenance costs, shorter production downtime, and enhanced sustainability of the production process (Stefanini et al., 2022). However, companies still grapple with how to successfully implement these technologies. Research shows there is no internationally recognized readiness model and that many proposed models do not receive positive feedback from companies (Ünlü et al., 2023). The literature shows that the scientific debate on Industry 4.0 is continually expanding, which is why this topic remains relevant 14 years after the term was first used (Rad et al., 2022).

Artificial intelligence – a term describing systems or software that simulates human intelligence – is not a new concept, having been coined in 1956 (Mishra, 2024; Xu et al., 2021). AI is often compared to transformative technologies like the internet or the steam engine, given its broad industry impact (Lei & Kim, 2024). Various AI models process vast amounts of data for downstream applications (Schneider et al., 2024). The best-known are generative language models (Chang et al., 2024). These generative models, most notably ChatGPT, are significantly transforming the world today and substantially affecting employee productivity (Noy & Zhang, 2023). AI is changing industry and manufacturing as well as science, enabling new research opportunities (Karpatne et al., 2025). Additionally, discussion is growing around linking AI

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with IoT to create the Artificial Intelligence of Things (AIoT), enhancing human-machine interaction and improving operational efficiency (Siam et al., 2025).

Small and medium-sized enterprises (SMEs) are a crucial component of global economies, representing roughly 90% of all businesses and employing about 50% of the global workforce. Thus, their performance during digital transformation is highly significant (Costa Melo et al., 2023). Current literature suggests SMEs should pursue digital transformation through incremental changes and innovations, while investing in education and continuous learning oriented toward Industry 4.0 (Sagala & Őri, 2024). It is especially important to implement these changes in ways that align with sustainability, one of central goals of Industry 4.0 (Philbin et al., 2023). Nonetheless, several barriers hinder SMEs from adopting these innovations more rapidly, including limited financial resources, shortages of skilled personnel, high IT requirements, and lack of knowledge (Kumar et al., 2023; Restrepo-Morales et al., 2024). These observations underscore the need for research on implementing modern technologies in SMEs, both generally and for specific technologies.

The V4 group includes Hungary, Slovakia, Poland, and the Czech Republic, and its goal is close cooperation between these countries and mutual assistance within the framework of European integration (Kovacs & Domonkos, 2024). Unfortunately, research shows that the V4 countries are poorly prepared for the implementation of Industry 4.0, with no significant progress evident, although the Czech Republic performs best among the four (Molendowski et al., 2024). Studies indicate that the Czech Republic's preparedness is very good, particularly in AI – the strongest among the V4 countries – yet there are few cases of excellence (Filipec, 2022). Across the EU, the share of companies with more than 10 employees using at least one AI-related technology is small – just 13% (Ionaşcu, 2025). Given these facts, research on AI in SMEs in the V4 region remains relevant and requires updating and new contributions to the scientific debate. Therefore, the research question (RQ) is: “Are there differences in the field of AI between the individual countries of the V4 region?”

This study contributes to the existing literature on the adoption of artificial intelligence in businesses in two main ways. First, it provides a focused comparative analysis of AI adoption in the Visegrad Four (V4) countries, a region that has so far received limited empirical attention in the context of AI adoption, despite its distinctive economic, institutional, and technological characteristics. By explicitly examining differences within this specific regional grouping, the study enhances understanding of how national context shapes the uptake of artificial intelligence in enterprises. Second, the study combines harmonized Eurostat data with comparative statistical testing, which allows not only for the identification of differences in AI adoption across countries and enterprise size categories, but also for a more systematic assessment of the structural nature of these differences. In doing so, the results extend existing knowledge on the role of enterprise size and national context as key determinants of AI implementation in businesses. The findings provide empirically grounded insights that are relevant for academic research, policymakers, and managers of small and medium-sized enterprises, particularly in relation to addressing and reducing adoption gaps within the V4 region.

2 Methods

The main aim of this paper is to examine the application of artificial intelligence in small and medium-sized enterprises and to investigate whether the adoption of AI in enterprises across the V4 countries varies not only by country but also by enterprise size. The fact that different countries use AI to varying degrees is supported by the professional literature (Filipec, 2022; Ionaşcu, 2025; Kovacs & Domonkos, 2024; Molendowski et al., 2024). This study is a comparative secondary analysis. To achieve the set aim, secondary data from the Eurostat database (2025a; 2025b) was used. The year 2023 was selected for analysis, as it is the last year with complete data in the database.

As mentioned above, the V4 geographical area (Czechia, Slovakia, Poland, Hungary) is the standard area for analyzing individual differences. The data were extracted on September 12, 2025, from the Eurostat database (2025a) to determine the number of companies reporting the use of AI, as well as the number of companies in each size category in the individual countries (Eurostat, 2025b). These are structural and cross-sectional statistics that the database provides as part of gathering information on the digital economy and society. The data are offered in percentage form, so it is important to also determine the total number of enterprises in the regions to calculate the actual number of enterprises using AI. For size categories, the standard European Union approach was used, i.e., dividing enterprises by number of employees, with up to 10 employees are micro-enterprises, 10–49 employees are small enterprises, and 50–249 employees are medium-sized enterprises (Child et al., 2022). The research uses with two of these categories (small and medium-sized), as the database does not contain information on micro-enterprises. The dependent variable is the use of artificial intelligence, with individual countries and size categories used as predictors.

Several methods and procedures were used to achieve the aim. First, descriptive statistics were computed (Ali & Bhaskar, 2016). Subsequently, a chi-square test of goodness-of-fit was used to determine whether differences between countries were random or statistically significant (Pfeifer, 2008), along with a chi-square test of independence to examine

differences between size categories within the observed countries (Ranganathan, 2021). Two-proportion tests were used to compare pairs of countries (Kim, 2016). A standard significance level of 0.05 (Miller & Ulrich, 2019) was applied for all statistical tests, which is the value commonly recommended for interpretation in most scientific disciplines. All calculations and graphical processing were performed using RStudio and Microsoft Excel.

3 Research results

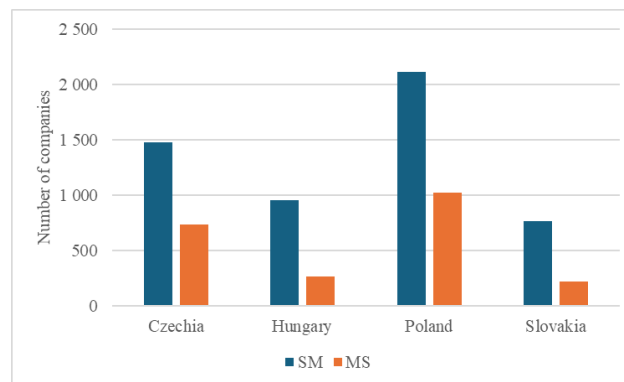
The first step provides a descriptive overview of AI adoption in businesses. Table 1 presents the use of AI across individual firm-size categories in V4 countries, expressed both as percentages (original data) and as absolute values, which were subsequently calculated. Figure 1 offers a graphical representation of the number of companies using AI in the V4 region in absolute terms. Both Table 1 and Figure 1 employ abbreviations for firm-size categories, where SM denotes small enterprises and MS denotes medium-sized enterprises. The Summary column reports aggregated values for these two categories only.

Table 1 Intensity of AI adoption in V4 countries (SM – small enterprises, MS – medium-sized enterprises)

Country	SM (%)	SM (absolute)	MS (%)	MS (absolute)	Summary (%)	Summary (absolute)
Czechia	4.00	1,479	9.79	736	4.99	2,215
Hungary	2.98	953	5.54	269	3.31	1,221
Poland	2.25	2,110	6.49	1,020	2.91	3,129
Slovakia	5.95	764	8.57	223	6.42	986

Source: Own processing according to Eurostat (2025a; 2025b)

Figure 1 Graphical visualization of AI adoption intensity in V4 countries (SM – small enterprises, MS – medium-sized enterprises)



Source: Own processing according to Eurostat (2025a; 2025b)

As shown in Table 1, the adoption of AI varies across both regions and firm-size categories. Among small enterprises, Slovakia records the highest share in relative terms, followed by the Czech Republic. In absolute terms, however, Poland leads this category, with the Czech Republic in second place. In the category of medium-sized enterprises, the Czech Republic performs best in relative terms, followed by Slovakia, while Poland again records the highest values in absolute terms. When considering the aggregated results for these two size categories, Slovakia ranks first in relative terms, followed by the Czech Republic, Hungary, and Poland in last place. In contrast, the absolute terms place Poland in the leading position, followed by the Czech Republic, Hungary, and Slovakia. From an interpretative perspective, relative indicators of AI adoption are particularly important, as they highlight the strong position of Slovakia in the small enterprise category and of the Czech Republic, especially among medium-sized enterprises. Overall, Poland (with less than 3%) and Hungary (just over 3%) appear to have the lowest shares of enterprises using AI.

Subsequently, a chi-square goodness-of-fit test was applied to examine whether statistically significant differences exist between countries in the overall distribution. The null hypothesis H_0 , stating that “The proportion of companies using AI is the same in all countries” was tested against the alternative hypothesis H_A , which assumes “The proportion of companies using AI differs in at least one country”. The results of the test are presented in Table 2.

Table 2 Chi-square goodness-of-fit test

Test characteristics	Value
χ^2	730.58
Degrees of freedom	3
p-value	<0.001

Source: Own processing

The resulting p-value is significantly lower than the selected significance level of 0.05; therefore, the null hypothesis is rejected. The results indicate that the proportion of companies using AI differs statistically significantly in at least one country, suggesting that the observed differences between countries are not random. As part of the same analysis, a pairwise comparison were subsequently conducted to identify between which countries these differences occur. For all pairwise comparisons, the p-values were also below 0.05, indicating that the differences between all countries are statistically significant. From a practical perspective, this finding indicates that AI adoption in the V4 region is strongly influenced by country-specific conditions, suggesting that a uniform EU-level policy approach may be insufficient and that national-level measures are necessary.

The question then arises as to whether statistically significant differences exist between firm-size categories within individual countries. In the first step, individual countries were not considered; instead, differences between small and medium-sized enterprises across regions were examined. The null hypothesis H_0 was formulated as "Both categories show the same level of AI use," while the alternative hypothesis H_A stated that "There is a difference in the level of AI use between the two categories under review." The results of this test are presented in Table 3.

Table 3 Chi-square test of independence

Test characteristics	Value
χ^2	1,370.60
Degrees of freedom	1
p-value	<0.001

Source: Own processing

The test results indicate statistically significant differences between the two size categories under consideration, as the p-value is below 0.05; therefore, the null hypothesis is rejected. The findings reveal that the level of AI adoption differs between the two categories. Medium-sized enterprises exhibit a higher level of AI adoption compared to small enterprises, while small enterprises display a higher incidence of non-adoption of this technology. In practical terms, the results suggest that medium-sized enterprises possess organizational and resource advantages that enable more frequent AI adoption, while small enterprises remain structurally disadvantaged.

Subsequently, partial comparisons of firm-size categories within individual countries were conducted using the chi-square test. In this step, several pairwise comparisons were found to be statistically insignificant. An overview of all statistically insignificant pairwise comparisons is provided in Table 4.

Table 4 Pairs of statistically insignificant size categories in countries (SM – small enterprises, MS – medium-sized enterprises)

First comparison group	Second comparison group	P-value
Hungary MS	Poland MS	0.068
Slovakia SM	Poland MS	0.182
Czechia MS	Slovakia MS	0.182
Slovakia SM	Hungary MS	0.299

Source: Own processing

Most pairwise comparisons still indicate statistically significant relationships; however, medium-sized enterprises in Hungary and Poland exhibit twice as many statistically insignificant relationships as medium-sized enterprises in Slovakia.

Specifically, no statistically significant differences were identified between Hungarian and Polish medium-sized enterprises. Similarly, the differences between Hungarian medium-sized enterprises and Slovak small enterprises, as well as between Polish medium-sized enterprises and Slovak small enterprises, were found to be statistically insignificant. These results suggest that medium-sized enterprises in Poland and Hungary, together with small enterprises in Slovakia, stand out from the overall pattern observed in the analysis, as these categories display the lowest levels of statistical differentiation.

The statistical significance of the differences observed between individual countries indicates not only variations in AI adoption levels, but also the systematic influence of the national context on the extent to which artificial intelligence is used in businesses. From a practical perspective, this implies that differences in AI adoption cannot be regarded as random; rather, they reflect long-term economic, institutional, and structural factors. Similarly, the differences identified between company size categories suggest that firm size is a key determinant of the capacity to implement and effectively use artificial intelligence. Medium-sized enterprises exhibit higher absorptive capacity, which is reflected in their significantly higher level of AI adoption compared to small enterprises.

4 Conclusions

The main aim of this paper is to examine the application of artificial intelligence in small and medium-sized enterprises and to investigate whether the adoption of AI in enterprises across the V4 countries varies not only by country but also by enterprise size. This aim has been achieved, as the study identifies clear differences in AI adoption across the V4 countries as well as between enterprise size categories. Statistically significant differences in AI adoption among countries were confirmed, and the results further indicate that medium-sized enterprises adopt and work with AI more frequently than small enterprises. In relative terms, Slovakia performs best among small enterprises, while the Czech Republic shows the strongest performance among medium-sized enterprises. In absolute terms, Poland records the highest number of enterprises using AI; however, this outcome primarily reflects its larger business base compared to the other countries. Overall, the findings demonstrate that factors such as firm size and country-specific conditions play a significant role in shaping AI adoption in enterprises.

The empirical findings can be interpreted in light of existing theoretical insights on AI adoption barriers in SMEs. Previous studies identify limited financial resources, lack of skilled personnel, insufficient digital infrastructure, and uncertainty about return on investment as key obstacles to AI adoption in smaller firms (Kumar et al., 2023; Restrepo-Morales et al., 2024). The observed lower AI adoption rates among small enterprises compared to medium-sized enterprises across the V4 countries are consistent with these theoretical expectations. Similarly, cross-country differences within the V4 region reflect differences in national innovation systems, digital readiness, and policy support, as highlighted in prior studies on Industry 4.0 preparedness in Central and Eastern Europe (Molendowski et al., 2024).

The results of this study have several practical implications. First, the findings indicate that support for artificial intelligence adoption should not be uniform but should reflect both enterprise size and national context. The consistently lower adoption rates observed among small enterprises suggest that these firms face structural constraints that limit their ability to implement AI solutions, even when the technology is increasingly accessible. As a result, measures aimed at promoting AI adoption should explicitly account for differences in absorptive capacity between small and medium-sized enterprises. Second, the identified cross-country differences within the V4 region imply that national institutional and economic conditions play an important role in shaping AI adoption outcomes. This suggests that policy interventions should be tailored to country-specific conditions rather than relying solely on generalized approaches at the regional or EU level. From a managerial perspective, the results highlight the importance of a gradual and strategic approach to AI adoption, particularly in smaller enterprises, where resource constraints are more pronounced. Overall, the study underscores the need for targeted and differentiated strategies to support effective AI adoption among SMEs in the V4 countries.

Several limitations and barriers of this study should be acknowledged. First, the analysis is based on secondary data from the Eurostat database for 2023, which represents the most recent complete dataset available. Second, the study does not provide a detailed perspective on micro-enterprises, as this category is not monitored by Eurostat with respect to AI adoption. The statistical methods and analytical approaches employed were appropriate for fulfilling the aim of the paper by identifying differences between countries and firm-size categories; however, they do not allow for an examination of the underlying causes of these differences or for the establishment of causal relationships. Moreover, the analysis does not account for sector-specific differences, the quality or maturity of AI implementation, or the economic performance of individual enterprises, which could otherwise serve as relevant control variables. As a result of these data-related limitations, the study is unable to assess the depth of AI adoption or to evaluate the actual effectiveness and success of the implemented AI solutions. With regard to directions for further research, several avenues may be pursued. First, the existing dataset could be extended by incorporating a representative sample of micro-enterprises in order to examine additional

differences across firm-size categories. Furthermore, sectoral affiliation could be included as an additional explanatory variable to capture industry-specific patterns of AI adoption. Another promising direction involves complementing the quantitative analysis with qualitative research, which could enable the identification and subsequent compilation of best practices in AI adoption. In addition, future studies could focus on assessing the economic impacts of AI adoption in enterprises, particularly with respect to both costs and revenue effects, as well as identifying the key success factors associated with successful adoption. Finally, extending the analysis to a time-series perspective would allow for the examination of short-term fluctuations in relation to long-term trends. Collectively, these research directions could contribute to a deeper understanding of AI adoption in enterprises and support the development of more effective policy measures aimed at fostering AI adoption in the V4 region.

This study's recommendations can be summarized as follows. The findings indicate that effective support for artificial intelligence adoption among small and medium-sized enterprises should be differentiated according to enterprise size and national context. Smaller enterprises require more tailored approaches reflecting their more limited resources and absorptive capacity, while cross-country differences within the V4 region underline the importance of country-specific strategies. Overall, the results suggest that targeted and context-sensitive measures are more appropriate than uniform approaches when promoting AI adoption among SMEs.

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Regional Disparities in R&D and Innovation Expenditures: A Comparison between the Bratislava Region and Other Slovak Regions

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Abstract: This paper examines regional disparities in research and innovation (R&D) expenditures across Slovakia, with particular emphasis on differences between the Bratislava Region and the remaining NUTS 2 regions. The aim of the study is to identify the extent of these disparities and to assess whether they are statistically significant. The analysis is based on secondary data obtained from the Regional Innovation Scoreboard (RIS) 2023, compiled by the European Commission in cooperation with Maastricht University. Using descriptive statistics and inferential analysis, including independent samples t-tests, the study compares public and private R&D expenditures as a percentage of GDP across Slovak regions. The results reveal that the Bratislava Region significantly outperforms other regions in both public and private R&D investment, confirming the presence of pronounced regional disparities in innovation financing. These findings highlight the need for targeted, region-specific innovation policies aimed at strengthening R&D capacity in less developed regions and supporting more balanced regional development in Slovakia.

Keywords: regional disparities, research and development, innovation expenditure, Regional Innovation Scoreboard, Slovakia

JEL Classification: R11, O31, O32

1 Introduction

Innovation is widely recognized as a key driver of economic growth, productivity, and regional competitiveness. In the context of the European Union's efforts to reduce regional disparities, the promotion of research and innovation (R&I) has become a central pillar of cohesion policy. Despite significant investments, however, innovation performance remains highly uneven not only between countries but also within them. Slovakia represents a striking example of this intra-national divide, with the Bratislava region consistently outperforming the rest of the country in R&D spending and innovation capacity.

The Bratislava region, classified as a “strong innovator” by the Regional Innovation Scoreboard (RIS) 2023, demonstrates markedly higher levels of both public and private sector R&D expenditures compared to other Slovak NUTS 2 regions (Western, Central, and Eastern Slovakia). These disparities raise important questions about the underlying drivers of regional innovation capacity, including institutional quality, human capital, industrial structure, and the effectiveness of regional policy instruments.

This paper aims to investigate the extent and nature of regional disparities in research and innovation expenditures in Slovakia. By comparing the Bratislava region with other NUTS 2 regions, the study seeks to identify the key structural and policy-related factors contributing to the observed gap. The analysis is based on data from RIS 2023 and employs both descriptive and inferential statistical methods. The findings are intended to inform more effective and region-sensitive

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innovation policies that can support balanced development and enhance the overall absorptive capacity of Slovakia's innovation ecosystem.

Understanding the territorial dynamics of R&D investment is essential for designing targeted interventions that address specific regional needs. While national innovation strategies often adopt a one-size-fits-all approach, regional disparities in absorptive capacity, institutional infrastructure, and knowledge spillovers require more nuanced solutions. By contextualizing Slovakia's regional innovation performance within broader European trends and theoretical frameworks—such as regional innovation systems and spatial inequality. This study contributes to the growing body of literature advocating for place-based innovation policies. Ultimately, reducing the innovation gap between the capital and the periphery is not only a matter of equity but a strategic imperative for achieving sustainable and inclusive economic growth.

2 Literature Review

Regional development and innovation performance are closely interlinked, with innovation serving as a key driver of economic growth and competitiveness. The relationship between these two factors is complex and influenced by a variety of determinants, including resource allocation, policy support, and socio-economic conditions. This synthesis examines the multifaceted nature of innovation performance across regions and highlights key factors that contribute to or hinder regional development. Innovation performance is a key prerequisite for the long-term competitiveness and economic growth of enterprises and regions. As Rubera and Kirca (2012) point out, companies that actively innovate are more likely to achieve sustainable growth and global competitiveness. According to Ivanová and Masárová (2019), the current state of innovation systems in EU countries shows significant disparities, with the intensity of research and development (R&D) expenditure and the absorptive capacity of regions being the main factors contributing to regional inequalities.

Several studies emphasize that the development of innovation capacities is influenced by the concentration of human capital, research infrastructure, and international cooperation, which gives metropolitan regions a natural advantage. Iammarino et al. (2020) stress that urban areas benefit from synergies between capital, knowledge, and technological platforms, while peripheral regions face problems such as low absorptive capacity, limited cooperation between universities and firms, and weak public innovation support. The importance of financial resources as a main condition for innovation development is also confirmed by Lesáková et al. (2017), who, based on a survey of Slovak SMEs, identified financial constraints, weak cooperation with research institutions, and bureaucratic barriers as the most common obstacles to innovation activity. The authors distinguish between innovation leaders, modest innovators, and non-innovative firms, emphasizing the need for targeted public support, the development of regional clusters, and networking.

Another important dimension is the regional and spatial context of innovation. Borseková et al. (2017) highlight the significance of smart specialization and local potential as tools to enhance regional competitiveness. According to the authors, the effective use of endogenous resources and strategic coordination among institutions lead to the sustainable development of innovation ecosystems. From a regional perspective, Rentková and Gejdoš (2019) provide a detailed view of the impact of small and medium-sized enterprises on the economic performance of Slovak regions. Their research points to a close link between GDP growth, unemployment reduction, and entrepreneurial activity, with SME innovation representing one of the most important sources of regional growth. Visegrad Group regions show substantial disparities in innovation performance, particularly in public-private co-publications and SME collaboration, underlining the importance of tailored innovation strategies that address specific regional needs (Ivanová & Masárová, 2019). Spatial analysis across EU regions indicates that regional innovativeness and economic performance are significantly affected by geographic location and neighbouring regions. Social capital effects and competition between internal R&D and external technology acquisition play a decisive role in regional economic outcomes (Olejnik & Żółtaszek, 2020). In Portugal's Alto Minho region, progress toward Sustainable Development Goal 9 (industry, innovation, and infrastructure) varies significantly between municipalities, suggesting the need for targeted policy interventions to promote balanced regional development (Abreu et al., 2023). Policy support and cultural values also moderate the relationship between innovation input and performance. In China, policy support enhances innovation outcomes, while cultural dimensions such as egalitarianism and mastery positively influence innovation input efficiency. The effectiveness of R&D support depends on the existing level of innovation activity, with below-average R&D regions benefiting most from targeted interventions. While innovation is a key driver of regional development, the effectiveness of innovation strategies varies significantly across regions due to differences in resource utilization, political environments, and socio-economic contexts (Lesáková et al., 2017).

Regions with strong policy support and effective resource management tend to exhibit better innovation performance. However, disparities in innovation outcomes underscore the need for region-specific strategies that reflect local characteristics and potential. Understanding this dynamic is crucial for policymakers aiming to foster sustainable regional development through innovation. Regional disparities in R&D and innovation expenditures are a complex phenomenon

shaped by the capacity of innovation systems, institutional environments, and the economic performance of regions. R&D is considered a dominant driver of regional growth and competitiveness (Capello & Lenzi, 2016). Disparities between more and less developed regions (e.g., the Bratislava region vs. peripheral areas) are largely conditioned by industrial structure diversity, human capital absorption capacity, and geographic clusters (Boschma, 2004; Frenken et al., 2007). Mature agglomerations and knowledge networks foster regional spillovers, whereas their absence hinders the development of peripheral regions (Scherngell & Barber, 2010;). Institutional development theory emphasizes the necessity of stable formal institutions and coordination mechanisms for the growth of regional innovation systems. Less developed regions often suffer from weak integration of intellectual capacities and insufficient policy support (Ayuso S. et al, 2011). Capital cities and metropolitan areas such as Bratislava are among the so-called "smart urban regions," characterized by high concentrations of capital, talent, and social interaction that support innovation growth (Iammarino et al., 2020). In contrast, less developed regions often fall into the "middle-income trap," where short-term firm-level innovations are insufficient for sustained economic growth (Iammarino et al., 2020).

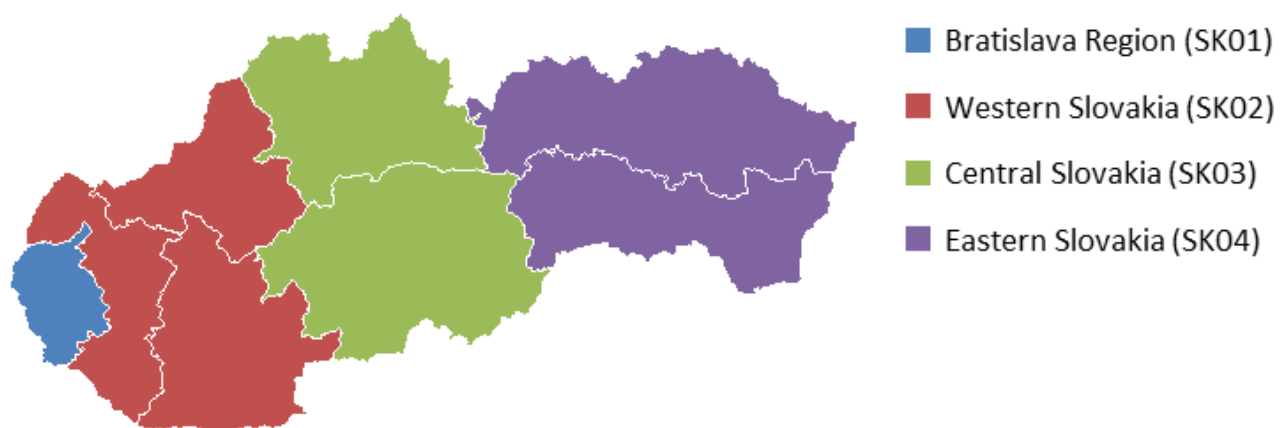
R&D and innovation expenditures are typically measured using composite indices such as the Regional Innovation Scoreboard (RIS), which aggregates public and private investment, patent activity, academic output, and technology transfers (European Commission, 2023). Studies on innovation convergence show that R&D investments in urban centers converge more rapidly than in peripheral areas, contributing to regional stratification. These findings confirm that geographic and cognitive proximity increase the likelihood of sustained cooperation (Scherngell & Barber, 2010).

In summary, the theoretical framework builds on an integrated understanding of innovation systems, institutions, geographic clusters, and their interactions as key determinants of the regionalization of R&D investment. This framework supports the hypothesis that the Bratislava region exhibits higher R&D spending as a result of its strong absorptive capacity, robust intellectual ecosystem, and favorable institutional background.

3 Methods

This study adopts a quantitative research design based on secondary data analysis. The data were obtained from the *Regional Innovation Scoreboard (RIS) 2023 – Regional Profiles: Slovakia*, published by the European Commission in cooperation with Maastricht University (UNU-MERIT). The RIS provides harmonized and comparable indicators of regional innovation performance across European Union regions at the NUTS 2 level.

This study employs a quantitative research design and utilizes secondary data analysis to examine regional disparities in research and innovation expenditures between the Bratislava Region (SK01) and the other NUTS 2 regions of Slovakia. The primary objective is to assess whether significant differences exist in public and private R&D investment levels across these regions.



The data were obtained from the publication *Regional Innovation Scoreboard 2025 – Regional Profiles Slovakia*, published by the European Commission (Directorate-General for Research and Innovation) in cooperation with Maastricht University – UNU-MERIT. This source offers a comprehensive evaluation of regional innovation performance in Slovakia, based on data spanning the period 2018 to 2025, and structured according to the NUTS 2 classification.

The RIS assessment integrates multiple data sources, including the Community Innovation Survey (CIS), Eurostat, PCT patent statistics, and Scopus-indexed scientific publications. The analysis focuses on key indicators representing public and

private sector investments in research, development, and innovation (RDI). Statistical analyses were conducted using JAMOVI statistical software.

To assess the normality of selected variables, the Shapiro–Wilk test was applied prior to further inferential testing. Subsequently, independent samples t-tests were used to evaluate differences in R&D expenditures between the Bratislava Region and the aggregate of the remaining Slovak regions.

Selection of variables: The analysis concentrates on indicators capturing research and innovation expenditure, as these represent key input factors of regional innovation systems. Specifically, two indicators were selected from the RIS database; public sector R&D expenditure as a percentage of GDP, and business sector R&D expenditure as a percentage of GDP. These indicators were chosen for three main reasons. First, R&D expenditure is widely recognized in the literature as a primary determinant of innovation capacity and regional competitiveness. Second, both indicators are consistently available across Slovak regions and over time, ensuring comparability. Third, the distinction between public and private R&D investment allows for a more nuanced assessment of regional disparities and policy relevance, particularly in the context of capital versus peripheral regions.

Research Assumption was that it is assumed that the Bratislava Region exhibits significantly higher levels of R&D and innovation expenditure compared to other Slovak regions, both in the public and private sectors.

The main research question: *Are there statistically significant differences in research and innovation expenditure between the Bratislava region and other regions of Slovakia?*

Following the research question, two research hypotheses were established.

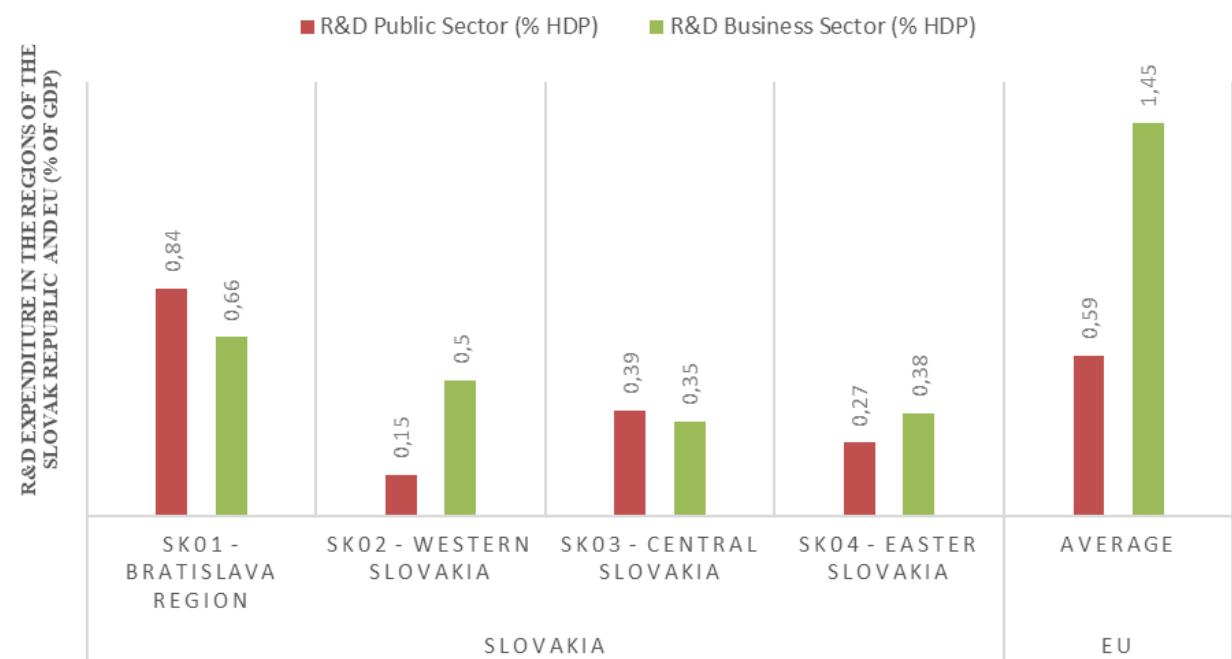
- ***H₀*:** There are no statistically significant differences in expenditure on research and innovation between the Bratislava region and other regions of Slovakia.
- ***H₁*:** There are statistically significant differences in expenditure on research and innovation between the Bratislava region and other regions of Slovakia.

4 Research results

Bratislava region and other regions of Slovakia. The aim of the analysis was to identify whether there are statistically significant differences in the level of public and private investment in research and development (R&D), with particular attention paid to comparison with the European Union average. Based on data from the *Regional Innovation Scoreboard 2023*, descriptive and inferential statistics were performed to assess regional disparities in the financing of innovation activities. The tables and graphs in this chapter show the differences between individual regions of Slovakia, as well as the position of the Bratislava region in relation to the EU average. The results of statistical tests then provide an answer to the research question and allow the hypotheses to be evaluated.

Table 1 shows public and private expenditure on research and innovation in individual regions of Slovakia for 2023. The values represent the share of public and business sector expenditure on research and development (R&D) as a percentage of gross domestic product (GDP). The highest share of public and private investment is in the Bratislava region (0.84% and 0.66% of GDP), while other regions (Western, Central, and Eastern Slovakia) show lower values. The data point to significant regional differences in support for innovation activities at the regional level. Chart 1 visually illustrates public and private expenditure on research and innovation in Slovakia's regions in 2023. The bar chart allows for a comparison of investment intensity between regions. The Bratislava region significantly outperforms other regions, especially in terms of public expenditure. This graph clearly illustrates the concentration of innovation activities and investments in the capital city and its surroundings.

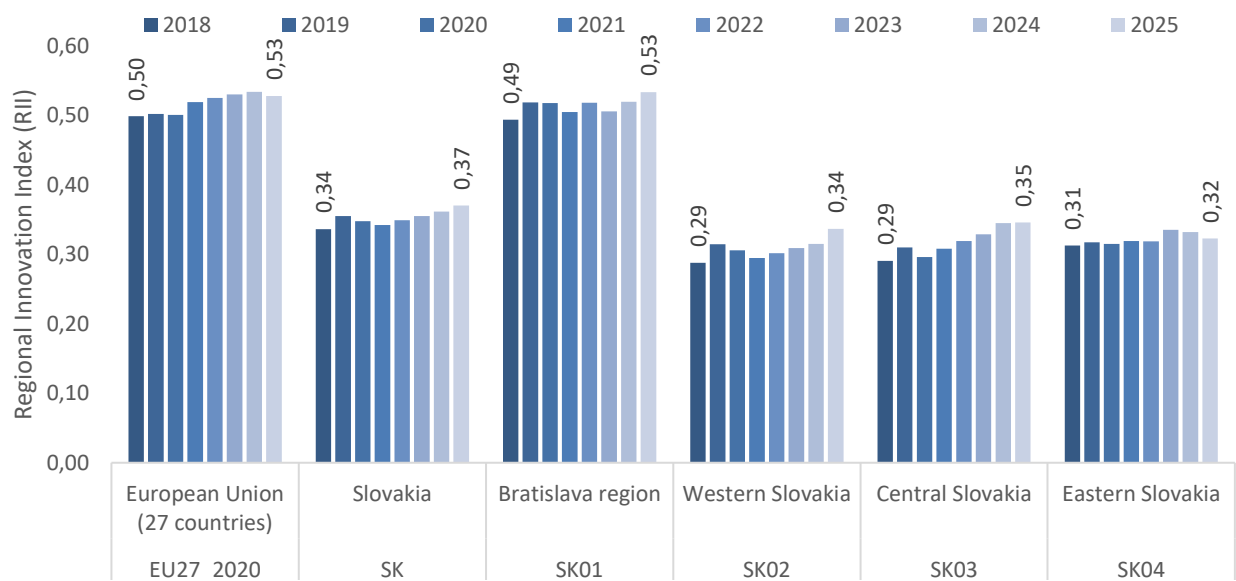
Figure 1 Visual representation of expenditure on research and innovation in Slovak regions with the EU average for 2023



Source: Own processing based on European Commission

This figure 1 presents the development of the Regional Innovation Index (RII) for Slovakia (SK) and its NUTS 2 regions—Bratislava Region (SK01), Western Slovakia (SK02), Central Slovakia (SK03), and Eastern Slovakia (SK04)—in comparison to the EU27 average between 2018 and 2025. The values range from 0.29 to 0.53, indicating notable disparities in regional innovation performance. The Bratislava Region (SK01) consistently shows the highest RII values among Slovak regions, growing from 0.49 in 2018 to 0.53 in 2025, closely aligning with the EU27 average. In contrast, the other Slovak regions remain significantly below both the national and European averages, with only moderate increases over the observed period. The national average for Slovakia (SK) improves from 0.34 to 0.37, reflecting slow but steady progress. These results highlight the persistent innovation gap between the capital region and the rest of the country, emphasizing the need for targeted innovation policies to strengthen regional capacities.

Figure 2 Regional Innovation Index (RII) for Slovakia and Its NUTS 2 Regions Compared to the EU Average, 2018–2025

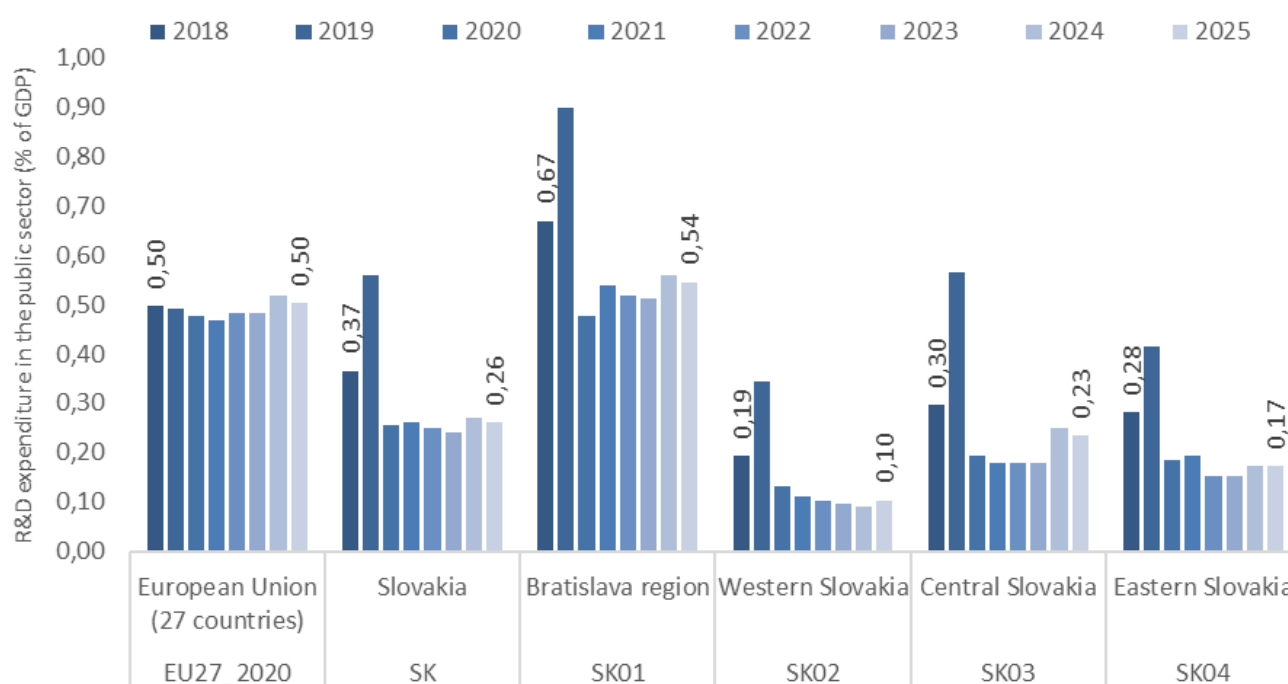


Source: Own processing based on Eurostat

The figure 2 presents the annual evolution of R&D expenditure in the public sector as a percentage of GDP for the European Union (EU27), Slovakia (national average), and its four NUTS 2 regions from 2018 to 2025.

The data reveal substantial disparities across Slovak regions: The Bratislava Region (SK01) consistently reports the highest public R&D spending, peaking at 0.90% in 2019, and stabilizing around 0.54% by 2025. In contrast, Western Slovakia (SK02) shows the lowest investment levels, declining from 0.34% in 2019 to only 0.10% in 2025. Central (SK03) and Eastern Slovakia (SK04) show modest and stable levels, with slight increases post-2023, reaching 0.23% and 0.17%, respectively. The national average for Slovakia fluctuates between 0.24% and 0.56%, with a noticeable decline after 2019. Compared to the EU27 average (which remains around 0.48–0.52%), only the Bratislava Region surpasses the European benchmark, underscoring the strong regional imbalance in public R&D investment. These findings highlight the capital region's dominant role in public research funding, while peripheral regions lag significantly behind, suggesting a need for policy interventions to support more balanced R&D development.

Figure 3 Public Sector R&D Expenditure (% of GDP) in Slovakia and Its NUTS 2 Regions Compared to the EU Average, 2018–2025

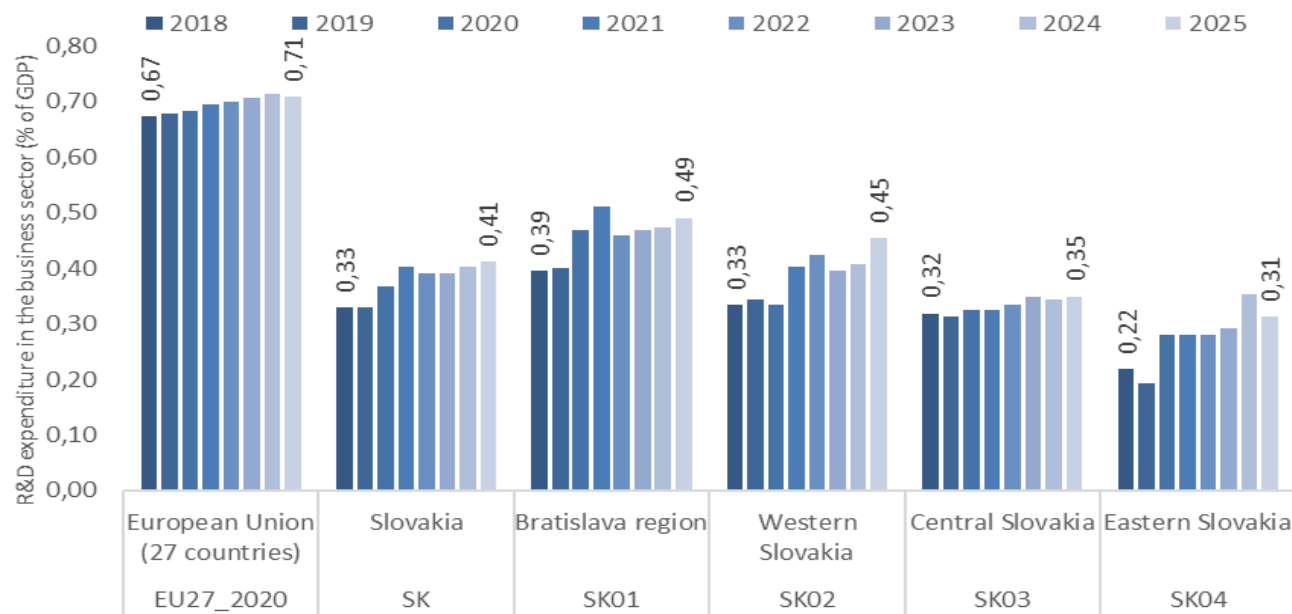


Source: Own processing based on Eurostat

Figure 3 displays the evolution of R&D expenditure in the business sector as a percentage of GDP from 2018 to 2025, comparing Slovakia's national average and its NUTS 2 regions (Bratislava Region – SK01, Western Slovakia – SK02, Central Slovakia – SK03, and Eastern Slovakia – SK04) to the EU27 average. The EU27 average shows a steady increase from 0.67% in 2018 to 0.71% in 2025, while Slovakia's national average rises from 0.33% to 0.41%, remaining below the EU benchmark throughout the period.

Among Slovak regions Bratislava Region (SK01) consistently leads in business R&D investment, growing from 0.39% in 2018 to 0.49% in 2025, peaking at 0.51% in 2021. Western Slovakia (SK02) shows significant improvement, rising from 0.33% to 0.45%, closing the gap with Bratislava. Central Slovakia (SK03) remains relatively stable with slight growth, ending at 0.35%. Eastern Slovakia (SK04) has the lowest figures overall but improves from 0.22% in 2018 to 0.31% in 2025. These trends reflect persistent regional disparities in private R&D investment, but also signal some convergence between the capital and other regions, particularly Western Slovakia.

Figure 4 Public Sector R&D Expenditure (% of GDP) in Slovakia and Its NUTS 2 Regions Compared to the EU Average, 2018–2025



Source: Own processing based on Eurostat

Figure 4 Results of statistical analysis

Independent Samples T-Test			
		Statistic	df
Value	Student's t	4.17	6.00
Note. $H_a \mu_{\text{Bratislavský kraj}} \neq \mu_{\text{Ostatné regióny}}$			
p			
0.006			

Group Descriptives						
Group		N	Mean	Median	SD	SE
Value	Bratislava region	2	0.750	0.750	0.127	0.0900
	Other regions	6	0.340	0.365	0.119	0.0486

Source: Own processing in the program JAMOVI based on the document https://ec.europa.eu/asets/rtd/ris/2023/ec_rtd_ris-regional-profiles-slovakia.pdf

Figure 4 extends the previous comparison with the European Union (EU) average benchmark. In addition to Slovak regions, it also includes average values for public (0.59% of GDP) and private (1.45% of GDP) expenditure on research and innovation in EU countries. The data show that the Bratislava region exceeds the EU average in public expenditure but lags significantly behind in private investment. Other Slovak regions lag behind the EU average in both sectors. The bar chart shows a significant difference between the Bratislava region and the rest of Slovakia, as well as between Slovak regions and the EU average, with the largest difference being in private investment. This chart highlights the need to stimulate private spending on research and innovation outside the capital.

Table 1 presents the results of statistical analysis performed in the JAMOVI program. The parametric t-test ($t(6) = 4.17$, $p = 0.006$) showed a statistically significant difference in research and innovation expenditure between the Bratislava region and other regions of Slovakia. Descriptive statistics show that the Bratislava region achieved an average value of 0.75% of GDP, while other regions achieved an average of only 0.34% of GDP. This result supports the alternative hypothesis of the existence of significant regional differences.

4 Discussion

The results of the analysis showed significant differences in research and innovation expenditure between the Bratislava region and other regions of Slovakia. Compared to Western, Central, and Eastern Slovakia, the Bratislava region shows significantly higher public (0.84% of GDP) and private (0.66% of GDP) investment in research and development. Statistical analysis confirmed these differences, with a parametric t-test indicating their statistical significance ($t(6) = 4.17$; $p = 0.006$). These findings are consistent with theoretical concepts about the concentration of innovation activities in metropolitan areas. As noted Iammarino et al. (2020), urban regions benefit from the synergistic effects of high concentrations of human capital, financial resources, and innovation infrastructure that support the creation of knowledge and technology. Conversely, less developed regions often face obstacles such as a weak research base, low absorption capacity, and limited cooperation between universities and the business sector (Capello & Lenzi, 2016). Lesáková et al. (2017) further elaborate on these challenges by identifying financial constraints, insufficient public support, and bureaucratic hurdles as key barriers to innovation in Slovak SMEs, particularly outside of major urban centers. These obstacles were also evident in the lower R&D activity observed in Western, Central, and Eastern Slovakia in this study, emphasizing the systemic limitations facing less developed regions. The analysis confirms that geographic location and structural conditions remain decisive in shaping innovation outcomes, echoing the observations of Borseková et al. (2017), who advocate for smart specialization strategies and local coordination as tools for enhancing regional innovation ecosystems. The strong performance of the Bratislava region can thus be attributed to its role as a knowledge and capital hub, with high levels of institutional coordination, supporting the view that regional innovation policy must be place-sensitive and context-driven.

The results point to the need for systematic measures to support the development of innovation ecosystems in less developed regions. Key recommendations include promoting private investment through tax incentives and grant schemes, developing regional innovation clusters, and strengthening cooperation between research institutions and the business sector. In addition, it is important to tailor innovation policies to the specific characteristics of individual regions, as universal approaches have proven to be less effective (Ivanová & Masárová, 2019).

5 Conclusions

The aim of this paper was to examine regional disparities in research and innovation expenditures between the Bratislava Region (SK01) and the other NUTS 2 regions of Slovakia, based on data from the *Regional Innovation Scoreboard 2023*. The results demonstrate that the Bratislava Region consistently achieves significantly higher levels of both public and private investment in research and development (R&D), confirming its role as the dominant innovation hub in the country. In contrast, the remaining Slovak regions lag not only behind Bratislava but also fall short of the European Union (EU27) average, particularly in the area of business sector investment.

Statistical analysis supported these observations. An independent samples t-test conducted to compare average R&D expenditures revealed a statistically significant difference between Bratislava and the rest of Slovakia ($t(6) = 4.17$, $p = 0.006$). This result allowed us to reject the null hypothesis that no differences exist, and to accept the alternative hypothesis, which posits the presence of regional disparities in research and innovation funding. The statistical evidence therefore affirms that the Bratislava Region significantly outperforms other regions in both public and private R&D investment as a share of GDP.

These findings underline the urgent need for targeted regional policies aimed at strengthening innovation capacity in less developed areas of Slovakia. Key policy recommendations include stimulating private R&D investment in underperforming regions, fostering the development of regional innovation clusters, and enhancing collaboration between universities, research institutions, businesses, and public administration. Such measures would help address structural imbalances and support more inclusive and sustainable regional development.

At the same time, this research faces several limitations that should be acknowledged. First, the analysis relied solely on secondary data drawn from the RIS 2023 report, which limits the ability to verify the quality, motivations, or contextual specifics of the data sources. Second, the study is based on a fixed time frame (mainly reflecting 2023), which may not fully capture recent policy changes or investment dynamics. Third, the small sample size—limited to four Slovak regions—constrains the statistical power of the tests and restricts the generalizability of the results to broader contexts.

To address these limitations, future research should incorporate primary data collection, such as expert interviews or firm-level surveys, to gain deeper insight into the regional innovation landscape. Furthermore, qualitative analysis of institutional frameworks, innovation policy implementation, and business-sector engagement would enrich our

understanding of the mechanisms driving regional disparities in R&D performance. These steps are essential for designing more effective and evidence-based innovation strategies in Slovakia and similar regional contexts across Europe.

Acknowledgement

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Innovation in Selected European Countries and Position of Czech Businesses

Petra Matoušková¹, Jaroslav Vrchota², Lukáš Klárner³, Petr Řehoř⁴,
Roman Buchtele⁵, Kamila Němečková⁶

Abstract: Innovation and the introduction of new processes are an essential part of the functioning of enterprises. The main aim of this paper is to evaluate the position of enterprises from the Czech Republic within Central Europe in terms of innovation and the introduction of new business processes, and to identify whether there are significant differences between enterprises from individual countries. To achieve this aim, harmonized secondary data from the CIS 2022 survey and descriptive statistics, together with the chi-square test of independence, are used. The Oslo Manual is used to classify particular types of innovation. The results show the dominance of Germany, both in absolute terms and in intensity. Slovakia lags significantly behind other Central European countries. Process innovations are most often represented in all countries, while Czech enterprises are well above average in marketing innovations, and they also stand out in product innovations. It is recommended to strengthen organizational and process innovations, in particular in order to create a suitable innovation mix leading to increased competitiveness.

Keywords: innovation, business process, improving, Oslo manual

JEL Classification: M21, O31, O32

1 Introduction

Improving business processes in companies is based mainly on two levels, namely (a) strategic innovation management and (b) Business Process Management (BPM), which helps to introduce innovations into an operational and, above all, measurable state (Mendling et al., 2020). We also recognize the term Business Process Innovation (BPI), which refers to changes in the design and operation of processes (Qerimi et al., 2024). BPM then offers support in the form of process models, analytics, and further improvement options, which help not only to create innovations themselves, but also to implement and maintain them in practice (van der Aalst, 2013).

In terms of basic concepts in the field of types of innovation, the most widely used OECD methodology, called the Oslo Manual, can be used. It distinguishes four basic types of innovation. First, there are product innovations (new or significant product improvements), process innovations (e.g., new methods, procedures), organizational innovations (innovations of structures, knowledge), and finally marketing innovations (innovations of positioning, design, or pricing) (Gunday et al., 2011). Progress within individual innovations is captured using both quantitative and qualitative indicators (Dzialis & Blind, 2019). In addition, a strong theme in the current literature is the complementarity between the particular types of innovation. Those organizations that can align product and process innovations are better able to achieve sustainable improvement (Camisón & Villar-López, 2014). However, the goal of an organization should be a balanced portfolio of innovations, which will include not only process and product innovations, but also other types of innovations (Polder et al., 2020).

Within the framework of innovation and business processes, there is a number of specificities for Central and Eastern Europe. These are summarized in the Community Innovation Survey. It was found that companies in this region are more oriented towards incremental and gradual innovations than radical product innovations (Hashi & Stojčić, 2013). The fact that companies in the Central European region – specifically ones from the Czech Republic – are strongly focused on product and marketing innovations is also confirmed by Vokoun & Píchová (2020). It is also interesting that, in general,

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for Central European countries, internal R&D has a positive impact on product innovations, while a negative impact on process innovations, applies. Moreover, external R&D is significant only in the case of the Czech Republic. In the framework of innovation, funding from EU sources appears to be crucial (Vávra et al., 2021). Likewise, for companies in this region, knowledge and membership in various associations and groups are important internal sources of innovation. It was also found that the source of external knowledge is usually not technology transfer from abroad or foreign technology (Prokop et al., 2021). Based on these differences, the research question was formulated as follows: “Are there differences between countries in terms of individual types of innovation?”

2 Methods

The main aim of this paper is to evaluate the position of enterprises from the Czech Republic within Central Europe and Germany in terms of innovation and the introduction of new business processes, and to identify whether there are significant differences between enterprises from individual countries. To achieve this aim, the latest available secondary data from the Eurostat database was used. (Eurostat, 2022a; 2022b).

The geographical area was selected based on several scholarly publications dealing with a similar topic in Central or Central and Eastern Europe and Germany, often with a specific focus on one country, as will be the case in this paper, and the topic has been discussed cross-sectionally for many years (Hashi & Stojčić, 2013; Lewandowska et al., 2016; Radosevic, 2002; Vokoun & Píchová, 2020). The analysis is based on the latest complete wave of harmonized Eurostat data available at the time of processing in the form of the Community Innovation Survey 2022, abbreviated CIS 2022. CIS is a survey with a reference period of 2020–2022; the results of this wave were published in 2024, and the next wave (CIS 2024) will not be published until 2026 (Eurostat, 2024). For structural business statistics, the standard lag is in the order of several months or lower tens of months (Eurostat, n.d.); therefore, 2022 is the last year with final and internationally comparable data for all monitored indicators. The choice of 2022 thus ensures the replicability of the analysis. Research dealing with Central Europe with data from the Community Innovation Survey is no exception (Makrevska Disoska et al., 2024; Vokoun & Dvouletý, 2022).

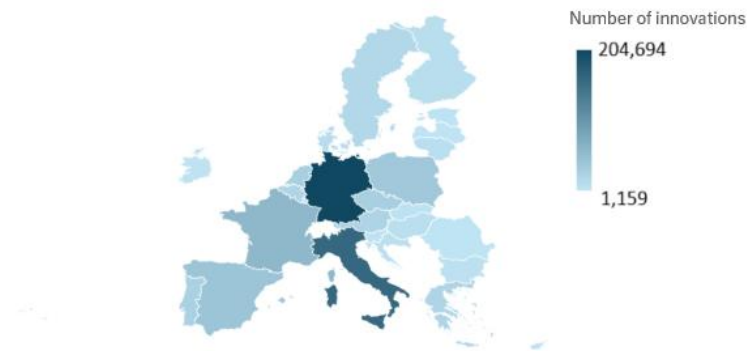
To enable cross-country comparability, absolute numbers of innovations were recalculated into relative indicators. First, innovation intensity was computed as the ratio of the number of new or improved business processes to the total number of enterprises in the country ($\text{Innovation intensity} = \text{Number of innovations} \div \text{Number of enterprises}$). Second, the indicator “companies per one innovation” was derived as the inverse of innovation intensity ($\text{Companies per innovation} = \text{Number of enterprises} \div \text{Number of innovations}$). For Figure 3, the number of innovations by type was normalized per company using the same approach, i.e., dividing the absolute count of each innovation type by the total number of enterprises in the respective country. Finally, the process/product ratio in Table 3 was calculated as $(\text{Process innovations} + \text{Organizational innovations}) \div (\text{Product innovations} + \text{Marketing innovations})$. These recalculations ensure that differences are not driven by country size but reflect relative innovation activity.

In order to answer the research question with statistical significance, it was necessary to use statistical analyses. First, basic descriptive statistics were used in the form of tables and graphs (Byrne, 2007). Subsequently, the chi-square test of independence was used, which answers the question of whether there is a statistically significant relationship between the individual variables (Franke et al., 2011). The calculation of standardized residuals was also used to observe whether companies in individual countries implement fewer or more specific types of innovations than the expected average (Ahad et al., 2023). If the residual value is > 0 , then this is a statistically significant positive deviation. If the residual is < 0 , then the value is smaller than the expected average and there is statistically significant negative deviation (Bewick et al., 2004). The initial significance level was chosen as $\alpha = 0.05$ (Wasserstein & Lazar, 2016). MS Excel and the statistical tool R Studio were used for all calculations and analyses.

3 Research results

Before looking at Central Europe and Germany, a look at all EU member states is offered in Figure 1. The total number of activities related to the implementation of innovations in existing business processes or introducing new ones was monitored.

Figure 1 Number of new or improved business processes in EU

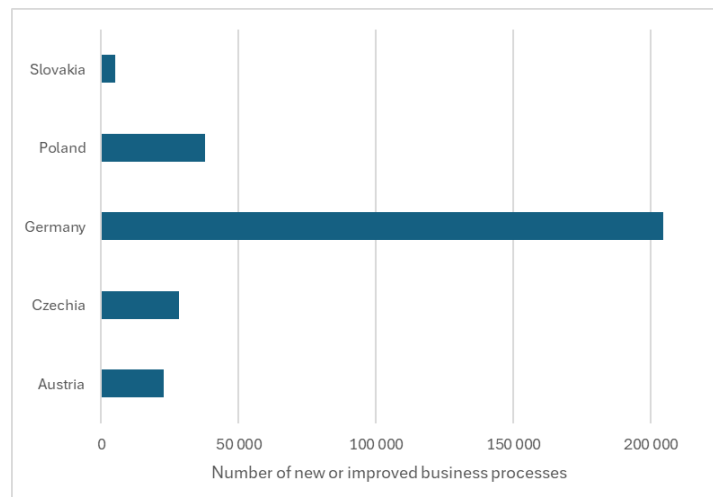


Source: Own processing according to Eurostat (2022b)

As can be seen, in the context of the entire EU, Germany is the leader in the number of innovations, followed by Italy. Companies in France, Spain, and Poland are also significantly active. The Czech Republic is located approximately in the middle of the color spectrum. Companies in the Baltic States or the Balkan Peninsula are significantly less active.

A simple comparison overview is now offered within the individual Central European countries. Figure 2 shows the total number of new and improved business processes in the individual countries.

Figure 2 Number of new or improved business processes in Central Europe and Germany



Source: Own processing according to Eurostat (2022b)

As can be seen from Figure 2, in absolute terms, Germany is clearly dominant, and very significantly so, as the total number of new or innovated business processes here reaches 204,694. Polish companies appear to be the second best (37,668), followed by the Czech Republic (28,300), Austria (22,716), and Slovakia (5,280). From this simple perspective, the situation of the Czech Republic appears to be significantly lagging Germany, but Czech companies are keeping pace with other Central European countries. However, looking at absolute numbers can distort reality, because each country has a different number of companies. More telling indicators are offered in Table 1, in the form of innovation intensity per company, or how many companies are involved in one innovation.

Table 1 The intensity of innovations per company in Central Europe and Germany

	Number of new or improved processes	Number of businesses	Innovation intensity	Companies to one innovation
Austria	22,716	583,947	0.039	25.71
Czechia	28,300	1,292,436	0.022	45.67
Germany	204,694	3,159,716	0.065	15.44
Poland	37,668	2,675,865	0.014	71.04
Slovakia	5,280	635,781	0.008	120.41

Source: Own processing according to Eurostat (2022a; 2022b)

If we focus on the characteristics of countries according to the innovation intensity of enterprises, we can observe slightly different conclusions. Germany also dominates Central Europe within this indicator, where its innovation intensity reaches a value of 0.065, i.e., 6.5% of enterprises here implement innovations. Austria appears to be the second best within this indicator (0.039), followed by the Czech Republic (0.022), Poland (0.014), and Slovakia (0.008). Within this indicator, it can be stated that 2.2% of Czech enterprises work with set business processes, implement new ones, or innovate existing ones. The situation in Slovakia is alarming, as not even 1% of enterprises here revise and improve processes. The situation is also completely identical in terms of the number of enterprises per one new process or its innovation, with Germany achieving the best values, while Slovakia, on the contrary, having the worst.

The numbers of individual business processes according to the type of innovation that was implemented are also interesting. These are the four basic types of innovations, namely process, product, organizational, and marketing. A basic overview in absolute terms can be seen in Table 2; a graphical representation can be seen after calculating the number of companies per innovation in Figure 3.

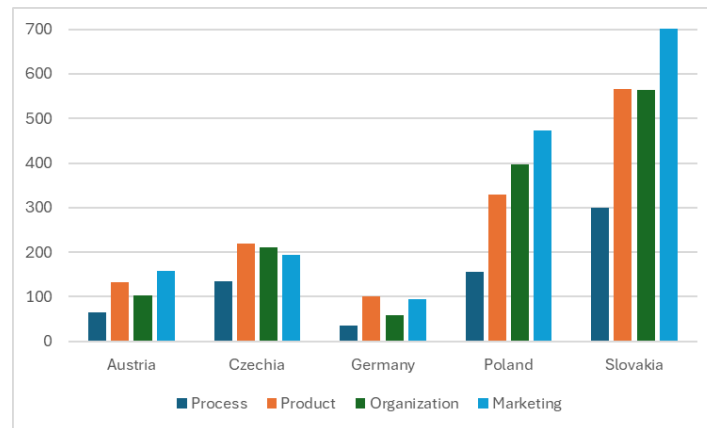
As can be seen, process innovations are implemented most often. Moreover, in all the countries studied, the “per business” number is the smallest. The second highest number represent organizational innovations is implemented, with two countries, namely the Czech Republic and Slovakia, having approximately the same “per business” frequency as for product innovations, and the number is even higher in Poland. Although fewer organizational innovations are implemented in total, in these countries, the differences between organizational and product innovations are negligible or very small. However, there is a significant departure from Germany, as here enterprises implement almost twice as many organizational innovations than product innovations, which are at the marketing level. These are implemented in total by far the least, and this is the case in all countries except the Czech Republic, where the marketing innovations account for the second-highest share. This significantly differentiates Czech enterprises from the rest of Central Europe.

Table 2 Number of new or improved business processes according to the kind of Innovation in Central Europe and Germany

	Process innovation	Product innovation	Organization innovation	Marketing innovation
Austria	9,002	4,375	5,643	3,696
Czechia	9,613	5,890	6,159	6,638
Germany	86,549	31,269	53,831	33,045
Poland	17,164	8,126	6,729	5,649
Slovakia	2,124	1,142	1,126	906
Sum	124,452	50,784	73,488	49,934

Source: Own processing according to Eurostat (2022b)

Figure 3 Relative intensity of innovation per company in Central Europe and Germany



Source: Own processing according to Eurostat (2022a; 2022b)

It was also investigated what proportion of process and product innovations there is in individual countries. Process innovations can be defined as process and organizational innovations alone, while product innovations can be defined as product innovations alone combined with marketing innovations. The results are presented in Table 3.

Table 3 Process/Product ratio

Austria	1.815
Czechia	1.259
Germany	2.183
Poland	1.735
Slovakia	1.601

Source: Own processing according to Eurostat (2022a; 2022b)

There can be drawn several conclusions from Table 3. The first is that Czech companies have the index closest to zero of all the countries monitored. This means that they focus on marketing and product innovations significantly more than neighboring countries. In contrast, Germany is significantly oriented towards process and organizational innovations. The same is true for Austria.

It was also investigated whether the differences between individual countries in terms of individual types of business process innovations are statistically significant. For this observation, the chi-square test of independence was used. The results of the test are presented in Table 4.

Table 4 Chi-square test of independence

χ^2 statistics	3,701.612
Df	12
p-value	<0.001

Source: Own processing according to Eurostat (2022a; 2022b)

The χ^2 test statistic reaches high values, indicating significant differences. Moreover, these are statistically significant, since the p-value is well below the significance level of 0.05. To determine which countries are more active or passive in innovating individual business processes according to the type of innovation, standardized residuals were calculated. The results are shown in Table 5.

Table 5 Standardized residuals

	Process innovation	Product innovation	Organization innovation	Marketing innovation
Austria	-6.494	9.414	0.857	-1.887
Czechia	-27.623	17.926	-11.670	31.919
Germany	10.008	-37.104	31.690	-12.448
Poland	16.407	25.249	-32.499	-9.585
Slovakia	-2.146	8.360	-5.584	0.864

Source: Own processing according to Eurostat (2022a; 2022b)

Table 5 shows significant differences in all countries. In the case of Czech companies, a higher number of process and organizational innovations of business processes is expected, while in the case of marketing and product innovations, Czech companies are above average. In process innovations, all countries are lagging, except Poland and Germany, while in product innovations, organizations from all countries except Germany are above expectations. In organizational innovations, German and Austrian companies are significantly above expectations, and in marketing innovations, Czech and Slovak companies are. In summary, it can be said that companies from the Czech Republic are very strong in product and marketing innovations of business processes, but they are lagging in process and organizational innovations. The closest to the value of 0 are Slovakia and Austria, in the case of marketing and organizational innovations, respectively. The stated research question can also be answered. Yes, there are a number of significant differences between individual countries in terms of individual types of innovations.

4 Conclusions

The main aim of this paper was to evaluate the position of enterprises from the Czech Republic within Central Europe and Germany in terms of innovation and the introduction of new business processes, and to identify whether there are significant differences between enterprises from individual countries. This aim was achieved thanks to secondary data from the Eurostat database, the identified descriptive characteristics, and the statistical examination of the data, using the chi-square test and standardized residuals.

The results show that in absolute terms and in the intensity of introducing new or innovating existing business processes, Germany clearly dominates, which is significantly different from other Central European countries. The Czech Republic, Poland, and Austria occupy approximately the same, let's say, middle position. Slovakia is significantly the worst country of all observed, lagging significantly behind in the overall assessment, not only in the number of innovations, but also in their intensity, with less than one percent of organizations innovating their processes or coming up with new ones. Descriptive statistics confirmed that process innovations are the most frequently implemented type in all countries; however, the other structure differs. The Czech Republic achieves above-average numbers of marketing and product innovations, but lags in process and organizational innovations. On the contrary, Germany has an unshakable strong position in process and organizational innovations, while Poland benefits mainly from process and product innovations. The results of the chi-square test clearly confirmed the statistical significance of the differences found between companies from different countries.

Based on these findings, several practical recommendations can be formulated. First, Czech companies should focus on strengthening process and organizational innovations, as these areas currently represent a weak point. The underlying cause may be the historical emphasis on product and marketing innovations, which has led to an imbalance in the innovation portfolio. To address this, companies should implement structured process management systems, invest in employee training for operational excellence, and adopt digital tools that support workflow optimization. Second, Slovak companies require more systematic support for innovation. This could include targeted government subsidies for process improvement projects, knowledge transfer programs from advanced economies, and partnerships with research institutions to foster organizational innovation. Finally, policymakers should consider creating incentives for collaborative innovation networks, which can help firms share best practices and reduce barriers to adopting process innovations. These concrete steps go beyond generic recommendations and aim to address the root causes of the observed disparities, thereby improving competitiveness in the region.

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Monitoring Stressors in Manufacturing Companies in the Czech Republic

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Abstract: Stress in the workplace is currently on the rise, and it is company employees who encounter stress daily. Companies should therefore actively address this issue. However, the starting point for an optimal solution to stress in the workplace lies in monitoring stressors, which is often overlooked by companies. The main objective of this article is to identify the current state of stressor monitoring in manufacturing companies in the Czech Republic. Data was collected using a questionnaire survey and then processed using descriptive statistics, logistic regression and Fisher's exact test. The analysis found that the state of stressor monitoring in the workplace is critical. The most frequently monitored stressors are workplace relationships, overtime and high workloads. Statistically significant factors influencing the introduction of stressor monitoring in the workplace are the company's participation in a foreign group and the recent introduction of digitalisation elements in the workplace.

Keywords: stressor, monitoring, stress, management, manufacturing industry, digitalisation

JEL Classification: M10, J28

1 Introduction

Stress is an important part of everyone's life and has the power to mobilise the energy needed to deal with the threats and challenges that exist in an individual's environment (Jourmault et al., 2023). Stress is caused by the occurrence of an external stimulus, called a stressor, in the environment in which the individual finds themselves (Rudland et al., 2018, Dartey-Baah et al., 2020).

A stressor is therefore a stimulus that can take many forms and can affect the organisational, social, psychological or physical level (Jasinski & Debris, 2022, Timotius & Octavius, 2022) and can have various origins, such as biological, chemical, microbial, developmental, socio-cultural or environmental (Papathanasiou et al., 2015).

In today's digitalised age, countries are beginning to recognise the importance of protecting their employees from psychological hazards (Chirico et al., 2019, Jain et al., 2022). Some studies present evidence of links between psychological hazards in the workplace and increased levels of stress, depression and anxiety (Jain et al., 2022).

Work stress is linked to job satisfaction, which includes factors such as career advancement, working environment and others. An employee's work performance is thus linked to the work stress they experience, specifically in that the higher the stress level, the worse the work performance. This fact is important not only for the company, but also for various other stakeholders of the company (Ahmad et al., 2021).

There are several common stressors that occur in workplaces, such as work overload, overtime, lack of autonomy, workplace relationships, or toxic work environments. These work stressors can generally be divided into several categories, namely workplace conflicts, relationships with others and career development, physical environment, job role-related stressors, organisational structure, and job characteristics (Gautam & Gautam, 2022).

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Stressors occurring in the workplace thus increase employees' stress levels, which can reduce their overall productivity (Kim & Jung, 2022, Bui et al., 2020). These types of stressors can be referred to as external stressors (Papathanasiou et al., 2015).

According to Eurofound (2023), workload and overtime are the most significant stressors occurring in workplaces in the European Union. On the other hand, job insecurity is among the least frequent.

Currently, businesses are undergoing a wave of automation and digitisation aimed at increasing labour productivity, flexibility and more efficient use of resources, which is also changing the role of workers, who now act as technology operators and multitask more than before. These changes affect not only large companies, but also small and medium-sized enterprises (Körner et al., 2019).

Small and medium-sized enterprises (SMEs) have a firm place in the Czech Republic, as they create jobs for approximately 66.4 % of employees in the Czech Republic. SMEs often bring many benefits, such as job creation at low capital costs (Šebestová & Sroka, 2020).

In the Czech Republic, small and medium-sized enterprises operate with limited resources for stress management compared to large enterprises, making this area very problematic (Soukupová et al., 2024).

2 Methods

The main objective of this paper is to identify prevalent stressors in manufacturing workplaces, followed by an assessment of stressor monitoring in workplaces and identification of the statistical significance of selected company characteristics on stressor monitoring.

In order to identify the factors that lead to good mental health and well-being in people who are exposed to many stressors, it is necessary to monitor these stressors and identify appropriate adaptation processes (Kalisch et al., 2021).

The following research questions have been formulated for the set objectives:

RQ1: What is the current state of stressor monitoring in manufacturing companies?

RQ2: What are the most frequent stressors in manufacturing companies?

RQ3: What factors have a significant impact on stressor monitoring in manufacturing companies?

The results are based on data collected using an electronic questionnaire survey conducted between May and November 2024, by selecting companies from the Orbis database based on their compliance with the conditions for operating in the manufacturing industry according to the CZ-NACE classification and company size, which was determined in accordance with European Commission Recommendation 2003/361, with the main criterion being the number of employees. The e-mail address for receiving the questionnaire also needed to be included.

Managers, executives and owners from approximately 5,200 companies operating in the manufacturing industry in the Czech Republic were approached, with the final sample comprising 371 active entities. The questionnaire included 26 questions divided into 12 sections and the topics of the questions were basic informationa about the company, stressors, stress management interventions and digitalization. These questions were mainly closed or semi-closed, single-choice or multiple-choice. The questionnaire was piloted on 5 managers, which ensured the correct formulation of questions and clarity of the questionnaire.

The sample surveyed includes micro-enterprises (94), small enterprises (123), medium-sized enterprises (117) and large enterprises (37).

Table 1 shows the criteria for classifying enterprises according to European Commission Recommendation 2003/361.

Table1 Definition of SMEs

Enterprise size	Number of employees	Turnover	Balance sheet
Microenterprise	<10	<2 million EUR	<2 million EUR
Small enterprise	<50	<10 million EUR	<10 million EUR
Medium-sized enterprise	<250	<50 million EUR	<43 million EUR

Source: European Commission (2003)

The main part of the questionnaire survey consists of questions concerning the occurrence of stressors, stressor monitoring and factors that influence stressor monitoring in companies. Descriptive statistics, logistic regression and

Fisher's exact test were used for data analysis. The questionnaire survey was constructed based on literature studied from the Web of Science and Scopus platforms.

Logistic regression was first performed to evaluate the influence of selected factors on stressor monitoring in the workplace. The selected factors include company size, company participation in a foreign group, and whether the company has digitised in the last year.

The following hypotheses were established:

$H_{0(A)}$: Company size does not affect the likelihood of stressor monitoring in the company.

$H_{0(B)}$: The company's participation in a foreign group does not affect the likelihood of stressor monitoring in the company.

$H_{0(C)}$: The introduction of digitalization elements in the company does not affect the likelihood of stressor monitoring in the company.

Fisher's exact test was used for the subsequent evaluation of the relationship between the selected factor and stressor monitoring.

The following hypotheses were established:

$H_{0(D)}$: There is no correlation between a company's participation in a foreign group and stressor monitoring within the company.

$H_{0(E)}$: There is no correlation between the introduction of digitalization elements in the company and stressor monitoring in the company.

Lai et al. (2015) argue that stressor monitoring and work stress are not statistically significantly affected by company size. Conversely, Cijan et al. (2019) say that the introduction of digitalisation elements in the workplace is a statistically significant factor for stressor monitoring that could influence this factor. As for the factor of a company's participation in a foreign group, Gabel-Shemueli et al. (2018) cite this factor as statistically significant for stressor monitoring, noting that it is precisely in an environment such as a company participating in a foreign group that unique interactions and group dynamics arise, producing more stressors in the workplace.

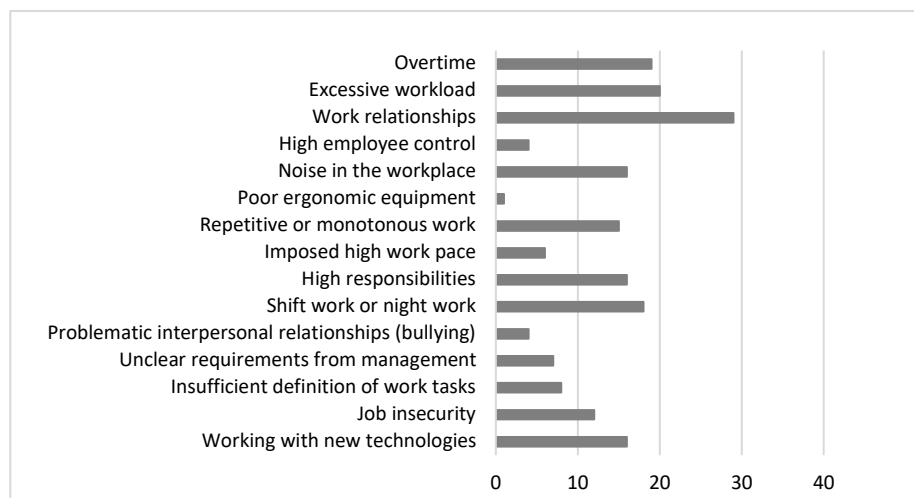
3 Research results

In general, the research has shown that monitoring stressors in manufacturing workplaces is relatively uncommon. Only 13.5 % of companies in the sample have stressor monitoring in place.

Companies most often monitor stressors through interviews with employees (62 %), observation (54 %) or group meetings (46 %). In terms of company size, large companies monitor stressors in the workplace most often (27.02 %) and microenterprises least often (8.51 %).

The following graph shows the most frequent stressors. The graph shows the number of companies that reported the occurrence of this stressor.

Figure 1 Frequency of stressors at workplaces of manufacturing companies



Source: own processing

According to the research conducted, the most frequent stressor in manufacturing workplaces is workplace relationships, which are reported across all categories of enterprises. Furthermore, for micro and small enterprises, significant stressors include excessive workload, high levels of responsibility and noise in the workplace. Small enterprises also report working with new technologies and shift work as significant stressors. For medium-sized enterprises, overtime and repetitive work are significant, while large enterprises report shift work and overtime.

According to Jasinski and Debris (2022) the most frequented stressors could include excessive workload, organizational restrictions or work relationships. This agrees with the results of this paper. On the other hand Eurofound (2023) is describing frequent stressors in the EU workforce: intensity of workload and overtime. Which is also in agreement with this paper.

Logistic regression was first used to determine the statistical significance of selected company characteristics on the implementation of stressor monitoring in companies.

Table 2: Logistic regression for the influence of selected factors on stressor monitoring in manufacturing companies in the Czech Republic

Variable	P-value	Estimate
Intercept	0.02	0.07
Small company	0.522	-0.02
Medium company	0.434	0.03
Large company	0.618	0.03
Participation in a foreign group	0.018	0.12
Recent digitization of the company	0.008	0.11

Source: own processing

The following hypotheses will be evaluated based on logistic regression:

$H_{0(A)}$: The size of the enterprise has no effect on the probability of monitoring stressors in the enterprise.

$H_{0(B)}$: The company's participation in a foreign group does not affect the probability of stressor monitoring in the company.

$H_{0(C)}$: The introduction of digitalisation elements in a company does not affect the probability of monitoring stressors in the company.

For individual categories, the p-values according to logistic regression were as follows: small enterprise ($p=0.5229$), medium-sized enterprise ($p=0.4346$), large enterprise ($p=0.6181$), enterprise participation in a foreign group ($p=0.0183$) and introduction of digitalisation elements ($p=0.0088$).

According to the p-values determined by logistic regression, it is possible to reject only the null hypotheses $H_{0(B)}$ and $H_{0(C)}$ in favour of the alternative hypotheses at a significance level of 5 %. The null hypothesis $H_{0(A)}$ in favour of the alternative hypothesis cannot be rejected at a significance level of 5 %.

By converting the estimate to odds ratio, an odds ratio of 2.42 was determined for the factor "company participation in a foreign group" and an odds ratio of 2.35 for the factor "introduction of digitalisation elements in the company".

Fisher's exact test was used for statistically significant factors, which indicates the statistical significance of the relationship between the selected factor and the monitoring of stressors in the workplace.

Table 3: Fisher's exact test for the influence of selected factors on stressor monitoring in manufacturing companies in the Czech Republic

Test characteristics	Factor $H_0(D)$	Factor $H_0(E)$
P-value	0.002	0.0008
Odds Ratio	2.9514	2.8841

Source: own processing

The following hypotheses were established for this test:

$H_{0(D)}$: There is no correlation between a company's participation in a foreign group and the monitoring of stressors within the company.

$H_{0(E)}$: There is no correlation between the introduction of digitalisation elements in the company and the monitoring of stressors in the company.

Based on the results of Fisher's exact test, the hypotheses can be evaluated as follows:

The null hypothesis $H_{0(D)}$ can be rejected at a 5 % significance level based on a p-value of 0.0029 in favour of the alternative hypothesis. The null hypothesis $H_{0(E)}$ can be rejected at a 5 % significance level based on a p-value of 0.0008 in favour of the alternative hypothesis.

4 Conclusions

The main objective of this paper is to analyse and evaluate the current state of stressor monitoring in manufacturing companies as a basis for the subsequent optimal implementation of stress management interventions. The achievement of this objective was determined by three research questions concerning the current state of stressor monitoring, the most frequent stressors, and the impact of selected factors on the implementation of stressor monitoring in companies.

It was found that stressor monitoring in manufacturing companies is in a critical state and many companies do not implement stressor monitoring.

However, companies that do implement stressor monitoring do so using basic tools such as questionnaires or interviews. They see workplace relationships, overtime, and high workloads as the most frequent stressors. It was also pointed out that the frequency of individual stressors varies greatly depending on the size category of the company. However, the biggest problem that occurs across all categories is workplace relationships.

In terms of factors influencing the implementation of stressor monitoring in the workplace, it was found that the size of the company does not have a statistically significant effect, but the company's participation in a foreign group and the recent introduction of digitalisation increases the odds ratio of the probability of introducing and operating stressor monitoring in the workplace.

Within the framework of the specified null hypotheses for logistic regression, it was possible to reject the alternative hypotheses $H_{0(B)}$ and $H_{0(C)}$. In Fisher's exact test, it was possible to reject $H_{0(D)}$ and $H_{0(E)}$. It can therefore be argued that the selected factors related to the rejected null hypotheses have a statistically significant impact on stressor monitoring.

In terms of the limitations of this research, it should be noted that the logistic regression included only selected characteristics and that many other factors may influence stressor monitoring in companies. The research focused on the manufacturing industry in general, but there are many sectors within this industry, and each sector may have its own specific stressors and may approach stressor monitoring differently.

Further research in this area could therefore include a detailed analysis of individual manufacturing sectors and their differences. It could also include an analysis of companies that do not monitor stressors, which constitute the majority in this research, analysing why these companies do not want to monitor stressors and what percentage of these companies implement stress management without monitoring stressors.

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The Role of Machine Learning Adoption in Enterprises: Literature Review and European Insights

Diana Pallérová¹

Abstract: Machine learning (ML) represents one of the most transformative technologies shaping modern business environments. Its ability to process large volumes of data and generate predictive insights offers new opportunities for data-driven decision making and strategic management. However, despite its growing potential and benefits, the actual adoption of ML in enterprises remains relatively limited. The aim of this paper is to explore the current state of ML adoption across enterprises in the European Union and to synthesize existing research on how ML is applied in different business functions. Using secondary data from Eurostat and a structured literature review, the study identifies key areas of implementation, major benefits, and persistent barriers that influence the adoption and effective use of ML in organizations. Findings suggest that while ML enhances accuracy, efficiency, and strategic agility, its diffusion in European enterprises is still constrained by data related challenges, implementation costs, and shortages of skilled professionals. The paper underscores that closing widening cross-country gaps and moving beyond pilot stages will require stronger data pipelines and stewardship, practical model explainability, and change management to scale ML across enterprises, especially in lagging sectors such as manufacturing and transportation.

Keywords: Machine learning, EU, business functions

JEL Classification: L86, M21, O33

1 Introduction

Recently, the adoption of artificial intelligence (AI) has been the subject of intense research, focusing on the drivers and barriers to its deployment, as well as its wider economic and social consequences. AI has evolved from largely theoretical concepts into a technology that increasingly forms the 'foundational layer' of the digital economy. Central to this development is machine learning (ML), a practical mechanism that converts data into predictions and decisions, combining insights from statistics, optimization, and software engineering (Jordan & Mitchell, 2015 ; Russell & Norvig, 2021). ML is effectively a data-driven computational approach where algorithms learn from examples and improve over time without explicit rule programming. Consequently, the literature frequently characterizes it as the automation of knowledge extraction from data. (Bose & Mahapatra, 2001)

The European Union provides a compelling context for investigating AI/ML adoption, characterized by marked heterogeneity among member states regarding digitalization levels, data availability, innovation capacity, and the organizational readiness to absorb new technologies. This divergence translates into an uneven pace of AI deployment, notwithstanding the substantial potential for macroeconomic gains. While projections frequently indicate that widespread AI adoption could augment European economic activity by approximately one-fifth by 2030, realizing this growth is contingent upon the effective integration of these technologies at the firm level – encompassing processes, data, human capital, and management. (Bughin et al., 2019)

Public policy and regulatory frameworks serve as critical mechanisms that modulate national patterns of AI deployment. In an effort to cultivate a fertile environment for AI uptake, the EU has introduced strategic measures including the European AI Strategy and the Digital Compass 2030 framework (European Commission, 2021). However, the practical application

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of these directives is inconsistent, leading to significant divergence in the levels of AI preparedness observed across member states (Veale & Binns, 2017)

Yet real-world adoption remains uneven. The European Union offers a particularly suitable context for examining these technologies: its member states exhibit substantial diversity in levels of digitalization, data availability, and innovation capacity, enabling comparisons of the institutional and organizational conditions that shape ML deployment across economies of countries and sectors.

This article addresses that need with a two-part contribution. First, it assembles a current snapshot of ML adoption in EU enterprises using recent Eurostat indicators to outline the overall landscape across countries and sectors. Second, it complements this perspective with a targeted literature review that systematically maps how ML is deployed across key business functions, identifies the most common study designs and algorithmic approaches in prior research, and synthesizes the main constraints that continue to limit broader diffusion of machine learning within enterprises. To enhance analytical clarity and academic transparency, the study is structured around a set of explicit research questions. These questions reflect the dual approach of the paper:

RQ1: What is the current level and recent evolution of machine learning adoption among enterprises across EU Member States?

RQ2: What role does machine learning play in the most frequently addressed business functional areas within enterprises?

RQ3: What barriers and constraints to ML adoption are most frequently reported in the recent academic literature?

The findings have practical relevance for managers, by offering a decision-oriented framework for developing ML initiatives, for policymakers, by informing more targeted support measures, and for the academic community, by laying a basis for further empirical research and teaching.

2 Methods

The objective of this study is to analyze the current state of machine-learning adoption in enterprises across the European Union and to understand the principal business functions in which these technologies are being deployed. The first part of research analyzes secondary statistics from Eurostat (2021–2024), and the second part presents a literature review of empirical and application-oriented studies, indexed in Web of Science, Scopus and Google Scholar.

In the Eurostat data analysis, the extent of machine-learning adoption (using „Artificial intelligence by NACE Rev. 2 activity“ - isoc_eb_ain2) is examined across EU member states for 2021–2024 (2022 was excluded due to a missing dataset). To capture adoption trends, an average growth index and quantified cross-country variability using the standard deviation is calculated.

Calculation formulas:

- growth ratios: $g1_i = \frac{x_{i,2023}}{x_{i,2021}}$, $g2_i = \frac{x_{i,2024}}{x_{i,2023}}$
- average growth index: $GI_i = \frac{g1_i + g2_i}{2}$
- standard deviation: sample SD using STDEV.S

Calculations and data processing were carried out in Microsoft Excel. ML adoption by sectors across the EU is visualized using chart.

The literature search employed combinations of keywords, pairing “machine learning” with “business,” “enterprise,” or “organization,” and with “implementation” or “adoption,” alongside functional qualifiers such as “marketing,” “finance,” “HR,” “manufacturing,” and “logistics.”

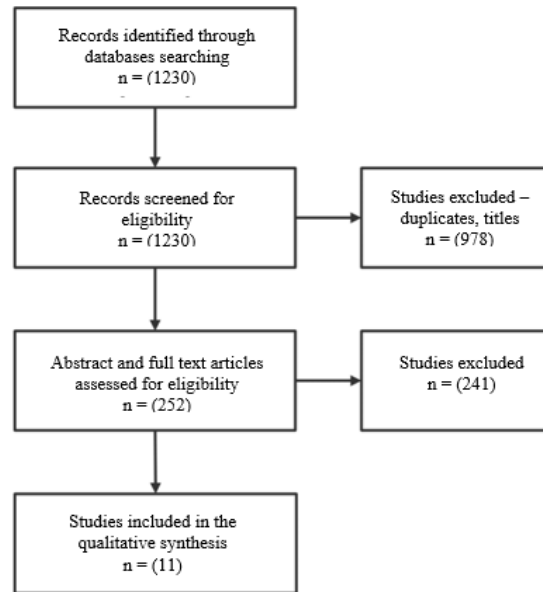
Inclusion criteria:

- Scholarly journal article or peer-reviewed conference paper

- Empirical application documenting real-world organizational use of ML (not purely theoretical modeling)
- Focus at least in part on a specific business function (e.g., marketing, finance, HR, manufacturing, logistics)
- Published between 2020 and 2025

The selected publications (11) were synthesized into a consolidated overview table organized by business function (Table 2). For each study, the empirical methodology is extracted, the types of ML models and algorithms applied, and the authors' key findings and implications for practice. Schematic diagram of the steps of the Literature review is shown in Figure 1.

Figure 1 Flow diagram of the Literature review



Source: Own processing

The final subsection of the Results section distills the main organizational and technical barriers observed across the evidence base and discusses their implications for successful ML adoption in firms.

3 Research results

The first part of the chapter focuses on identifying and analyzing ML adoption within enterprises across EU countries, as well as across individual sectors. The second subsection presents a literature review that identifies the main functional areas and practical modes of ML use. The analysis covers both the benefits of ML adoption and the barriers that constrain it.

3.1 Current state of Machine Learning adoption across EU countries

This subsection focuses on presenting the current state of machine-learning adoption in enterprises across EU member states. To better illustrate the evolution of adoption, an average growth index was employed, and to clarify the variability and cross-country differences in values, the standard deviation was used. The results are reported in Table 1.

Table 1 Percentage of enterprises using Machine learning technologies by European countries in the period 2021-2024

Countries	2021	2023	2024	AVG growth index
European Union	2.44	2.60	4.24	1.3482
Belgium	4.42	4.78	8.07	1.3849
Bulgaria	0.94	0.94	2.11	1.6223
Czechia	1.40	2.32	4.53	1.8049
Denmark	8.84	7.05	10.74	1.1605
Germany	2.87	2.97	5.26	1.4029
Estonia	1.08	1.60	3.53	1.8439
Ireland	3.53	2.98	5.53	1.3499
Greece	1.16	1.02	4.02	2.4102
Spain	2.32	2.96	3.91	1.2984
France	2.41	2.65	4.04	1.3121
Croatia	2.50	2.15	4.14	1.3928
Italy	1.45	1.51	2.57	1.3717
Cyprus	1.43	2.12	5.25	1.9795
Latvia	1.08	1.10	2.04	1.4365
Lithuania	1.19	1.28	2.80	1.6316
Luxembourg	3.48	3.93	6.28	1.3636
Hungary	0.72	0.98	1.82	1.6091
Malta	4.47	4.70	6.49	1.2162
Netherlands	6.05	5.82	6.52	1.0411
Austria	3.69	4.60	6.89	1.3722
Poland	0.74	1.02	1.56	1.4539
Portugal	1.98	2.06	2.88	1.2192
Romania	0.51	0.60	1.26	1.6382
Slovenia	3.21	2.88	4.19	1.1760
Slovakia	0.89	1.88	2.61	1.7503
Finland	6.10	6.51	9.68	1.2771
Sweden	4.43	3.96	8.09	1.4684
Norway	4.31	4.72	8.95	1.4957
Bosnia and Herzegovina	:	3.10	3.07	-
Montenegro	1.16	1.79	:	-
North Macedonia	0.90	:	:	-
Albania	:	:	:	-
Serbia	0.43	0.72	3.00	2.9205
Türkiye	1.18	2.27	2.32	1.4729
Standard deviation	1.9783	1.7284	2.5267	-

Source: Own processing based on the statistical data of Eurostat (2024)

Table 1 presents the evolution of ML adoption among enterprises in the European Union between 2021 and 2024 (year of 2022 is missing in the Eurostat database), based on data from Eurostat (2024). The indicator measures the proportion of enterprises using ML for data analysis, reflecting the degree of integration of advanced data-driven technologies into business processes. The results show that, on average, 2.44% of EU enterprises used ML in 2021, 2.60% in 2023, and 4.24% in 2024. This steady increase corresponds to an average growth index of 1.35, indicating a gradual but continuous diffusion of ML across the European business landscape. Nevertheless, the overall adoption level remains relatively low, suggesting that ML technologies are still in the early stages of business implementation compared to broader AI tools.

In terms of country performance, the highest ML adoption rates in 2024 were observed in Denmark (10.74%), Finland (9.68%), Norway (8.95%), Sweden (8.09%), and Belgium (8.07%). These countries belong to the group of digital frontrunners identified in previous studies (OECD, 2023; Eurostat, 2024), characterized by strong innovation ecosystems, advanced data infrastructure, and a high availability of digital skills. Their enterprises are typically more capable of incorporating ML solutions for predictive analytics, process automation, and decision support. In contrast, the lowest

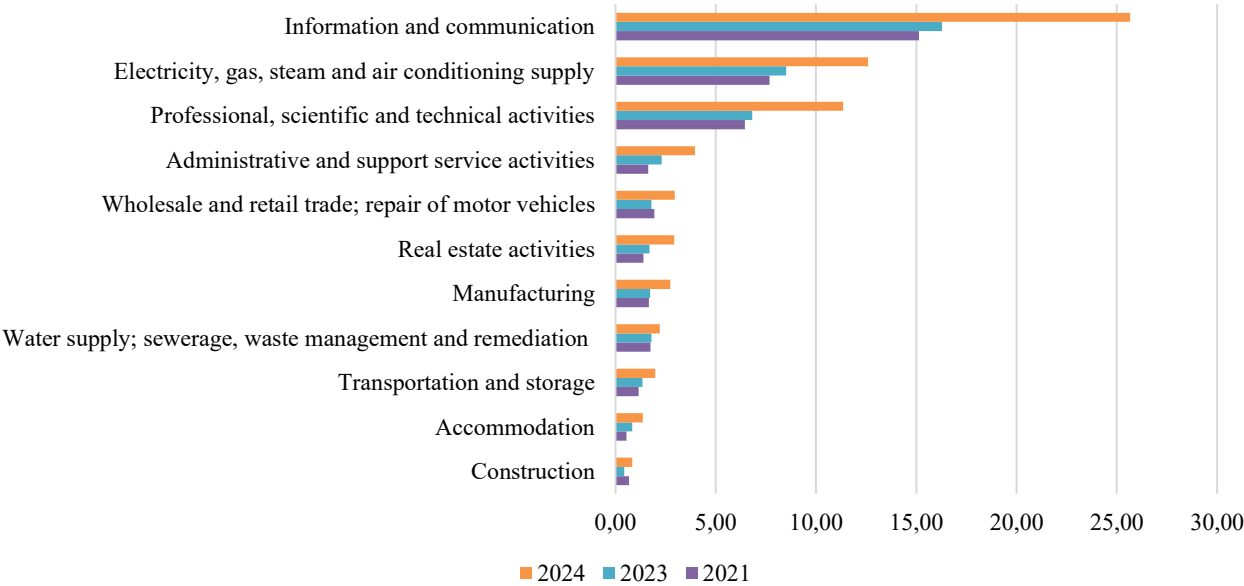
adoption rates were found in Romania (1.26%), Hungary (1.82%), Poland (1.56%), and Bulgaria (2.11%), reflecting persistent disparities in digital transformation and technological readiness across the EU. These patterns are consistent with findings from the Digital Economy and Society Index (DESI, 2023), which highlights a pronounced digital divide between Western/Northern Europe and Central/Eastern Europe.

The growth index reveals that several countries with initially low adoption levels experienced notable progress. For instance, Greece (2.41), Serbia (2.92), Cyprus (1.98), Estonia (1.84), and Czechia (1.80) recorded the fastest relative increases between 2021 and 2024, suggesting a catching-up effect in the adoption of advanced analytics. These improvements may be associated with targeted national strategies supporting digital innovation and EU-level initiatives under the Digital Europe Programme. Conversely, countries such as the Netherlands (1.04) and Denmark (1.16) show slower growth, which can be explained by their already mature level of ML diffusion, resulting in limited room for relative expansion.

From a statistical perspective, the standard deviation of adoption rates across EU countries increased from 1.98 in 2021 to 2.53 in 2024, indicating rising heterogeneity in ML diffusion. This growing variability suggests that while the overall trend is positive, the speed of adoption differs significantly between member states. The results thus confirm a positive but uneven trajectory in ML adoption: innovation leaders continue to advance towards deeper integration of ML into business strategies, whereas less digitally developed economies are still in the phase of initial implementation.

Building on the ML adoption analysis, a chart (Figure 2) visualizes the 2021–2024 trend across EU sectors.

Figure 2 Use of Machine learning technologies in enterprises by economic activity in the period 2021-2024



Source: Own processing based on the statistical data of Eurostat (2024)

Figure 2 shows the evolution of Machine Learning (ML) adoption across different sectors of economic activity in the European Union between 2021 and 2024, based on Eurostat (2024) data. The indicator captures the share of enterprises using ML or deep learning for data analysis. Overall, the use of ML technologies has increased across nearly all sectors during the observed period, though the growth has been highly uneven. In 2021, only a few sectors exceeded 5% adoption, whereas by 2024 several knowledge- and data-intensive industries achieved double-digit values.

The information and communication sector recorded the highest level of ML adoption, rising from 15.14% in 2021 to 25.66% in 2024. This reflects the sector’s strong digital maturity, advanced data infrastructure, and direct engagement in technological innovation. Similarly, electricity, gas, steam and air conditioning supply reached 12.59%, and professional,

scientific and technical activities increased from 6.46% to 11.35%, confirming that ML technologies are most widely used in sectors characterized by high information intensity and analytical capabilities. These industries rely on ML for predictive maintenance, energy optimization, data modeling, and research applications.

By contrast, more traditional and labor-intensive sectors show only marginal adoption levels. For example, construction (0.83%), accommodation (1.37%), and transportation and storage (1.98%) remain below the 2% threshold in 2024. Such sectors often face barriers including limited data availability, lower digitalization levels, and a shortage of skilled staff able to implement ML-based solutions. The manufacturing sector, although relatively advanced compared to other traditional industries, shows only moderate growth from 1.67% in 2021 to 2.73% in 2024, which suggests that ML adoption in production environments remains in its early stage and often limited to pilot projects or predictive maintenance systems.

Administrative and service-related sectors demonstrate intermediate adoption rates. For instance, administrative and support service activities grew from 1.63% to 3.96%, while real estate activities rose from 1.39% to 2.93%. This moderate progress indicates a growing interest in using ML for operational efficiency and customer data management, yet adoption remains constrained by organizational and resource limitations.

3.2 The role of Machine learning adoption in key business functions

The selection of relevant functional business areas was grounded in several studies, notably Pramanik & Jana (2022), who examined how machine learning can optimize enterprise processes across operations, supply chain, marketing, human resources, and customer relationship management. To synthesize the principal insights from the empirical literature, Table 2 provides a structured overview that specifies the business area, authors, year of publication, study title or objective, data and methodology, the machine learning algorithms employed, and the key findings/implications.

Table 1 Overview of empirical studies on ML in business functions

Enterprise Function	Author, Year	Title / Focus	Methodology	Algorithms / Approach	Key Findings
Manufacturing & Operations	Kaparthi & Bumblauskas (2020)	Designing predictive maintenance systems using decision tree-based ML	Empirical case-based system design	Decision Trees	Decision tree models are effective in modeling maintenance triggers and downtime prediction.
	Sauer, Burggräf & Steinberg (2024)	Bridging human expertise and machine learning in production management: a case study on ML-based decision support systems to prevent missing parts at assembly	Empirical case study of manufacturing assembly line using ML-DSS	ML-based DSS integrating human-expert feedback	The study demonstrates that the decision support system effectively aids complex decision-making, making it a valuable asset for contemporary manufacturing settings.
Supply Chain & Logistics	Leung et al. (2020)	Modelling near-real-time order arrival demand in e-commerce	Empirical ML modeling on e-commerce data	XGBoost, LSTM, Linear Regression	ML improves accuracy of short-term demand prediction in online retail operations.
	Zheng Y. (2024)	Application of ML Algorithms in Enterprise Supply Chain Demand Forecasting	Empirical with comparison of classical and ML models	LSTM, RF, SVR	ML outperforms traditional models in handling demand volatility and seasonality.
	Ferreira et al. (2025)	A Decision Support System for Classifying Suppliers Based on Machine Learning Techniques: A Case Study in the Aeronautics Industry	Case study using CRISP-DM on supplier data from aeronautics	K-Means, Hierarchical K-Means, AGNES, Fuzzy Clustering	Supplier segmentation via ML improved classification accuracy and supported supplier decision-making.
Finance & Risk Management	Yang A. (2025)	Big data-driven corporate financial forecasting and decision support	Deep learning with time-series financial datasets	CNN-LSTM	Hybrid models yield better forecast accuracy in financial planning and strategy.
	Parimi S. (2024)	Optimizing Financial Reporting and Compliance in SAP	Applied system integration + ML model training on SAP data	Decision Trees, SVM	ML improves anomaly detection and reporting efficiency in enterprise financial systems.
	Wyrobek, 2020	ML to identify companies with unfair corporate culture	Empirical study using financial disclosures	RF, XGBoost, Neural Nets, Decision Trees	Tree-based models effective at detecting unethical corporate behaviors.
Marketing & CRM	Sikri et al. (2024)	Enhancing customer retention in telecom via churn prediction	Empirical study with classification models	SVM, RF, Logistic Regression	ML models improve churn prediction and customer targeting in telecom.
HR & People Analytics	Tian et al. (2023)	ML-based HR recruitment system using BERT and SVM	System design + ML classification on resume datasets	LSA, BERT, SVM	ML improves resume screening accuracy and offers interpretable HR decisions.
	Hasan et al. (2024)	Employee Performance Prediction with Analytics and ML	Empirical model on HR metrics and performance reviews	Ensemble methods, Decision Trees	Integrated ML models accurately predict employee performance from historical records.

Source: Own processing

Table 2 identifies the principal domains and the role of machine learning across business functions. Based on a review of empirical studies, machine learning emerges as a universal and adaptable instrument that effectively supports decision making, optimizes business processes, and improves predictive accuracy across functional domains, as evidenced by findings in manufacturing, logistics, finance, marketing, and human resources. In manufacturing and operations, Kaparthi and Bumblauskas (2024) showed that decision-tree algorithms efficiently model maintenance triggers and predict

downtime, thereby enhancing process reliability, while a case study by Sauer, Burggräf, and Steinberg (2024) demonstrated that implementing a decision support system based on machine learning and enriched with expert feedback materially improves complex decision processes in assembly-line management and constitutes a valuable tool for modern production environments. Within supply chains and logistics, Leung et al. (2020) demonstrated that XGBoost and LSTM enable more accurate real-time prediction of order arrivals in e-commerce and thus increase operational flexibility; similarly, Zheng (2024) confirmed that LSTM, Random Forest, and SVR outperform traditional forecasting approaches when processing seasonal and volatile demand data, and the case study by Ferreira et al. (2025) used K-means, AGNES, and fuzzy clustering to optimize supplier classification in the aerospace industry, thereby supporting more effective decision making across supply networks. In finance and risk management, Yang (2025) showed that deep neural architectures such as CNN-LSTM deliver higher accuracy in financial forecasting and provide a more robust basis for strategic planning, Parimi (2024) examined the integration of decision trees and SVM into SAP environments and documented efficiency gains in anomaly detection and financial reporting, and Wyrobek (2020) provided empirical evidence that Random Forest, XGBoost, and neural networks applied to firms' financial statements are effective in detecting unethical or fraudulent practices. In marketing and customer relationship management, Sikri et al. (2024) empirically demonstrated that SVM, Random Forest, and logistic regression substantially increase the accuracy of churn prediction and improve retention strategies, giving firms a competitive advantage through better personalization and customer segmentation. Finally, in human resources and people analytics, Tian et al. (2023) showed that combining BERT, LSA, and SVM improves the accuracy of résumé classification and yields interpretable recommendations for candidate selection, and Aboagarib et al. (2024) built on this work by using ensemble methods and decision trees to predict employee performance from historical HR metrics, thereby confirming the practical potential of machine learning for developing and managing human capital. Taken together, these studies indicate that machine learning approaches have not only theoretical relevance but also demonstrable empirical impact on performance improvement, cost optimization, and strategic decision support across corporate functions, fostering stronger data orientation within organizations, reducing decision uncertainty, and enabling innovative forms of organizational agility.

3.3 Main constraints and barriers of Machine learning adoption

Despite the mentioned advantages across individual business functions/areas, numerous studies point to barriers and potential constraints in the adoption of machine learning. Firms often lack sufficient high quality and well labeled data, face fragmented data architectures, and struggle to define concrete entry points for systematic data collection, which delays pilot viability and scale up (Giermindl et al., 2021; Jöhnk et al., 2020). Beyond data, organizations contend with the opaque logic of ML models that complicates error triage, accountability, and regulatory defensibility, which in turn suppresses trust among decision makers and slows deployment in sensitive domains (Benbya et al., 2021; Berente et al., 2021; Asatiani et al., 2021).

Early iterations of ML systems frequently underperform in the wild due to distribution shift and incomplete feature pipelines, which triggers defensive user responses and workflow workarounds, especially in high stakes settings such as healthcare where tolerance for false positives and false negatives is low and must be negotiated with frontline experts (Lebovitz et al., 2021; Benbya et al., 2021). These technical constraints are amplified by organizational capability gaps that include insufficient ML literacy, immature MLOps and governance processes, and a weak alignment between ML use cases and strategic objectives, a pattern documented across multiple industries and echoed in large scale practitioner surveys that rank data limitations, talent shortages, and integration with legacy systems as leading blockers (Jöhnk et al., 2020; Kaggle, 2020). Together these studies indicate that successful adoption requires concurrent investments in data pipelines and stewardship, mechanisms for model transparency and error discovery, iterative deployment with human in the loop learning, and change management that builds durable acceptance among both internal professionals and external stakeholders (Benbya et al., 2021; Berente et al., 2021).

4 Discussion

Section provides the clarifications and answers to the research questions:

RQ1: What is the current state and recent evolution of machine learning adoption among enterprises and sectors across EU Member States?

Current state indicates that the adoption of machine learning (ML) in EU enterprises is increasing but remains relatively low and increasingly uneven across countries: the EU average share of enterprises using ML for data analysis rose from 2.44% (2021) to 2.60% (2023) and then more markedly to 4.24% (2024), with the highest 2024 levels concentrated in digitally advanced economies (Denmark 10.74%, Finland 9.68%, Norway 8.95%, Sweden 8.09%, Belgium 8.07%), while the lowest shares persist in less digitally mature countries (Romania 1.26%, Poland 1.56%, Hungary 1.82%, Bulgaria 2.11%); although some countries show faster “catch-up” dynamics (based on growth indices), overall cross-country heterogeneity is widening, as reflected in the increase of the standard deviation from 1.98 (2021) to 2.53 (2024), suggesting that gaps in ML adoption across the EU are deepening rather than closing. These findings lend further support to the conclusions advanced by Ionaşcu (2025), Mazurencu et al. (2025), and Drago et al. (2025), whose analyses based on Eurostat indicators of AI/ML uptake similarly portray adoption as steadily increasing yet still comparatively limited overall, while remaining markedly heterogeneous across Member States, with persistent clusters of frontrunners and laggards shaped by broader structural conditions within national economies.

RQ2: What role does machine learning play in the most frequently addressed business areas within enterprises?

Machine learning in the most frequently addressed business functional areas primarily plays the role of a predictive and decision-support layer, improving planning accuracy, increasing process efficiency, and partially automating routine decisions. In manufacturing and operations, it is used mainly for predictive maintenance and to support the management of production flows; in supply chain and logistics, for demand prediction and supplier segmentation/classification; in marketing and CRM, especially for customer churn prediction and personalization; and in finance, for forecasting as well as anomaly detection in reporting or compliance. In HR and people analytics, ML is applied to screening and evaluating candidates (e.g., CV processing) and to predicting employee performance based on historical data. Similar mappings of where ML is used in enterprises are also confirmed by other review and systematic studies across domains (e.g., predictive maintenance in manufacturing, AI in supply chains, ML in marketing, ML in financial risk/scoring, and AI in HRM). (Ngai & Wu, 2022; Douaioui et al., 2024; Benhanifa et al., 2025)

RQ3: What barriers and constraints to ML adoption are most frequently reported in the recent academic literature?

Key barriers to ML adoption include, first and foremost, data-related constraints – limited availability of high-quality, consistent, and accessible data, together with underdeveloped data pipelines and infrastructure – which directly undermine model reliability and impede scaling beyond initial use cases. A second major obstacle concerns capability gaps, namely the shortage of qualified personnel and in-house expertise in data and ML, which is often compounded by high implementation costs and the complexity of integrating ML into legacy systems, including the establishment of MLOps practices and robust lifecycle governance. In addition, trust, transparency, and explainability remain critical. These factors help explain why ML initiatives frequently remain at the pilot stage and why cross-country and cross-sector adoption gaps tend to persist or even widen.

5 Conclusions

The findings indicate that ML adoption among EU enterprises is on a steadily positive trajectory, yet the gap between countries is widening as traditional leaders with strong digital infrastructure and capabilities, notably the Nordic states and the Benelux, advance more rapidly, while several Central and Eastern European countries lag behind, even though some late adopters show signs of catching up. Sectorally, uptake is highest where data and process maturity are strong, for example in information and communications, in professional, scientific and technical activities, and in energy, whereas traditionally labor-intensive industries such as construction, accommodation and food services, and parts of transport trail behind; manufacturing is progressing more gradually, suggesting that many initiatives remain at the pilot stage. The overview table further shows that the greatest benefits are concentrated in functional areas such as operations, particularly predictive maintenance and quality, supply chain through demand forecasting and inventory management, marketing and CRM via churn prediction and personalization, finance and risk through anomaly detection and risk signals, and HR through talent selection and performance assessment, with ML improving decision making, predictive accuracy, automating routine decisions, and more tightly linking analytics with strategy. Despite this potential, barriers persist in the form of insufficient data readiness, limited model transparency, weaker initial performance in real-world settings, and organizational constraints in ML operations, governance, and skills, which directly explain uneven adoption across countries and the modest uptake

in several traditional sectors including manufacturing. Embedding ML into everyday processes therefore requires parallel investment in data pipelines and stewardship, practical model explainability, and change management that can convert pilot initiatives into scaled, value-creating solutions.

This paper has three main limitations. First, the Eurostat analysis relies on secondary, aggregate data with cross-country measurement differences and a missing 2022 series, which limits comparability; the analysis focuses on a single indicator of ML use, which may not fully capture the broader scope. Moreover, the underlying Eurostat survey is based on a specific sample of enterprises rather than the full population, and responses are self-reported, meaning that reported ML use may reflect subjective interpretation and uneven reporting practices across countries. Second, the literature review is based on a subjective selection of relevant studies from 2020–2025 drawn from WoS, Scopus, and Google Scholar, which may introduce selection and publication bias. Third, without primary empirical research, the key mechanisms of ML adoption are inferred rather than directly observed. Future research should employ advanced statistical methods and structured interviews.

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Auditory Environments in Fashion Retail: Music's Impact on Consumer

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Abstract: Music is a key atmospheric element that significantly shapes the retail experience by enhancing emotional engagement, increasing dwell time, and improving overall customer satisfaction. In fashion retail, where sensory cues are central to brand identity, well-selected background music—considering genre, tempo, and familiarity—can influence consumer attitudes and behavior. This study explores the impact of auditory environments in fashion stores, focusing on how music affects consumer experience and emotional responses at the point of sale. The research was conducted across 90 fashion retail stores using mystery shopping, with data collected by an external agency. Observations were structured into three main components: evaluation of customer impressions, store managers' assessments, and in-store audio recordings from three spatial zones—entrance, main shopping area, and checkout zone. Findings reveal that background music has a measurable impact on consumer cognition, affect, and behavior—including time spent in-store, willingness to spend, and the overall perception of the store environment. A relationship between musical preferences and fashion sensibilities was observed, with specific genres evoking distinct emotional and behavioral responses. Fashion settings appear to reflect and amplify emotional atmospheres generated by music. Although the study relies on self-reported data, its results underscore the strategic value of music in retail marketing. Future research should explore these dynamics in controlled environments, using both explicit and implicit tools to assess emotional impact more precisely. These insights offer practical implications for fashion retailers, suggesting that tailored music strategies can enhance customer engagement, shape brand perception, and contribute to a more immersive shopping experience.

Keywords: consumer behavior, fashion stores, managers, music, mystery shopping

JEL Classification: M30, M31, M37

1 Introduction

The influence of background music on consumer behavior has been widely studied, yet findings remain fragmented—especially concerning how musical features such as tempo, intensity, and gender associations affect emotional and behavioral responses. Research suggests interactive and fast-paced music enhances engagement and purchase intention compared to silence (Hwang & Oh, 2020; Pantoja & Borges, 2021) emphasizing the need to investigate music placement in new retail formats like live-streaming commerce.

Based on Miller (2011) highlights the cultural and linguistic links between fashion and music, suggesting fashion can express music's symbolic qualities (Na & Agnhage, 2013). Previous studies have explored musical attributes such as tempo, familiarity, and congruence, and their effects on consumer outcomes (Hee, Kwan & Ok, 2014; Mas, Mas et al. 2020). Authors Pantoja & Borges (2021) examined how tempo influences affective, cognitive, and physiological responses. Based on Garlin & Owen (2006) meta-analysis categorized music's effects into affective, financial, attitudinal, temporal, and behavioral domains, finding music significantly shapes emotional states, stay duration, and perceived value. Oakes & North (2008) emphasized that musical congruity—alignment between music and brand or context—can enhance consumer responses. Manipulating genre, tempo, and volume allows marketers to influence mood, pace, waiting time, and spending. Similarly presented also Areni (2003), and states that ambient music can attract or repel customers, influence time perception, and shape social behavior.

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The COVID-19 pandemic highlighted music's psychological functions, showing that it reduces stress, increases life satisfaction, and supports emotional regulation (Hansen et al. 2021). However, deep engagement may also cause distress and rumination (Saarikallio, Gold & McFerran, 2015). Music affects both cognitive and emotional processing (Bennet & Bennet (2008), and its alignment with shopper profiles can evoke targeted psychological states. It also plays a vital role in retail identity (Beverland et al. 2006), and consumer perception adds Alpert, M., Alpert J., & Maltz, (2005). While studies have assessed music familiarity and coherence (Hee, Kwan & Ok, 2014), as well as interactivity (Hwang & Oh, 2020), few address spatial or temporal placement (Scott, Sheinin & Labrecque, 2022). This study addresses that gap in the context of fashion retail and live-streaming commerce. Unlike most prior research, we examine how music placement—at entrances, inside stores, and near checkouts—affects emotions, pace, and store experience.

Impact of music on consumers

Audio marketing, a form of sensory marketing, uses sound—particularly music—to influence consumer emotions and behaviors (Ksiazek, 2014). Music can shape purchasing decisions by creating emotional associations; however, music with negative or violent themes may lead to adverse effects (Olsen et al. 2020; Ter Bogt et al. 2019). In live-streaming commerce, optimizing background music is essential for capturing attention, enhancing enthusiasm, and increasing purchase rates (Loureiro et al. 2021). Effective audio marketing involves curating uplifting music combined with relevant commercial content, including product information and promotions (Deluga, 2018).

While music can promote calmness and well-being (Joy et al. (2023) and support rational, sustainable decisions, it can also drive impulsive and hedonistic behaviors. In online settings, music may intensify fast consumption, leading to irrational spending and environmentally unsound choices. Thus, although music enhances engagement, its emotional and cognitive effects must be managed to align with responsible marketing and consumption goals (Nguyen & Huynh, 2023).

Music tempo, genre and intensity

Tempo, defined by beats per minute (BPM), is a core element of music alongside rhythm, mode, melody, harmony, duration, and loudness. Tempo significantly influences affective states, often enhancing positive emotional responses (Barnes, 2023). Its impact is observable in physiological measures such as breathing patterns (Mikutta et al. 2013), and skin conductivity (Dillman & Potter, 2007). Tempo, along with pitch and timbre, shapes the emotional meaning of music, with tempo considered the most expressive component (Juslin & Lindström (2010). Typically, 70–110 BPM is preferred, with 40–76 BPM categorized as slow, 77–107 BPM as moderate, and 108–208 BPM as fast.

Faster music increases behavioral tempo—listeners tend to eat, move, drive, and read more quickly (Su, He & Li (2023). Music also affects consumers' willingness to pay. Oxenham (2018) states that tone and contour are vital aspects of musical perception, with Western music favoring regular tonality (Huron, 2001). Based on Muchitsch & Werner, (2024) Genre influences both identity and consumption, even in algorithm-driven streaming, and can affect food choices—for example, classical or jazz promotes healthier selections (Motoki et al. 2022).

Emotions and music

The desire for rawness in music consumption is linked to authenticity, meaning-making, and emotional well-being, contributing to hope, self-esteem, and positive affect (Neff & Harter, 2002). Neuroimaging studies reveal how music evokes emotions, showing that pleasurable music activates brain regions tied to reward, including the ventral striatum, orbitofrontal cortex, anterior insula, and somatosensory areas (Koelsch, 2015). Zentner, Grandjean & Scherer, (2008) found that in contrast, sad music stimulates the hippocampus, amygdala, and medial temporal regions associated with anxiety and negative emotions.

Musical emotions range from joy and sadness to more music-specific states like wonder, nostalgia, and transcendence. Enjoyment—an aesthetic emotion—arises from assessing a piece's acoustic and structural features and is shaped by personal factors like mood, taste, and familiarity (Brattico & Pearce, 2013). Research on basic emotional responses to music includes self-reports, patient studies (Kiseol, HaeJung & Zimmerman (2020), and physiological measurements (Mitterschiffthaler et al. 2007). Music-induced emotions are central to rituals (Lonsdale & North, 2011), and therapy (MacDonald, Kreutz & Mitchell, 2012), yet the mechanisms remain only partially understood, with no consensus on which emotions are most relevant to musical experience.

2 Methods

Dual approach has been applied. A consumer survey measuring emotional and cognitive impressions and employee assessments of the same environment. Observations were conducted via mystery shopping in 90 fashion stores located in Shopping Malls and downtown at different times of day. Mystery shopping visits were arranged by a slovak research agency

using their internal database of mystery shoppers. These shoppers were of various ages and had to meet the requirement of shopping in fashion stores at least once a month. The criterion for store selection was determined by a single factor, i.e. the main subject of activity must be the sale of fashion products. No other factors influencing the selection were applied. In each store, we recorded auditory conditions at three locations. Most stores played pleasant pop or dance music (rated 3–5 on a 5-point scale). We explore how contextual factors influence the music–behavior relationship, how music shapes emotional responses, and how employees perceive its effects.

In the survey, it was explained the evaluation of impression from sale fashion environment and a perception of music impact by mystery shoppers and managers.. The research was divided into three parts:

- 1) A survey of shoppers' evaluation of their impressions of the sales environment.
- 2) Survey of managers' evaluation of their impressions of the sales environment.
- 3) In-shop audio recording.

90 fashion stores were visited. While visiting the fashion stores, we evaluated the musical background through a questionnaire consisting of 7 questions. We then interviewed the managers of the outlets, who answered 11 questions. The survey was conducted exclusively with store managers or their representatives who were responsible for managing the store at the time of the survey. Store managers were predominantly women of various age groups. We measured the actual noise level in each store using a free mobile app called decibel meter (sound meter) in all 90 stores. The Decibel Meter mobile app for measuring sound volume is one of several freely available tools for measuring volume. This tool is available for mobile phones in the Google Store free of charge. The app uses the device's microphone to measure the volume of sound in the environment in which it is located and displays it in real time on the phone's display. The aim of the research was to find out whether music was playing in the fashion outlets, what genre of music was playing there and what emotions the music evoked in people. We then related these objectives to the opinion of the managers, who mostly know/can influence the background music in the establishment. Measuring the noise level gave us information about the current background music settings in the venues we visited and its impact on customers.

All the shops we visited had music playing and were half empty. The music was pleasant and marked only on a scale of 3 (neutral) to 5 (very pleasant). The genre was almost identical and labelled as pop, dance on selected radio. The music evoked positive emotions in mystery shoppers and was very pleasing to them with medium to low intensity. All indicated that the music should be played throughout the space. Observed fashion stores can be characterised as fashion stores located in shopping malls (83.3%) with estimated size of the store area more than 80m² (73%) and rectangular shape of store establishment (80%). Mostly it was a rectangular store plan.

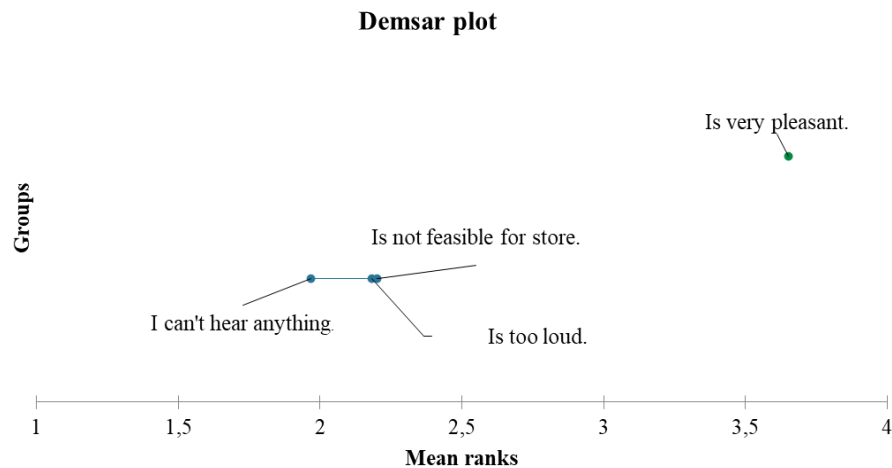
Acquired data were processed and analysed using XLstat. Descriptive statistics, inferential statistics, or multivariate analysis were applied. Non-parametric tests such as the Friedman test and Nemenyi's procedure was applied to study differences in evaluations of musical genres, store factors, level of agreement/ disagreement with statements regarding the real-time in-store music, and factors evoking positive emotion when listening to the music. Furthermore, Principal Component Analysis (PCA) was executed to reduce the number of variables and to identify patterns and relationships in data. Kaiser-Meyer-Olkin Test for Sampling Adequacy and Bartlett's Test of Sphericity were used to assess the suitability of data for PCA. Using these methods, the main goal of this research was find the answer on research question: What is the identification of music background in fashion store and its impact on customer decision, mood and buying behaviour.

3 Research results

Analysis of shoppers' survey evaluations on the sales environment.

The evaluation of in-store music from the consumer's point of view showed that most respondents perceived it as very pleasant or pleasant. Approximately 70% considered the intensity of the music in the store to be moderate. On average, respondents agreed that the real-time in-store music was very pleasant and disagreed with the following statements: "It is not feasible for the store," "It is too loud," or "I can't hear anything" see in Figure 1.

Figure 1 Level of agreement/ disagreement with statements regarding the real-time in-store music



Source: Author' s own processing

Based on respondents' perceptions of music, several genres of real-time in-store music were identified: pop, hip-hop, dance, jazz and blues, radio music (various genres), and relaxing music. Additionally, respondents were asked which music genres they would prefer to hear in retail stores. The results revealed a diversity of opinions regarding the suggested genres. A Friedman test indicated statistically significant differences (p-value = 0.001).

According to Nemenyi's post-hoc procedure presented in Table 1 respondents expressed a strong preference for pop music in fashion stores, followed by dance, soul, disco, and hip-hop music. The least preferred genres were church music, folk music, and children's music.

Table 1 Pairwise comparisons of musical genres

Sample	Mean	Mean of ranks	Groups
church music	1.033	4.117	A
folk	1.267	5.067	A B
kids music	1.300	5.250	A B
heavy-metal	1.467	5.400	A B
rock-n-roll	1.967	7.367	A B C
piano	1.967	8.067	A B C D
reggae	2.100	8.067	A B C D
rock	2.267	8.283	A B C D
blues	2.467	9.150	B C D
jazz	2.667	9.683	C D
hip-hop	2.900	10.817	C D E
disco	2.933	11.000	C D E
soul	3.000	11.300	C D E
dance	3.467	12.250	D E
pop	4.667	15.050	E

Source: Author' s own processing

Items with different letters were found to differ significantly. Furthermore, the principal component analysis revealed three latent components of the suggested music genres for fashion stores. The component extraction reduced 11 items into three components, explaining a cumulative variance of 70.03 %. Table 2 provides a summary of the loadings, with loadings below 0.360 excluded from consideration. Bartlett's Test of Sphericity yielded a p-value below 0.001, and the overall Kaiser-Meyer-Olkin (KMO) Test for Sampling Adequacy produced a value of 0.701, indicating a middling degree of common variance (Blbas & Kadir, 2019).

Based on individual KMO values, five items pop music, folk music, church music, children's music, and folk were removed from further analysis. The first latent component includes music genres such as jazz, blues, and soul, all of which have roots in African-American musical traditions. The second latent component primarily comprises harder music genres, including rock, rock and roll, heavy metal, and reggae. The third component consists of dance music, hip-hop, and disco. Notably, pop music is associated with both the second and third latent components.

Table 2 Component Loadings – music genres

	Component			Uniqueness
	1	2	3	
jazz	0.933			0.113
blues	0.910			0.151
soul	0.830			0.238
rock		0.881		0.213
rock-n-roll		0.777		0.268
heavy metal		0.764		0.312
reggae		0.639		0.588
pop		0.433	0.370	0.645
dance			0.907	0.176
hip-hop			0.856	0.221
disco			0.756	0.340

Source: Author' s own processing

Moreover, respondents evaluated the importance of various factors when selecting a fashion store using a 5-point scale (1 = least important, 5 = most important). The Friedman test revealed significant differences among the factors (p-value = 0.001). According to Nemenyi's post-hoc procedure (Table 3), the most important factor is the variety of products and services offered, followed by the price of products and services, staff, interior design, location, and in-store fragrance. The least important factor is communication on social media. Interestingly, while music is not among the most important factors, it was, on average, rated as slightly important.

Table 3 Pairwise comparisons of store factors

Sample	Mean	Mean of ranks	Groups				
communication on soc. media	2.633	2.533	A				
music	3.167	3.950	A	B			
recommendation	3.333	4.167	A	B	C		
popularity / familiarity	3.567	5.067		B	C	D	
instore fragrance	4.033	5.933		B	C	D	E
location	4.067	5.967		B	C	D	E
interior	4.067	6.133		B	C	D	E
staff	4.233	6.600			C	D	E
price of products / services	4.400	7.000				D	E
offer of products / services	4.633	7.650					E

Source: Author' s own processing

In addition, principal component analysis was applied to extract latent factors. Items with different letters were found to differ significantly. In total, two components were identified, explaining a cumulative variance of 57%. Table 4 provides a summary of the loadings, with loadings below 0.360 excluded from consideration. Bartlett's Test of Sphericity yielded a p-value below 0.001, and the overall Kaiser-Meyer-Olkin (KMO) Test for Sampling Adequacy returned a value of 0.611, indicating a mediocre degree of common variance (Blbas & Kadir, 2019). Based on individual KMO values, two items (location and the offer of products/services) were removed from further analysis. The first latent component, titled "In-Store Customer Experience," includes factors such as in-store fragrance, interior design, staff, music, and the price of products/services. The second latent component, titled "Online Engagement and Store Popularity," involves factors such as popularity/familiarity, communication on social media, and recommendations.

Table 4 Component Loadings – store factors

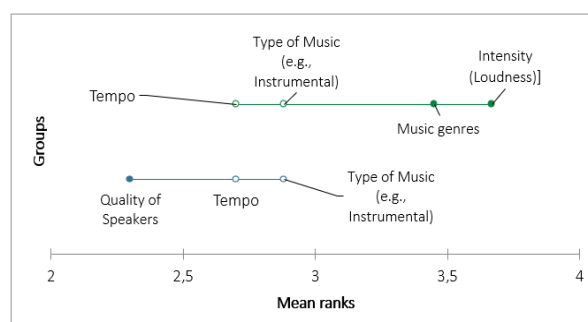
	Component		Uniqueness
	1	2	
instore fragrance	0.790		0.324
interior	0.757		0.427
staff	0.628		0.567
music	0.550		0.617
price of products / services	-0.524		0.630
popularity / familiarity		0.833	0.305
recommendation		0.831	0.277
communication on social media		0.776	0.289

Source: Author' s own processing

Survey of managers' impression of the sales environment.

Results collected from store managers and staff indicated that 73.3% of them can influence the music intensity in their stores. Approximately 40% of stores use streaming platforms such as Spotify, Apple Music, YouTube, online radio, or central systems. In general, managers perceived in-store music as positive (33.3%), very positive (26.6%), or neutral (30%). The majority of stores use ceiling speakers distributed throughout the store, while only 23% rely on small speakers placed at specific points, such as the checkout area, entrance, and fitting rooms. Additionally, 76.6% of store managers and staff consider in-store music to be an important marketing tool for influencing customers. Music influences almost all managers, with 70% perceiving it very positively or neutrally. Ceiling speakers are typically installed in various locations throughout the store to provide consistent sound coverage.

The results also showed that respondents believe the most important factor eliciting positive emotions in consumers when listening to in-store music is the intensity (volume), followed by the music genre and type of music. The least important factor is the quality of the speakers (see Figure 2).

Figure 2 Demsar plot – Factors evoking positive emotion when listening to the music

Source: Author' s own processing

Sound recording in operation.

Using a free mobile app called Decibel Meter (Sound Meter), mystery shoppers recorded one minute of sound in each establishment. They then used the free Audioalter BPM Detector software to calculate the beats-per-minute (BPM) value of the background music. In addition, the minimum, maximum, and average noise levels were measured at the entrance, in the main area, and at the checkout counters. On average, the stores were half-empty at the time of the recordings. The data collected using the Decibel Meter app are presented in Table 5.

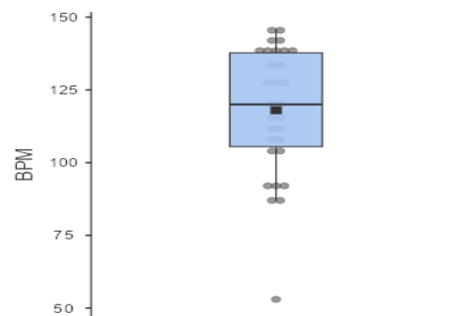
The results revealed that the average sound level at the entrance was 61.2 dB, with a maximum value of 75.8 dB and a minimum value of 48.6 dB. The highest sound levels were measured in the middle of the store, with an average of 76.7 dB, a maximum of 60.1 dB, and a minimum of 48.1 dB. The lowest values were recorded at the checkout area, where the sound meter showed an average of 48.8 dB, a maximum of 76.5 dB, and a minimum of 60.7 dB.

Table 5 Recording the measured sound levels in the fashion stores via mobile application - Decibel Meter (Sound Meter)

	Entrance			At store - middle			Checkout		
	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG
Mean	48.6	75.8	61.2	48.1	60.1	76.7	60.7	76.5	48.8
Standard deviation	16.7	17.2	16.0	21.8	20.7	20.5	17.3	16.4	19.5
Minimum	20.2	38.0	32.0	15.8	30.0	37.0	30.7	47.0	16.9
Maximum	106	122	118	140	146	151	128	131	124

Source: Author' s own processing

In addition, the beats per minute (BPM) of the music were measured in each fashion store. The results showed an average of 118 BPM with a standard deviation of 22.4. The maximum recorded value was 146 BPM, while the average minimum value was 53 BPM (Figure 3).

Figure 3 Box plot – Beats per minute (BPM)

Source: Author' s own processing

Research shows that music strongly influences consumers' knowledge, emotions, and behavior, particularly their attitudes, feelings, the time and money they are willing to spend, and their overall shopping experience. These effects of music are measurable at the point of sale, time of purchase, and in relation to other environmental factors.

Preferences for music styles and fashion can interact, with the correlation varying across different music genres and being influenced by individuals' interest in music and fashion. Our study found that fashion can transfer sensitivity from music, identifying similar sensitivities between music and its influence on shoppers.

The stores observed in the study were predominantly fashion stores located in shopping malls, characterized by a store size of more than 80 m² (73%) and a rectangular layout (80%). The results suggest that a significant proportion of managers have the ability to influence the intensity of music in their stores and use various music platforms. Approximately 40% of stores use streaming services such as Spotify, Apple Music, YouTube, online radio, or centralized systems.

In general, managers perceived in-store music positively, with 33.3% rating it as positive, 26.6% as very positive, and 30% as neutral. The majority of stores utilize ceiling speakers distributed throughout the premises, while only 23% use small speakers positioned at specific points, such as the checkout, entrance, and fitting rooms. Additionally, 76.6% of store managers and staff consider in-store music to be an important marketing tool for influencing customers.

4 Conclusions

This study provides important insights into the impact of music on consumer behavior in fashion retail and highlights its significance as a marketing tool. The positive economic findings of this study suggest that managers are aware of the importance of music in retail, although they often lack detailed information about its direct effects and rely on subjective judgment when making decisions. The creation of playlists using consumer neuroscience tools could lead to future improvements, not only in the economic performance of stores but also in the overall perception of the shopping environment.

Here we summarize the implications of our research into three parts:

Research Implications: This study advances research on the impact of background music in retail environments, particularly within fashion stores. By exploring the relationship between music intensity, genre, and consumer emotions, this work contributes to understanding how these factors influence consumer behavior. Future research can expand on these findings by exploring other retail environments (e.g., grocery stores, technological shops or services) and online shopping platforms like live-streaming commerce, which has become increasingly important.

Practical Implications: For retail managers and brand marketers, the findings offer valuable insights into how to strategically use music as a tool to enhance the shopping experience. The research also shows that factors like the volume of music and its appropriateness to the store's atmosphere are essential considerations. In practice, retailers can optimize their music strategy to improve customer mood and shopping experience, potentially increasing sales.

Social Implications: This research highlights how background music in retail settings not only influences consumer behavior but also contributes to shaping the emotional atmosphere of public spaces. The study also draws attention to the varying preferences for different music genres, suggesting a need for more personalized and culturally sensitive approaches in retail settings to ensure that music is inclusive and resonates with diverse consumer groups.

Research Limitations: The study's limitations stem from its focus on the declarative component of mystery shopping and questionnaires. One of the shortcomings of this study is the inaccuracy of noise level measurements in the establishments surveyed. The decibel meter used is not certified for sound measurement and depends on the quality of the mobile phone and its microphone. Since these devices are not calibrated, the measurement results may vary significantly. These and other factors could have affected the accuracy of the measurements, which could have led to inaccurate findings and subsequent recommendations for improvement. In the future, we plan to conduct research under laboratory conditions, utilizing both explicit and implicit tools to better understand the targeted impact of audio stimulation on human emotions.

Using this research in practice:

- By adopting these practices, retailers can use the research to optimize customer engagement, enhance in-store experiences, and ultimately drive sales and brand loyalty.
- Retailers can use the insights into music genre/ intensity preferences (e.g., pop, dance, and soul music being preferred in fashion stores) to curate playlists that align with their target customers' tastes.
- The study found differences in sound levels at various areas within the store, such as the entrance, the main store area, and the checkout area. Retailers can use this information to place music strategically, such as using softer music at checkout counters to reduce stress and create a relaxed atmosphere, while more upbeat music can be played in the main shopping area to energize customers and encourage them to explore the store further.
- Store managers who recognize music as a valuable marketing tool can leverage it in promotional campaigns or sales events to trigger specific emotional responses.
- The research indicates that music influences the emotional climate not only for customers but also for employees. Managers can consider creating a more employee-friendly music environment by adjusting the intensity or type of music played to ensure it doesn't negatively affect their mood or productivity.

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Change Management in Higher Education Administration: Perceptions of an AI Chatbot for Student Affairs Office

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Abstract: Digital transformation is increasingly influencing the way universities deliver administrative and support services. AI-powered chatbots are emerging as promising tools to enhance communication, efficiency, and user experience in student–university interactions. However, their successful implementation requires not only technological preparedness but also thoughtful change management to align organizational culture, stakeholder expectations, and service workflows. This paper presents a qualitative study exploring how university students perceive the planned introduction of an AI chatbot at a faculty’s student administration office. Using semi-structured interviews, the research examines expectations, perceived benefits, and concerns related to the chatbot’s integration into academic service processes. The analysis will be grounded in the theoretical framework of change management and institutional adaptability. The study aims to contribute to a deeper understanding of how students conceptualize AI-driven change in university administration, offering practical insights for managing digital transformation in higher education institutions.

Keywords: change management, AI, higher education, student’s affairs

JEL Classification: I23, M15, O33

1 Introduction

Digital transformation is reshaping how universities deliver both academic and administrative services. Among these changes, AI-powered chatbots have emerged as promising tools for improving communication, efficiency, and accessibility in student–university interactions (Alenezi & Akour, 2023; Antonopoulou, Begkos, & Zhu, 2023). By automating routine inquiries—such as deadlines, procedures, or form submissions—chatbots can reduce administrative workload and offer 24/7 support, aligning with growing expectations for immediacy and transparency in higher education. However, successful integration of AI systems extends beyond technology. It requires organizational change, adaptation of workflows, and cultural acceptance across institutional levels (Kotter, 1996; Scott, 2014; Schein, 2010). Without addressing these human and institutional dimensions, technological innovation may face resistance or underuse despite its technical potential (Labadze, Grigolia, & Machaidze, 2023). Recent scholarship further emphasizes that the lack of long-term sustainability strategies and clear ethical guidelines remains a significant barrier to adoption (Prokhorova et al., 2024). Moreover, the integration of AI tools often outpaces the development of necessary regulatory frameworks, creating a gap between technological capability and institutional readiness (Chukwuere, 2024; El mourabit et al., 2025). Therefore, understanding how stakeholders—students and academics—perceive such innovations becomes essential for sustainable digital transformation.

This study examines perceptions surrounding the planned introduction of an AI chatbot at the Faculty of Informatics and Management, University of Hradec Králové (FIM UHK). The chatbot, designed as a knowledge-base system trained on official faculty regulations and procedures, aims to assist the Student Affairs Office in responding to frequently asked questions. The investigation focuses on expectations, perceived benefits, and concerns related to its deployment. Although several studies have explored AI chatbots in educational contexts, most focus on learning outcomes or technological performance (Balderas, García-Mena, Huerta, Mora, & Dodero, 2023; Stöhr, Ou, & Malmström, 2024). Far fewer examine the organizational and cultural implications of implementing such systems in administrative environments. Addressing this gap contributes to understanding how universities can align AI innovation with institutional culture and user trust.

The research integrates theoretical perspectives from change management (Kotter, 1996; Hiatt, 2006; Hussain et al., 2018), institutional theory (DiMaggio & Powell, 1983; Scott, 2014), technology acceptance (Davis, 1989; Venkatesh,

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Morris, Davis, & Davis, 2003; Venkatesh, Thong, & Xu, 2012), and service quality (Parasuraman, Zeithaml, & Berry, 1988). Together, these frameworks provide a multi-level lens for analyzing both human and organizational readiness for AI adoption.

Accordingly, the study seeks to answer three research questions:

RQ1: How do students and academic staff conceptualize the role of an AI chatbot in student administrative processes?

RQ2: What benefits, limitations, and concerns do they associate with its use?

RQ3: What organizational and cultural conditions are necessary for successful implementation and acceptance?

By exploring these questions, the paper aims to contribute to a broader understanding of how AI-driven change is perceived and negotiated in higher education administration, offering practical insights for managing digital transformation in similar institutional contexts.

2. Theoretical Framework

Understanding the implementation of AI chatbots in higher education administration requires an interdisciplinary approach that combines technological, organizational, and cultural perspectives.

Five theoretical areas inform this study: digital transformation, change management, institutional and cultural theory, technology acceptance, and service quality and governance.

In higher education, digital transformation extends beyond digitizing processes to a systemic reconfiguration of workflows, services, and institutional culture (Alenezi & Akour, 2023). Universities are increasingly adopting AI tools to enhance efficiency and responsiveness (Antonopoulou, Begkos, & Zhu, 2023). However, as Labadze, Grigolia, and Machaidze (2023) note, transformation initiatives often fail without adequate stakeholder communication and cultural alignment. Chatbots represent a socio-technical change: they automate knowledge access but also redefine human roles in service delivery.

Organizational change models explain how institutions adapt to innovation. Kotter's (1996) eight-step model emphasizes leadership, communication, and early wins to establish commitment, while the ADKAR framework (Hiatt, 2006) focuses on individual transitions—awareness, desire, knowledge, ability, and reinforcement. Lewin's classical “unfreeze–change–refreeze” process remains a useful metaphor for shifting entrenched routines when paired with participatory leadership (Hussain et al., 2018). Together, these models stress that successful technological adoption depends on managing both structural and emotional aspects of change.

Universities are embedded in institutional environments governed by norms, traditions, and professional expectations (Scott, 2014). Institutional theory explains organizational behavior through mimetic (imitation), normative (professional standards), and coercive (policy pressures) mechanisms (DiMaggio & Powell, 1983). Schein (2010) extends this view by showing how shared assumptions and values form an organization's culture, shaping openness to innovation. In the context of FIM UHK, institutional culture may both enable and constrain the adoption of an AI chatbot, depending on how it is communicated and framed.

User perceptions are central to implementation success. The Technology Acceptance Model (TAM) posits that Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) drive behavioral intention (Davis, 1989). The Unified Theory of Acceptance and Use of Technology (UTAUT) expands this with social influence and facilitating conditions (Venkatesh, Morris, Davis, & Davis, 2003), while UTAUT2 adds hedonic motivation and habit (Venkatesh, Thong, & Xu, 2012). These frameworks illuminate why students often welcome chatbots for convenience, whereas staff may hesitate if perceived benefits are unclear or workload increases.

Service quality in digital contexts depends on reliability, responsiveness, assurance, empathy, and tangibles (Parasuraman, Zeithaml, & Berry, 1988). These dimensions apply directly to chatbot evaluation—accuracy, tone, empathy, and escalation to human staff when necessary. Furthermore, compliance with privacy and data protection standards, particularly the GDPR, underpins user trust and institutional legitimacy (European Parliamentary Research Service, 2020; Dushi, Lainati, & Hernandez, 2025). Trust in AI systems thus rests on both performance and transparent governance.

By integrating these frameworks, the study conceptualizes chatbot adoption across three interconnected levels: the micro level of individual acceptance (TAM/UTAUT, SERVQUAL), the meso level of organizational change and culture (Kotter,

Hiatt, Schein), and the macro level of institutional governance and legitimacy (Scott, DiMaggio & Powell, EPRS). This multi-level lens guides both data collection and analysis of stakeholder perceptions.

3. Methodology

This section describes the research design, participants, data collection, analytical procedures, and ethical considerations used in this study. The methodological approach was shaped by the study's aim—to explore perceptions of AI chatbot adoption within a real university environment—requiring qualitative depth and contextual understanding rather than statistical generalization.

The research employed a qualitative, interpretivist design to investigate how students and academic staff perceive the planned introduction of an AI chatbot at the Faculty of Informatics and Management, University of Hradec Králové (FIM UHK). A qualitative approach was chosen because it enables insight into individual experiences, beliefs, and expectations (Braun & Clarke, 2006). Semi-structured interviews provided a balance between guided discussion and open exploration. During the sessions, participants were shown a working prototype of a knowledge-based chatbot trained on faculty rules and regulations. This ensured their reflections were based on concrete interaction rather than abstract assumptions.

Ten individuals participated: five students and five academics. The sample was deliberately diverse in terms of study programs, teaching areas, and digital literacy. The sampling strategy followed a purposeful "maximum variation" approach to capture a dyadic perspective of the service encounter—analyzing views from both service receivers (students) and service providers (academics). This dual approach was critical for identifying the friction points between the demand for instant digital service and the institutional need for accuracy and protocol. Each interview lasted around 30 minutes, conducted in person or online. The small but information-rich sample aligns with both the Nielsen heuristic—five users uncover most usability issues (Nielsen, 2000)—and the information-power concept that values depth over breadth (Malterud, Siersma, & Guassora, 2016).

Table 1 Composition of participants and key parameters of the conducted interviews at FIM UHK

Group	Number	Duration	Mode	Focus
Students	5	~30 min	In-person / Online	Expectations, benefits, and trust
Academics	5	~30 min	In-person / Online	Organizational readiness, risks, and governance

Source: Own processing

Interviews followed seven guiding themes derived from the theoretical framework: current communication challenges, expectations and benefits, concerns about reliability and empathy, privacy issues, and organizational readiness for change. Questions reflected constructs from TAM/UTAUT (Davis, 1989; Venkatesh et al., 2003), SERVQUAL (Parasuraman, Zeithaml, & Berry, 1988), and change-management models (Kotter, 1996; Hiatt, 2006). All sessions were audio-recorded, transcribed verbatim, and anonymized. Data were analyzed using thematic analysis (Braun & Clarke, 2006). Coding combined deductive categories (usefulness, empathy, readiness, trust) with inductive themes that emerged from narratives such as “loss of human touch” or “AI as a neutral assistant.” Credibility was ensured through member checking, peer debriefing, and reflexive memoing documenting analytical choices.

The study adhered to institutional ethical standards. All participants provided informed consent, participation was voluntary, and confidentiality was guaranteed. Because the chatbot prototype operated in a sandbox environment, no personal data were processed. Transcripts were stored securely and stripped of identifiers. Attention to GDPR compliance followed European Parliamentary Research Service (2020) guidance. Clear communication of privacy and data-handling practices—emphasized by Dushi, Lainati, and Hernandez (2025)—helped strengthen participant trust and institutional transparency.

In summary, the study's qualitative design, purposeful sampling, and thematic analysis provided a reliable foundation for exploring how members of an academic community perceive AI-assisted administration. The next section presents the thematic findings derived from these interviews.

4. Results

Thematic analysis of ten interviews revealed five interrelated themes reflecting both enthusiasm and skepticism toward the planned AI chatbot. Students emphasized convenience, fairness, and faster access to information, whereas academic staff expressed concerns regarding reliability, empathy, and institutional accountability. Together, the themes illustrate how technological acceptance interacts with organizational culture and trust.

Efficiency and Accessibility. Participants frequently highlighted the chatbot's potential to make administrative communication faster, clearer, and available 24/7. Students viewed it to reduce dependence on email delays and improve equity of access to information. This expectation aligns with the Perceived Usefulness and Effort Expectancy constructs of the TAM/UTAUT frameworks (Davis, 1989; Venkatesh et al., 2003) and the Responsiveness dimension of the SERVQUAL model (Parasuraman, Zeithaml, & Berry, 1988). Students thus perceive the chatbot as an efficiency-enhancing companion rather than a novelty.

"It would save me a lot of time—I wouldn't have to wait for an email just to ask when to submit something." (Student)

Reliability and Trust. While efficiency was welcomed, both groups expressed reservations about accuracy and accountability. Academics stressed that an incorrect response could undermine institutional credibility. Participants valued transparency—knowing when the chatbot was unsure and being redirected to a human officer. Trust therefore emerged as a mediating factor between usefulness and sustained use, supporting findings by Dushi, Lainati, and Hernandez (2025) that data governance and reliability are inseparable. This theme corresponds with Reliability and Assurance in SERVQUAL and the Reinforcement stage of ADKAR (Hiatt, 2006).

"If the chatbot gives wrong advice about an exam or scholarship, who takes responsibility?" (Academic)

Loss of Human Touch. Despite positive views on accessibility, several students and staff noted concerns about the impersonal nature of automated interaction. Administrative communication often serves emotional as well as informational purposes. This reflects the Empathy dimension of SERVQUAL and Schein's (2010) perspective on organizational culture as a social system. Participants agreed that the chatbot should complement, not replace personal contact, particularly for sensitive or complex issues. Hybrid models—AI for routine tasks, humans for nuanced cases—were widely supported.

"Sometimes you just need someone to listen, not a robot." (Student)

Change Readiness and Institutional Fit. Perceptions of change varied sharply between students and academics.

Students saw the chatbot as a natural step toward modernization, while some academics perceived potential disruption to established routines and workload. This divergence illustrates different stages of organizational readiness (Kotter, 1996; Hiatt, 2006). Students display high desire and knowledge to adopt change, whereas academics emphasize ability and reinforcement. Institutional theory (DiMaggio & Powell, 1983; Scott, 2014) explains this tension as the coexistence of mimetic innovation pressure and normative conservatism typical in higher education. Addressing such asymmetry requires open dialogue, training, and visible leadership support.

"The younger generation expects this, but some colleagues are afraid it will complicate their work." (Academic)

Data Protection and Ethical Concerns. Both students and staff raised issues regarding privacy, transparency, and the handling of user data. Although participants generally trusted the university, they wanted clear communication about storage and processing. Data protection thus directly influenced trust and intention to use the chatbot. This theme resonates with GDPR principles and emphasizes that ethical transparency is integral to perceived service quality (European Parliamentary Research Service, 2020; Dushi et al., 2025). Participants suggested adding a visible privacy disclaimer or data summary to the chatbot interface.

"Before I ask personal questions, I want to know what happens with my data." (Student)

The five themes collectively depict a balanced narrative of optimism and caution. Students associate the chatbot with modernization and accessibility, while academics stress governance, reliability, and human presence. Together, these findings highlight that technological innovation in higher education is fundamentally a cultural and organizational transition, requiring both empathy and accountability. The next section interprets these findings through the theoretical frameworks introduced earlier.

5. Discussion

The findings demonstrate that the introduction of an AI chatbot in higher education administration is not perceived solely as a technological upgrade but as a transformative cultural process. Students viewed the chatbot primarily to simplify

administrative interactions, increase transparency, and save time, while academic staff were more cautious, highlighting the need for accuracy, accountability, and empathy. This contrast captures a fundamental duality in digital transformation—its ability to enhance efficiency while simultaneously challenging long-standing norms of human-centered service delivery. Such divergence underscores that technological success depends not only on system design but also on the extent to which institutions manage the accompanying organizational and emotional change (Alenezi & Akour, 2023; Antonopoulou, Begkos, & Zhu, 2023).

At the individual level, participants' responses correspond closely with constructs from the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). Students' willingness to use the chatbot was largely determined by perceived usefulness, ease of use, and perceived reliability (Davis, 1989; Venkatesh et al., 2003). Yet, unlike traditional technology adoption studies, this research highlights trust as a mediating factor between perceived usefulness and actual acceptance. Users are more likely to adopt an AI-driven service when they understand its data logic, boundaries, and escalation mechanisms. In this sense, trust functions as both a psychological and institutional currency, shaped by perceptions of fairness, competence, and transparency (Dushi, Lainati, & Hernandez, 2025; European Parliamentary Research Service, 2020). It links user-level adoption to institutional legitimacy, extending the TAM framework beyond functionality into the domain of ethics and governance.

From an organizational perspective, the findings reveal that adoption readiness depends on leadership communication, collective involvement, and cultural alignment. The contrast between student optimism and staff hesitation reflects different stages of change maturity, as conceptualized in ADKAR (Hiatt, 2006) and Kotter's eight-step model (1996). While students exhibit awareness and desire, some academics remain in the early phases of understanding and ability, wary of workflow disruption. This asymmetry confirms Hussain et al.'s (2018) view that leadership must create a shared vision and visible short-term wins to maintain momentum. Moreover, Schein's (2010) perspective on organizational culture helps explain why emotional safety—feeling heard and supported—is essential for effective digital transformation. Chatbots cannot simply be imposed as tools; they must be integrated into workflows that respect human expertise and institutional traditions.

The themes of empathy and service quality further align with the SERVQUAL model (Parasuraman, Zeithaml, & Berry, 1988). Students valued responsiveness and convenience, whereas staff emphasized reliability and assurance. These differences suggest that a hybrid service model—where chatbots handle routine queries and human staff address complex or sensitive issues—offers the most balanced approach. To navigate these complexities, universities should adopt "participatory change strategies" rather than top-down mandates. Research by Prokhorova et al. (2024) indicates that involving stakeholders in the co-design phase of AI tools significantly reduces resistance by fostering a sense of psychological ownership. Furthermore, a "bimodal" implementation strategy—where AI handles high-volume routine queries while specialized staff focus exclusively on complex cases—can help bridge the gap between efficiency and empathy (Chukwuere, 2024). This aligns with the necessity of establishing a "digital culture" that prioritizes transparency over blind automation, ensuring that the technology serves as an enabler of human connection rather than a barrier (El mourabit et al., 2025). Such a model respects the university's service ethos while achieving operational efficiency. It also reflects an evolution from pure automation to augmented service delivery, in which AI enhances human capacity rather than replaces it. Within this hybrid framework, empathy remains a critical quality indicator, reinforcing that successful digital transformation requires not just intelligent systems but emotionally intelligent design.

At the institutional level, the study reflects broader forces of isomorphism and legitimacy described by DiMaggio and Powell (1983) and Scott (2014). Universities are under normative and mimetic pressures to modernize through AI, yet innovation must align with ethical and regulatory boundaries to gain legitimacy. The strong emphasis on data protection and transparency indicates that GDPR compliance serves not only as a legal safeguard but also as a trust-building mechanism. Participants associated data governance with professional credibility, suggesting that effective communication of privacy policies, audit trails, and accountability structures is vital for sustained adoption (EPRS, 2020; Dushi et al., 2025). Taken together, these findings position trust as the central integrating construct—bridging individual perception, organizational culture, and institutional governance. Successful AI adoption in higher education thus depends on achieving harmony between efficiency and empathy, innovation and accountability, automation and human connection.

It is necessary to acknowledge the limitations of this study. First, the sample size (N=10), while sufficient for qualitative saturation within a specific faculty context, limits the transferability of findings to universities with different organizational cultures or lower baseline digital literacy. Second, the study utilized a prototype in a sandbox environment; user perceptions might differ in a live deployment scenario where real-world consequences (e.g., incorrect visa advice) are at stake. Finally, the participants were drawn from a Faculty of Informatics, potentially skewing the results toward a more techno-optimistic viewpoint compared to humanities or social science departments.

6. Conclusions and Implications

The study explored perceptions of students and academic staff regarding the planned introduction of an AI chatbot at the Faculty of Informatics and Management, University of Hradec Králové. By combining insights from ten semi-structured interviews, the findings revealed that AI-assisted communication in academic administration is viewed simultaneously as a source of efficiency and a challenge to established practices. Students generally welcomed the chatbot as a convenient, modern, and fair tool that improves access to information, while academics emphasized potential risks associated with accuracy, accountability, and loss of personal interaction. These dual perspectives illustrate that the adoption of AI in higher education is not merely a technological process but a cultural negotiation requiring transparency, dialogue, and institutional leadership.

The research contributes to a nuanced understanding of AI-driven change management in university settings. The results support a multi-level interpretation of adoption: at the micro level, perceived usefulness, ease of use, and trust determine user acceptance (Davis, 1989; Venkatesh et al., 2003); at the meso level, organizational readiness, communication, and culture define the pace of change (Kotter, 1996; Hiatt, 2006; Schein, 2010); and at the macro level, governance and legitimacy influence whether innovation becomes institutionally sustainable (Scott, 2014; DiMaggio & Powell, 1983). In this framework, trust functions as a connecting element—linking technological reliability, ethical transparency, and organizational reputation. When users believe the system is accurate, fair, and compliant with data protection standards (European Parliamentary Research Service, 2020; Dushi, Lainati, & Hernandez, 2025), their confidence extends from individual use to collective endorsement.

From a practical standpoint, the findings suggest several strategies for managing similar digital transformations. Universities should approach chatbot implementation as a strategic change project, not a software deployment. Clear leadership vision and participative communication help align expectations across stakeholder groups. Piloting the chatbot in limited administrative contexts, celebrating early successes, and establishing a transparent feedback loop can strengthen institutional readiness and reduce resistance (Kotter, 1996; Hiatt, 2006). Service design should follow a hybrid model, where the chatbot handles routine queries while human staff manage complex or emotionally sensitive cases. This balance between automation and empathy resonates with the principles of SERVQUAL—reliability, assurance, and empathy—as key determinants of perceived service quality (Parasuraman, Zeithaml, & Berry, 1988).

Finally, the study underscores the ethical and governance dimensions of AI in education. GDPR compliance and transparent data communication are not only legal requirements but crucial enablers of trust and legitimacy. Institutions should proactively inform users about how data are stored, used, and anonymized, embedding accountability mechanisms such as audit trails or data protection impact assessments (EPRS, 2020). Looking forward, sustainable integration of AI into higher education will depend on universities' ability to maintain a human-centered digital culture—one that values both innovation and care. By treating AI systems as collaborative partners rather than replacements for human expertise, universities can enhance accessibility, efficiency, and fairness while preserving the empathy and professionalism that define academic service.

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Absorptive Capacity of European Funds in the Czech Republic, the Slovak Republic, and Portugal: A Comparison of Participation in the Horizon Europe Programme

Jaroslav Vlach¹

Abstract: The article compares the participation of the Czech Republic, Slovakia, and Portugal in Horizon Europe (HE), the EU's main funding program for research and innovation. While the Czech Republic and Slovakia share a common historical and institutional background, Portugal serves as a comparable yet distinct reference case. Based on 2021–2024 data, the article assesses funding uptake, engagement capacity, and territorial imbalances. It highlights low absorption rates and failure to meet the 3% GDP target for R&D. Reflecting on warnings from the Draghi report about structural weaknesses in the EU's innovation framework, it proposes reforms to enhance efficiency and support place-based excellence.

Keywords: innovation, competitiveness, Horizon Europe, Czech Republic, Slovakia, Portugal, EU research and development policy, regional disparities

JEL Classification: O38, H52, O52, R58

1 Introduction

Over the past three decades, global economic and political power has shifted toward Southeast Asian countries, particularly China and India, as well as parts of Latin America. This raises the question of whether their growth is driven by innovation and research or merely by convergence through cheap labor and low initial GDP levels.

Europe is responding to these shifts by redefining its geopolitical role. As Nye (2004) argues, *soft power* a country's ability to attract others culturally, technologically, and institutionally is becoming increasingly important. Wallerstein (2005), however, warns that the world is entering a phase of systemic instability, where Europe no longer plays a dominant role.

Against this backdrop, the article analyses the Czech Republic and Slovakia two countries with a shared history and compares them with Portugal. It focuses on their ability to draw funding from *Horizon 2020* and HE, key EU programs for supporting research excellence and knowledge transfer. As the European Research Council (ERC, 2022) notes: “*Science knows no borders, but national systems are limited by borders.*” The success of small and medium-sized states thus depends primarily on their domestic institutional capacity.

In this context, absorptive capacity refers to the ability of a country not only to access EU research funding, but also to effectively implement projects, build institutional partnerships, and align outcomes with strategic innovation goals.

2 Objectives and Methods

2.1 Main Research Objective

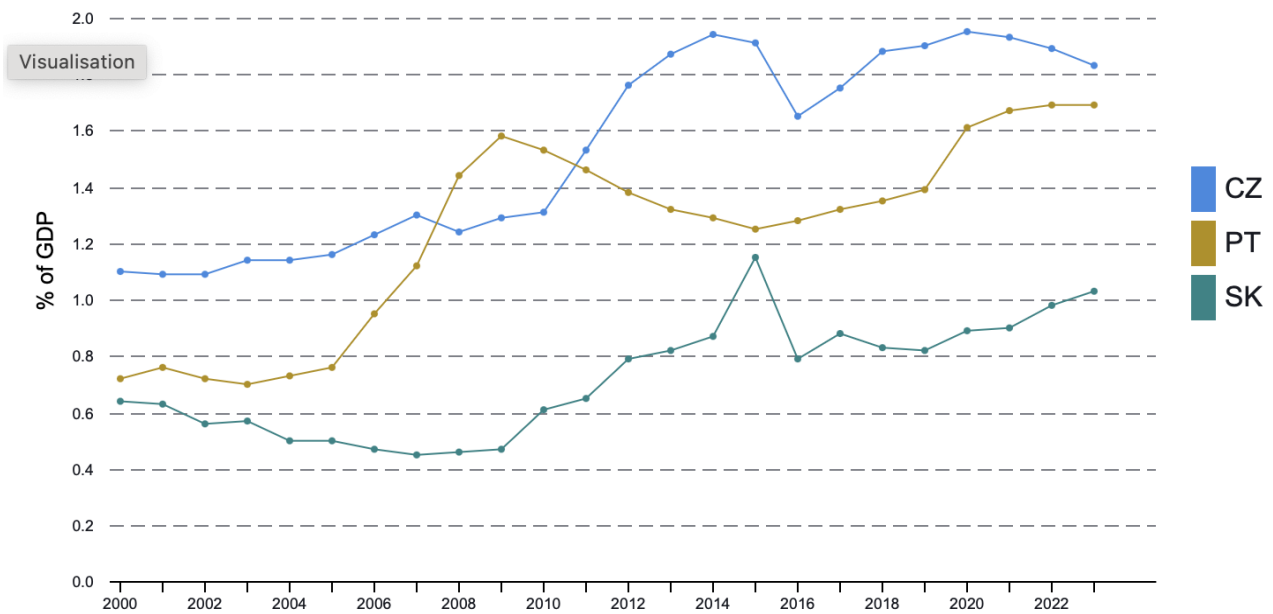
The article compares the ability of the Czech Republic, Slovakia, and Portugal to absorb funding from HE. While Czechia and Slovakia share institutional roots, Portugal serves as a similarly sized comparator with a different EU trajectory.

The main research question is: To what extent does the participation of these countries in HE reflect their declared innovation policy priorities and strategic competitiveness goals?

The study focuses on three core aspects: the amount of EU funding received, the number of supported projects and participating entities, and the role of institutional structures, including the business sector.

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Figure1 Share GDP of R&D



Source: Eurostat (2025)

2.2 Specific Research Objectives

In line with the central aim, the study focuses on the following concrete research questions: it assesses the national level absorption of HE funds (2021–2024), compares the volume and scope of project involvement, identifies regional disparities in funding distribution, examines structural conditions such as research infrastructure and institutional readiness, and interprets the results in the context of long-term EU innovation policy goals, including RIS3 strategies (national or subnational policy documents developed under the EU smart specialisation framework, identifying priority areas for targeted R&D and innovation investment) and the 2024 Draghi report.

2.3 Methodology

The study applies a comparative and descriptive approach, combining quantitative indicators with contextual institutional analysis. It focuses on national and area-level data related to HE participation in the Czech Republic, Slovakia, and Portugal.

Key sources include the official HE portals (for instance TC AV ČR, CVTI SR, ANI), Eurostat, the European Commission, and OECD datasets, particularly R&D expenditure as a share of GDP, as well as national strategy documents such as RIS3 strategies and the 2024 Draghi report.

The analysis uses basic indicators such as EU contribution, number of participations, and institutional typ alongside visual comparisons (graphs and maps) and policy frameworks such as the European Research Area (ERA), the Lisbon Strategy, HE, Missions, and Smart Specialisation policies (RIS3). Special attention is given to how institutional settings and regional disparities influence each country's ability to utilize EU research programmes effectively.

In addition to descriptive comparison, selected performance indicators (e.g. EU contribution per capita, business participation rates) were normalized and benchmarked against the EU average. A simple composite index of absorptive capacity was created by combining funding, participation counts, and institutional diversity. Exploratory correlation between national R&D investment (% of GDP) and Horizon Europe engagement was also analyzed to support contextual interpretation.

3 Comparative Results: Participation in Horizon Europe

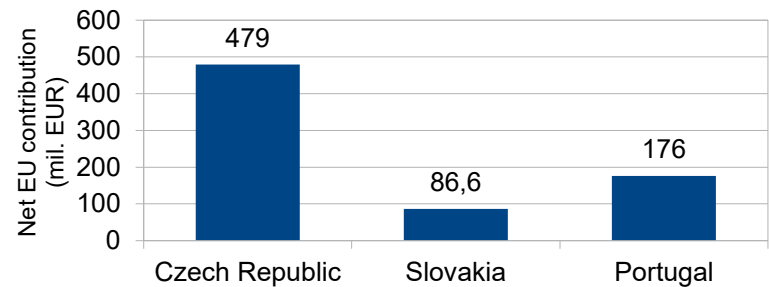
This section summarizes the participation of the Czech Republic, Slovakia, and Portugal in HE (2021–2024), focusing on funding volume, project numbers, institutional/subnational structure, and business sector involvement.

3.1 EU Contribution and Absorptive Capacity

As of August 2024, the Czech Republic received €479 million, Slovakia €86.6 million (PEDAL Consulting, 2024), and Portugal €176 million (EFMC, 2022; data as of October 2022), see Figure 2. Project participations: Czech Republic 1,361; Slovakia 291 (PEDAL Consulting, 2024); Portugal 551 (FCT Portugal, 2022), see Figure 3.

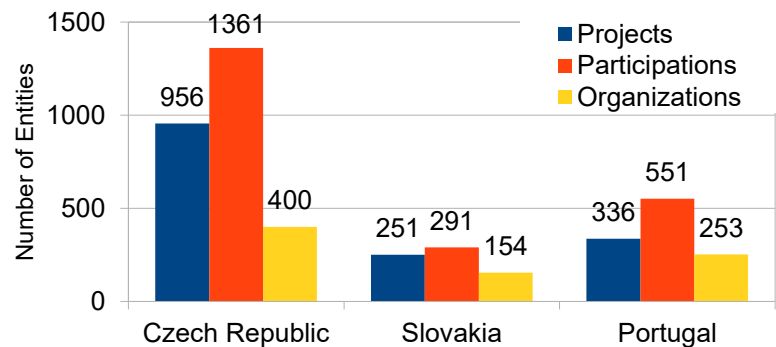
- Data represent cumulative figures since 2021.
- By August 2024, the program recorded over 102,000 participations in 15,600 projects, with a total EU contribution of €43.5 billion (TC AV ČR, 2024).

Figure 2 Net financial contribution for the given country



Source: Own processing

Figure 3 Number of projects, participations, and organizations²



Source: Own processing³

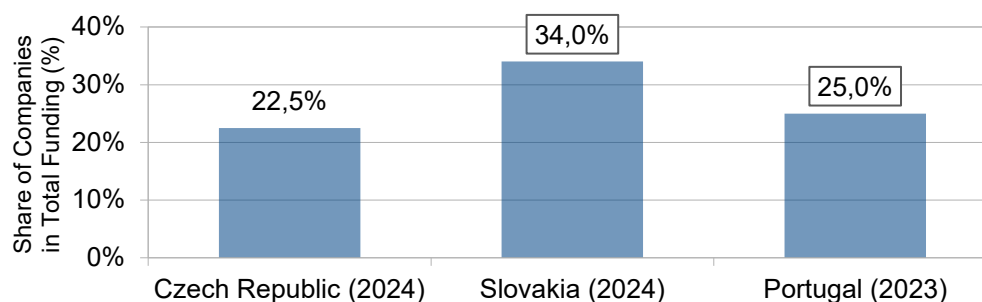
3.2 Institutional Involvement and Sectoral Structure

In the Czech Republic, HE funding is primarily absorbed by universities and research institutes main recipients include Masaryk University, Charles University, and CTU (European Commission, n.d.). A similar pattern is observed in Slovakia, led by STU Bratislava and TU Košice, though with significantly lower participation and funding levels (SLORD, 2024). The business sector's share differs: about 20–25 % in the Czech Republic and approximately 34 % in Slovakia, see Figure 4. These variations may relate to SME participation, project office quality, or the focus of specific calls. Portugal, detailed sectoral data is limited, but most funding goes to a few research centers, mainly in the Lisbon area indicating a similar concentration model as in Czechia and Slovakia, with academic dominance and limited regional diversification.

² Participation refers to each individual involvement of an organization in a project (an organization may participate in multiple projects); organization is counted only once, regardless of the number of participations

³ Data for Portugal are from 2022, while data for the other countries are from 2024.

Figure 4 Estimated share of businesses in total funding



Source: Own processing⁴

3.3 Regional Disparities in Fund Allocation

In the Czech Republic, over 70 % of HE funding goes to Prague (€249 million) and Brno (€105 million), while regions like Olomouc (€22 million) and České Budějovice (€11 million) lag behind (TC AV ČR, 2024).

A similar pattern appears in Slovakia, where most funds are concentrated in Bratislava, with minimal involvement from eastern and rural areas (SLORD, 2024; STU, n.d.).

In Portugal, funding is heavily centered in Lisbon, with limited participation from other regions reflecting a *rural–urban divide* linked to institutional capacity (Santos & Conte, 2023).

The *European Commission* (2023) calls for stronger RIS3 strategies and capacity-building in less-developed regions, but implementation remains limited in all three countries.

3.4 Context and Structural Barriers – Draghi’s Warning

In his report on European competitiveness, Mario Draghi (2024) highlights persistent structural weaknesses lack of cohesion, underfunding, and the absence of global tech leaders. He notes that no European company has reached a market capitalization of €100 billion in the past 50 years (p. 3).

His call for reform stands in sharp contrast to the continued disintegration of innovation policies and the lack of strategic coordination across EU member states.

Given his former roles as President of the ECB and Prime Minister of Italy, it is legitimate to ask why such reforms were not initiated earlier at a time when the problems were already visible but arguably more manageable.

4 Discussion and Recommendations

Differences in HE success depend less on country size and more on institutional readiness, project capacity, international partnerships, and motivated teams.

4.1 Barriers to Effective Participation

Participation in Horizon Europe is hindered by several interrelated barriers: concentration of funding in capital regions, low engagement from peripheral areas, and uneven business involvement. These are not isolated problems. They reflect a deeper misalignment between national strategies and implementation capacity. Despite rhetorical commitments to innovation (e.g., RIS3), actual investments remain insufficient, regional capacities weak, and internationalization superficial. As Draghi (2024) notes, Europe's innovation ambitions suffer from lack of leadership and operational follow-through.

⁴ The estimated 25% business share in Portugal is based on ANI (2023), referencing a broader funding volume of €500M. This figure is not directly comparable to the €176M reported in the *Horizon Dashboard* (Oct 2022, see Figure 1), which reflects the net EU contribution from approved grants. Portuguese data refer to 2023; Czech and Slovak figures are from 2024.

4.2 Recommendations

The results show that improving participation in Horizon Europe requires a combination of national and EU-level measures aimed at strengthening institutional capacity, regional balance, and business engagement. To ensure the recommendations move beyond general analysis, this section outlines practical steps and mechanisms that can be applied by national authorities and relevant institutions.

National level:

- Invest in research infrastructure outside capitals
 - Identifying regional centres of excellence within existing RIS3 priorities and supporting their project offices
 - Developing shared research infrastructure accessible to universities, firms, and public institutions
 - Establishing national co-funding schemes for Horizon Europe projects in regions with weaker absorptive capacity
- Support project preparation (training, mentoring, co-financing)
 - Expanding training and mentoring programmes focused on consortium building and administrative requirements
 - Providing small preparatory grants (seed funding) for concept development, partnership building, and pilot activities
 - Strengthening the role of national contact points and regional innovation centres in project support
- Boost business involvement through targeted incentives and R&D links
 - Introducing fiscal or financial incentives for firms participating in Horizon Europe consortia
 - Supporting joint research teams linking academic laboratories with private companies
 - Establishing sector-specific platforms that identify business needs and connect them with relevant Horizon Europe calls
- Ensure consistent monitoring of the effectiveness of support measures. To guarantee that public support leads to measurable improvements in research capacity, and does not merely reward administrative proficiency, it is essential to systematically evaluate outcomes achieved with allocated resources. This may include:
 - Monitoring project outputs such as publications, patents, partnerships, and regional impact
 - Providing structured feedback loops between funding authorities and project Teams
 - Promoting evaluation models that distinguish genuine scientific or innovation impact from activities focused primarily on proposal administration

EU level:

- Simplify administrative burden of Horizon Europe
 - Further standardisation of reporting tools, closer alignment with national information systems, and broader use of uniform contractual templates
- Target calls to less developed regions
 - Reserving specific calls or introducing preferential conditions such as higher funding rates or additional evaluation points for applicants from structurally weaker areas
- Promote know-how transfer (mentoring, twinning)
 - Strengthening institutional capacity by linking less experienced organisations with leading counterparts through twinning and related instruments

If implemented consistently, these measures can contribute to greater regional balance, more effective use of resources, and stronger national capacity to meet the EU's strategic objectives in research and innovation.

4.3 The Question of Strategic Governance

Low participation efficiency reflects a deeper failure of strategic governance fragmentation, poor coordination, and administrative overload remain unresolved.

Draghi (2024) clearly identifies these issues, but the EU needs more than strategy it needs the will to act. Without accountability and regional inclusion beyond capital hubs, the EU's ambition to be a tech leader will remain rhetorical, not real.

5 Limitations

This study is based on secondary data and a comparative approach, which come with inherent constraints.

5.1 Methodological Limitations

Data are not fully synchronized, Czech and Slovak figures are from 2024, Portuguese only up to 2022/2023. Subnational data vary in detail, limiting comparability.

The quantitative focus cannot capture project quality or long-term impact. Some indicators such as business share are estimates; this reduces precision. A simple descriptive approach was deliberately chosen with regard to the format of the conference paper and the purpose of the comparative analysis.

5.2 Content Limitations

The study focuses solely on HE, excluding other instruments (for instance ERDF, Digital Europe), which narrows the view of national innovation systems.

Strategic documents, including RIS3 and the Draghi report, are used as interpretive frameworks, their actual policy impact may be limited.

Geopolitical aspects (e.g., technological sovereignty, research security) are not addressed; the focus remains on structural and institutional participation in HE.

6 Conclusion

The comparative analysis of the participation of the Czech Republic, Slovakia, and Portugal in the HE program confirmed significant differences in engagement levels, institutional readiness, and the ability to utilize EU instruments for supporting research and innovation. Among the three, the Czech Republic shows the strongest performance, especially in terms of total funding received and the number of participating organizations. Slovakia and Portugal lag behind, each facing different types of structural limitations.

However, the differences are not purely quantitative. The findings emphasize that the ability to benefit from EU framework programs depends less on formal access and more on internal capacity both institutional and human. Successful participation is not merely a result of technical expertise but also of long-term strategy, effective management, and coordination across actors. This interpretation is derived from comparative patterns in funding distribution, institutional structures, and national performance rather than from direct evaluation of project-level practices.

A critical observation is the uneven geographical distribution of research activity. All three countries show a strong concentration of funding in a few metropolitan areas, while regions outside the main centers remain marginal to the innovation system. This imbalance challenges the practical fulfillment of the principles of regional cohesion and smart specialization, frequently emphasized in EU strategies.

Mario Draghi's 2024 report aptly identifies the structural problems of the European innovation framework: fragmentation, slow decision-making, and weak strategic governance. However, it is also worth noting that Draghi, as a long-serving governor of the European Central Bank and briefly as Italian Prime Minister of a founding EU member state, had opportunities to address these systemic weaknesses at a time when they were less acute than today.

If the European Union is to remain competitive with global leaders in research and innovation, it must move from analysis to implementation. This requires strengthening national support structures and deeper reform of the EU framework itself simplifying rules, supporting less-developed regions, and firmly linking strategic goals with concrete actions.

The future of European competitiveness will not be decided solely by the amount of money spent, but by how effectively these resources are managed, shared, and targeted. That is the real test of European innovation policy.

Acknowledgement

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The Intensity and Forms of Collaboration between Czech and Taiwanese universities

Ivo Zdráhal¹, David Bála²

Abstract: Recently, interactions between the Czech Republic and Taiwan in the business, tourism, and academic spheres have intensified following joint efforts by the governments of both countries. The article aims to evaluate the collaboration of Czech universities with their Taiwanese university partners. Specifically, the analyses focus on the intensity and forms of the collaboration and interrogate whether there are patterns regarding the type and size of the Czech universities. Forms of collaboration are defined as exchange of students, exchange of academics and joint projects. The dataset was derived from published long-term plans, internationalisation strategies, action plans, and university websites of 26 Czech public universities. The results indicate that student exchange is the most common form of cooperation between Czech and Taiwanese universities, followed by academic exchange. Joint projects appear to be a challenging and less frequent form of cooperation. Compared to other Czech universities, technical universities cooperate more intensively with Taiwanese partners (in all areas). Large and medium-large sized Czech universities intensively collaborate in all areas with Taiwanese universities. The intensity of collaboration between small and small-medium sized Czech universities and Taiwanese universities is rather low, except of the exchange of students that is moderate. These results can guide the policy makers when designing better internationalisation policies in higher education.

Keywords: higher education, Czech Republic, Taiwan, academic cooperation, universities

JEL Classification: I21, I23, F22

1 Introduction

The internationalisation of universities became a comprehensive global endeavour (Altbach, 2004) that goes beyond mere student mobility (Knight, 2004) and is determined by various internal and external drivers (de Wit, 2002). Despite Taiwan's unique diplomatic status under the One-China policy, recent interactions between the Czech Republic and Taiwan in the business, tourism, and academic spheres have intensified following joint efforts by the governments of both countries. Furthermore, the accompanying wave of Taiwanese investment in the Czech Republic is rapidly positioning Czechia as an important part of an emerging high-tech cluster within the European Union. Such a progression underscores the critical need to analyse the role of academic and research collaboration between the Czech Republic and Taiwan because the successful coupling of economic structures often necessitates local partnerships with universities to facilitate the exchange of knowledge, establish advanced manufacturing and future R&D centres and train of skilled workforce and future industry leaders.

Against this backdrop, the article focuses on understanding the expanding inter-country academic partnership between Czech and Taiwanese universities. The article aims to evaluate the collaboration of Czech universities with their Taiwanese university partners. Specifically, it analyses the intensity and forms of the collaboration and interrogates whether there are patterns regarding the type and size of the (Czech) university. A thorough understanding of these academic linkages is essential for informing public policy, ensuring alignment (among others) with national and European semiconductor strategies, and maximising the mutual benefits derived from high-tech research and talent development.

Collaboration in Education and Research between the Czech Republic and Taiwan

An important milestone in the development of educational and research collaboration between the Czech Republic and Taiwan was the opening of Economic and Cultural Offices, both in Prague in 1991 (Taipei Economic and Cultural Office in Prague, 2025a) and in Taipei in 1993 (Czech Economic and Cultural Office in Taipei, 2025). Given Taiwan's status in the system of international relations, these offices replace the traditional roles and functions of embassies.

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In 2008, a cooperation agreement was signed in Prague between the Czech Science Foundation and the National Science and Technology Council. The goal of this agreement was to establish or increase the level of cooperation in the field of science and research between researchers and institutions of both countries, as well as to enable the exchange of information, skills, and techniques in areas of common interest. The program supports joint Czech-Taiwanese projects in all scientific fields (Czech Scientific Foundation, 2025). The institutional framework for research cooperation was subsequently strengthened in 2010 by a memorandum between the Technology Agency of the Czech Republic and the National Science and Technology Council, focusing on applied research in priority areas such as nanotechnology, ICT, biotechnology, pharmaceuticals, genomic medicine, and digital archiving (Technology Agency of the Czech Republic, 2010). In 2015, the Oriental Institute of the Czech Academy of Sciences established the "Taiwan Center" a branch office at Academia Sinica, to support the exchange of academic staff and Ph.D. students (Oriental Institute, 2025). Furthermore, since 2016, the Project-based Personnel Exchange Program framework has been implemented between the Czech Academy of Sciences and the National Science and Technology Council, aiming to support bilateral scientific cooperation and the exchange of scientific personnel. Especially in the last decade, mutual delegation visits have intensified, and these visits have laid the groundwork for specific agreements and the strengthening of existing partnerships. In 2023, six memoranda were signed under the auspices of the Minister for Science, Research and Innovation (VědaVýzkum.cz, 2022). In 2024, the Czech Centre in Taipei (Czech Centre in Taipei, 2025) was opened, which focuses on promoting Czech culture and language abroad.

In 2024, a memorandum of cooperation between university alliances was signed, ratified by representatives of 13 Czech and 12 Taiwanese universities. The coordinators of this cooperation are Charles University and National Taiwan University. This memorandum covers a wide range of disciplines, including semiconductors, mechanical engineering, advanced technologies, life sciences, agriculture, social sciences and humanities, and arts. Various activities are anticipated, such as student programs, internships, courses, joint research, and cooperation between industry and academia (Czech National Agency for International Education and Research, 2024). These various cooperation activities were further complemented by projects within which the Taiwanese government supports the development of the semiconductor ecosystem in the Czech Republic. Specifically, this involves the Supply Chain Resilience Center (Supply Chain Resilience Center, 2025) at Charles University and the establishment of two "chip academies" (Advanced Chip Design and Research Centers, one in Prague and one in Brno). In January 2025, Charles University and the Taipei Economic and Cultural Office in Prague signed an agreement to establish the "Global Taiwan Chair" position at the Faculty of Arts, Charles University. The goal is to deepen academic and cultural dialogue between the Czech Republic and Taiwan through teaching and research (Taipei Economic and Cultural Office in Prague, 2025b).

Recently, in July 2025, the first Taiwan-Czech Higher Education Forum took place in Taipei. The event was jointly organized by the Foundation for International Cooperation in Higher Education of Taiwan, the Czech National Agency for International Education and Research, and the Czech Economic and Cultural Office in Taipei. The forum was attended by nearly 100 representatives from 51 Taiwanese institutions and 36 representatives from 17 Czech universities. The goal of this event was to deepen mutual cooperation and exchange in the field of higher education between Taiwan and the Czech Republic, and discussions covered the current situation in higher education, emerging development opportunities, industry-academia cooperation, and talent cultivation (StudyinTaiwan, 2025).

2 Methods

The analysis is focused on factors determining the intensity and forms of collaboration of Czech universities with Taiwanese university partners. Scholarly work (e.g. Mok & James, 2005; Choudaha, 2015; Cattaneo et al., 2016; Seeber, 2016; Alhalwaki & Hamdan, 2019; Sahin & Brooks, 2023; De Wit & Altbach, 2023) have unfolded the multi-level determinants of a university's level of internationalisation e.g. organisational factors (e.g. leadership and strategy, faculty engagement or resources and infrastructure), political and regulatory factors (national government policy and funding or geopolitics and diplomacy), economic and market factors (knowledge economy and global labour market, competition for revenues, research funding landscape, Global University Rankings), technological factors (rise of digital communication and online learning platforms), socio-cultural factors (need for intercultural skills, demographics in sending countries), and environmental factors (pandemics). Specifically, the analysis is centred around two hypotheses.

First, the literature on organisation capabilities and learning (Penrose, 1959; Teece, 2019) suggests that developing the capability to engage in international collaboration effectively may be highly difficult and time-consuming and increase costs associated with skills' development and additional labour requirements. Drawing from this earlier work we hypothesise that the size of a Czech university serves as a predictor of its level of engagement in collaborations with

Taiwanese partners, with larger universities showing greater activity. We used the number of enrolled students in the recent period to represent the size of the university.

Second, as mentioned in the introduction, the intensifying relationship between the Czech Republic and Taiwan, coupled with significant Taiwanese investment into an emerging high-tech cluster in Czechia, highlights a critical need for university-industry partnerships. The successful integration of these economic structures—specifically in areas like establishing advanced manufacturing and future R&D centres, and the training of a skilled workforce—demands academic collaboration focused on technical expertise. Given that these specific requirements are the primary domain of technical universities, it is reasonable to hypothesize that Czech technical universities will exhibit a greater intensity of collaboration with Taiwanese academic institutions compared to other types of universities in the Czech Republic. This collaboration is driven by the necessity of matching the educational and research output with the specialized needs of the incoming high-tech Taiwanese investment.

Data and other methodological notes

Unfortunately, there is no database that contains information about the internationalisation activities of Czech universities. Thus, the methodology of data collection for this publication was in the form of secondary data analysis combined with document analysis. The dataset was derived from published long-term plans, internationalisation strategies, action plans, and university websites of 26 Czech public universities: Charles University (47,000 students), Masaryk University (35,000), Palacky University Olomouc (21,000), Czech university of Life Sciences Prague (19,000), Brno University of Technology (19,000), Czech Technical University in Prague (19,000), Technical university of Ostrava (16,000), Prague University of Economics and Business (15,500), University of West Bohemia (11,500), University of South Bohemia in České Budějovice (10,500), Mendel University in Brno (9,500), Tomas Bata University in Zlín (9,400), University of Ostrava (9,000), Jan Evangelista Purkyně University in Ústí nad Labem (8,700), University of Pardubice (8,400), University of Hradec Králové (7,200), Technical University of Liberec (6,600), Silesian University in Opava (5,500), Institute of Technology and Business in České Budějovice (4,000), University of Chemistry and Technology Prague (4,000), University of Veterinary Sciences Brno (3,000), College of Polytechnics Jihlava (2,300), The Academy of Performing Arts in Prague (1,400), The Janáček Academy of Performing Arts (750), Academy of Arts, Architecture and Design in Prague (500), The Academy of Fine Arts in Prague (320).

However, such an approach also has its weaknesses. The primary weaknesses of using document analysis as a research method revolve around issues of availability, bias, and completeness of the documents (Yin, 2016). Researchers are constrained by the documents that are accessible, meaning they often deal with an incomplete picture and may suffer from low retrievability of crucial information. Crucially, documents are often riddled with author or creator bias, reflecting the specific perspective, agenda, or institutional narrative of the originator. Furthermore, the quality and reliability can be uneven, as documents may be incomplete, contain errors, or lack the specific detail required to comprehensively answer a research question, forcing researchers to triangulate their findings with other data sources to ensure validity.

The documents were analysed to identify and measure the intensity and forms of collaboration with Taiwanese university partners. Intensity is defined as a variable indicating whether cooperation occurs or not (yes or no). Thus, it doesn't reveal any quality of collaboration, nor does it reveal intensity in a strict sense (how many students or how many projects?).

The specific forms of collaboration extracted from these documents served as the key variables:

- Exchange of Students
- Exchange of Academics
- Joint Projects

The final step involved a form of systematic evaluation of the gathered data to assess the frequency and presence (intensity) of each collaboration form and the relationship between collaboration intensity and the characteristics of the Czech university (technical vs. other type; size).

3 Research results

Specialisation as a predictor of engagement in collaborations with Taiwanese partners

The collaboration of Czech universities with their Taiwanese university partners was analysed in terms of the area of specialisation to evaluate whether there are any patterns regarding the exchange of students, exchange of academics and

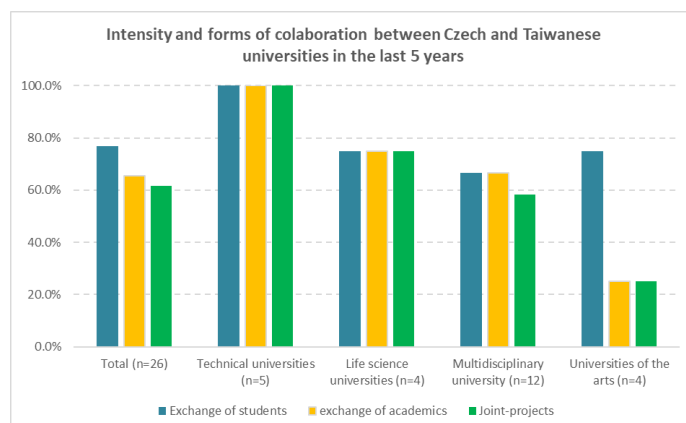
joint projects (Figure 1). Universities were grouped according to their specialisation, and the following four groups were constructed:

- Technical universities: Brno University of Technology, Czech Technical University in Prague, Technical University of Ostrava, Technical University of Liberec, University of Chemistry and Technology Prague,
- Life Science Universities: Czech University of Life Sciences Prague, Mendel University in Brno, University of South Bohemia in České Budějovice, University of Veterinary Sciences Brno,
- Multidisciplinary universities: Charles University, Masaryk University, Palacky University Olomouc, University of West Bohemia, Tomas Bata University in Zlin, University of Ostrava, Jan Evangelista Purkyně University in Ústí nad Labem, University of Pardubice, University of Hradec Králové, Silesian University in Opava, Institute of Technology and Business in Ceske Budejovice, College of Polytechnics Jihlava,
- Universities of Arts: Academy of Performing Arts in Prague, The Janáček Academy of Performing Arts, Academy of Arts, Architecture and Design in Prague, and the Academy of Fine Arts in Prague.

This division captures the prevailing nature of the universities, but it is important to note that these universities often consist of faculties of various specialisations, both technical and non-technical in nature.

Generally, about one fourth (23.1%) of the Czech universities do not have any form of collaboration with any Taiwanese university. The rest of the Czech universities implement with their Taiwanese university partners at least one of the following three internationalisation activities: exchange of students, exchange of academics and joint projects. The student exchange is the most common form of collaboration between Czech and Taiwanese universities (76.9%), followed by academic staff exchange (65.4%) and joint projects (61.5%). The academic staff exchange and joint projects appear to be a challenging and less frequent form of cooperation when compared to the exchange of students.

Figure 1 Intensity and forms of collaboration according to the specialisation of the Czech universities



Source: Own construct based on the collected data

The data show that technical universities collaborate more intensively with Taiwanese partners when compared to life science and multidisciplinary universities and universities of arts. The academic staff exchange and joint projects appear to be a challenging and less frequent form of cooperation when compared to the exchange of students. All analysed technical universities exchange students and faculty and participate in joint projects with Taiwanese university partners. Our results suggest that Czech technical universities exhibit a greater intensity of collaboration with Taiwanese academic institutions compared to other types of universities in the Czech Republic.

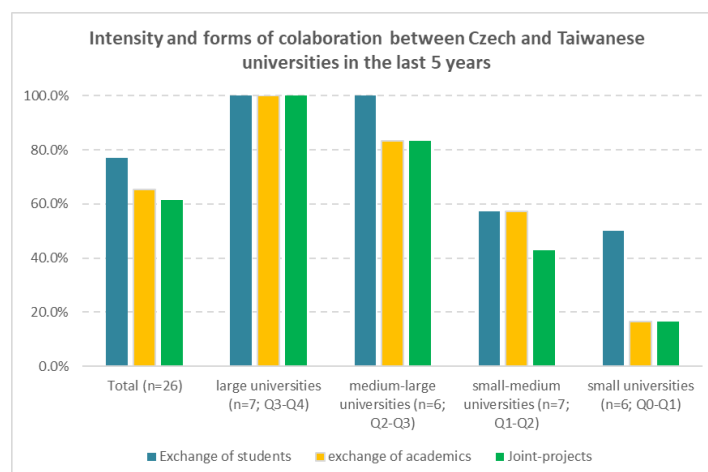
Size as a predictor of engagement in collaborations with Taiwanese partners

The collaboration of Czech universities with their Taiwanese university partners was also analysed in terms of the size of Czech universities (Figure 2). Universities were grouped according to their size (approximated using the total number of enrolled students), and the following four groups were constructed:

- Large universities: Charles University, Masaryk University, Palacky University Olomouc, Czech University of Life Sciences Prague, Brno University of Technology, Czech Technical University in Prague, Technical University of Ostrava,

- Medium-sized to large-sized universities: Prague University of Economics and Business, University of West Bohemia, University of South Bohemia in České Budějovice, Mendel University in Brno, Tomas Bata University in Zlín, University of Ostrava,
- Small-sized to medium-sized universities: Jan Evangelista Purkyně University in Ústí nad Labem, University of Pardubice, University of Hradec Králové, Technical University of Liberec, Silesian University in Opava, Institute of Technology and Business in Ceske Budejovice, University of Chemistry and Technology Prague,
- Small-sized universities: University of Veterinary Sciences Brno, College of Polytechnics Jihlava, The Academy of Performing Arts in Prague, The Janáček Academy of Performing Arts, Academy of Arts, Architecture and Design in Prague, The Academy of Fine Arts in Prague.

Figure 2 Intensity and forms of collaboration according to the specialisation of the Czech universities



Source: Own construct based on the collected data

Results show that large and medium-sized to large-sized Czech universities intensively collaborate with Taiwanese partners in all forms. The intensity of collaboration between small and small to medium-sized Czech universities and Taiwanese universities is rather low, except for the moderate exchange of students. Our results suggest that the size of a Czech university (measured by the number of enrolled students) serves as a predictor of its level of engagement in collaborations with Taiwanese partners, with larger universities showing greater activity. This is in line with studies (Wagner, 2008; McAleer, et al., 2019; Bicak & Taylor, 2020) that positive link between the size of the university and its international activity.

4 Conclusions

This article investigates the expanding academic partnership between universities in the Czech Republic and Taiwan. The central research objective was to evaluate the intensity and forms of the inter-country collaboration specifically within the population of Czech higher education institutions engaged with Taiwanese counterparts. The article contributes to the global knowledge by corroborating the positive link between the size of a university (measured by the number of enrolled students) and its level of engagement in international collaboration activities, with larger universities showing greater activity. It also contributed to the local knowledge (in the context of Czech and Taiwanese relations), providing evidence that technical universities in the Czech Republic collaborate more intensively with Taiwanese partners when compared to other universities.

Policy implication

A thorough understanding of these academic linkages is essential for informing public policy, ensuring alignment (among others) with national and European semiconductor strategies, and maximising the mutual benefits derived from research and talent development. This suggests that larger, more resource-rich universities often serve as the hubs in the global science system. Their scale and established reputation (a proxy for size and quality) allow them to attract and sustain more international partnerships. Policymakers should also consider interventions that support the internationalisation activities of smaller and local Czech universities with Taiwanese partners. Such a policy could help to expand the university collaboration between Czech Republic and Taiwan also in non-technical disciplines as well as it can facilitate knowledge spill-over effects to other regions outside the main educational hubs in the Czech Republic.

Limitations and perspectives of future research

This investigation provides valuable insights based on a university-wide analysis; however, a more granular examination at the faculty level was not feasible within the current scope. Furthermore, the lack of open-source information on certain key metrics necessitated a constrained methodology. Further research should use more extensive triangulation to cross-validating the document analysis findings with data from other sources, such as interviews, observations, or surveys. Therefore, these findings should be considered preliminary, and further research is strongly recommended to validate and expand upon these results by incorporating faculty-level data and seeking alternative data sources. This analysis was limited to the variables reported herein. However, a review of the literature reveals several other factors, including organisational, political and regulatory, economic and market, technological, socio-cultural, and environmental factors, that may influence the outcome and should be integrated into future investigative models.

Acknowledgement

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Artificial Intelligence as a Driver of Innovation and Sustainable Growth in Business and Bioeconomy

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Abstract: The aim of this article is to present the results of a bibliographic and conceptual analysis in the field of artificial intelligence (AI) and business economics, focusing on its impact on innovation, efficiency, and enterprise competitiveness. The analysis is based on recent scientific sources from databases such as Web of Science, Scopus, and Google Scholar, published mainly after 2020. The findings highlight the main research areas: AI as a driver of innovation and productivity, the transformation of business models and cost structures, and the role of AI in sustainable technologies. In recent years, AI has also entered areas that were once considered purely biological. Significant advancements have been achieved in the development and genetic editing of living organisms, particularly yeasts, which play a key role in producing biofuels. These applications illustrate how AI can connect digital and biological innovation, fostering progress in renewable energy and the broader bioeconomy. The results confirm the growing interconnection between AI, innovation management, and sustainable development, underlining the importance of further research on AI integration to strengthen long-term competitiveness and digital transformation of enterprises.

Keywords: artificial intelligence (AI), business economics, innovation, efficiency, bioeconomy, yeast, biofuels, competitiveness, digital transformation

JEL Classification: M21, O33, O44, Q16, Q55

1 Introduction

Artificial intelligence (AI) is rapidly transitioning from a futuristic concept to a fundamental force reshaping the global economic landscape. Its influence is not merely technological but deeply economic, driving new models of value creation, competition, and operational efficiency (Santhosh et al., 2024). As enterprises navigate a volatile economic environment, the strategic integration of AI has become a critical determinant of competitiveness and long-term sustainability (Soni et al., 2020). This transformation is evident across all sectors, fundamentally altering cost structures, enhancing productivity, and enabling unprecedented levels of innovation (Wamba-Taguimdje et al., 2020).

The discipline of business economics itself, traditionally focused on optimizing resource allocation, cost control, and strategic decision-making, is being challenged by these intelligent systems (Bruno, 2024). AI accelerates analytical processes, enhances managerial decisions, and redefines competitive dynamics (Acemoglu & Restrepo, 2018). This shift is influencing the balance between labor and capital, as enterprises transition from labor-intensive models to machine-supported decision ecosystems changing how value is generated and distributed within the firm (Chen et al., 2025).

The impact of AI extends beyond traditional business operations, creating new frontiers in sustainable development (Machucho & Ortiz, 2025). A prime example is the bioeconomy, a sector focused on the sustainable production and conversion of biological resources into value-added products, such as bio-based products or bioenergy (Kisliuk et al., 2023). This paper explores AI's impact on two of the bioeconomy's most critical pillars: agriculture and bioenergy (Zhang, 2023; Wang et al., 2021). In agriculture, systems face mounting pressure from regulations and environmental degradation, creating significant opportunities for AI-based technological solutions (Alexander et al., 2023; Morkūnas et al., 2024; Zhang, 2023). In bioenergy, AI is being applied to optimize complex conversion processes and even in the genetic editing of microorganisms like yeasts to produce novel biofuels (Owusu & Marfo, 2023; Okolie, 2024; Wang et al., 2021). In both domains, AI serves as a powerful enabling technology and a key contributor to global sustainability goals (Mana et al., 2024; Miller et al., 2025), bridging the gap between digital computation and biological innovation.

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This article presents a bibliographic and conceptual analysis of AI's dual role as a driver of innovation in both general business economics and the specific context of the bioeconomy. It aims to map the primary research areas, synthesize key findings, and highlight the growing interconnection between AI, enterprise competitiveness, and sustainable growth.

To ensure a substantive academic contribution and address the identified gaps in the current conceptual literature, the main objective of the article is refined and addressed through the following research questions. These questions serve to structure the conceptual synthesis and focus the discussion on both the general economic implications and the specific sectoral applications of AI in the bioeconomy.

RQ1 (General Impact): How does the adoption of Artificial Intelligence (AI) influence the fundamental concepts of business economics, specifically related to enterprise innovation and efficiency?

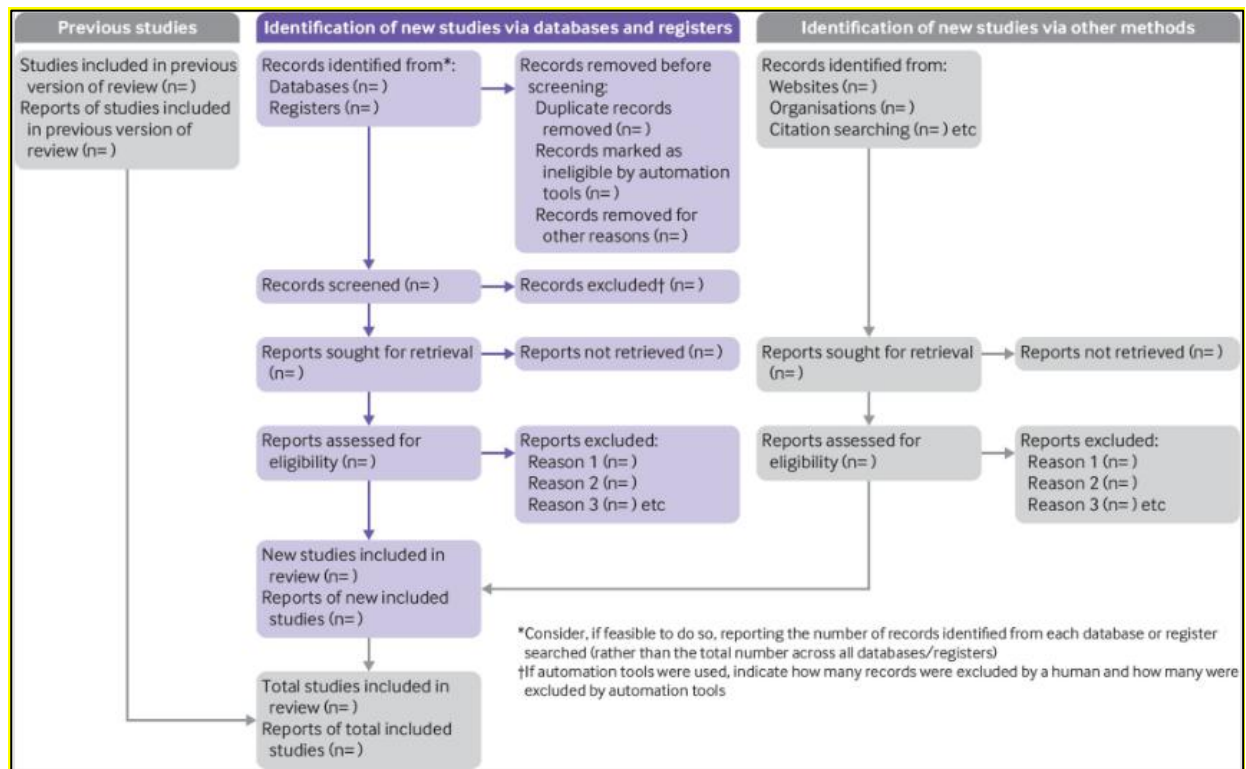
RQ2 (Bioeconomy Application): What are the key technological and economic applications of AI for achieving sustainable growth in the bioeconomy, focusing specifically on agriculture and bioenergy?

2 Methods

This study was conducted as a hybrid conceptual analysis, which synthesizes two distinct but related streams of research: a conceptual thematic analysis focused on business economics (RQ1) and an expert review focused on specific bioeconomy applications (RQ2). The overall methodological approach is the thematic synthesis of these two components, structured based on the core phases of a systematic literature review (identification, screening, eligibility, and synthesis). It is important to note that this study is a qualitative review; no quantitative bibliometric mapping was performed.

The selection of a conceptual review methodology was necessary due to the interdisciplinary nature of the research questions, which span economic theory, innovation management, and applied bioscience. While this study is not a quantitative systematic review or meta-analysis, it strictly adheres to the core reporting principles of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) statement to ensure transparency. This approach allows for the identification of overarching conceptual patterns and underlying mechanisms, thus providing a structured framework for understanding the complex interaction between AI and both general business performance and sectoral sustainability. The process, outlined below, was designed to ensure maximal transparency and replicability of the conceptual synthesis, addressing the need for a rigorous protocol. Fig. 1 PRISMA 2020 flow diagram template illustrates the structured process of literature identification, screening, eligibility assessment, and inclusion applied in this conceptual review (Page et al., 2021). The diagram provides a visual representation of the systematic approach applied in this conceptual synthesis, ensuring transparency and replicability, even though exact numbers of records are not reported. The findings from this conceptual synthesis will be presented in a structured manner according to the research questions (RQ1 and RQ2), ensuring clear linkage between the methodological process and the results.

Fig. 1 PRISMA 2020 flow diagram template for systematic reviews



Source: Page et al. (2021)

Data sources and selection criteria - The methodological approach for each component was distinct. For the primary analysis concerning RQ1 (AI in business economics), the data sources included the scientific databases Web of Science, Scopus, and Google Scholar. The search was systematically limited to peer-reviewed articles and conference papers published primarily after 2020. This timeframe was selected to capture the most recent advancements and impacts of Generative AI and Machine Learning, which have fundamentally altered the business landscape post-2020. The inclusion criteria were defined as: 1) Relevance to both AI and Economic/Management concepts; 2) Publication in a peer-reviewed journal or recognized conference proceeding; 3) Full text availability in English. The search query combined keywords such as: "artificial intelligence" AND "business economics" OR "innovation" OR "firm performance" OR "bioeconomy" OR "biofuel" OR "bioenergy" OR "yeast". The sources for the integrated review on AI in agriculture and biofuels (RQ2) were selected by the co-author based on their direct relevance to sustainability, precision farming, and recent technological advancements. Potential selection bias was mitigated by using multiple, intersecting databases (WoS and Scopus) and applying clear inclusion/exclusion criteria (publication type and date) during the screening process. The specific exclusion criteria were: 1) Studies published before 2020; 2) Editorials, book reviews, or grey literature (e.g., unpublished reports); 3) Articles focusing purely on technical AI implementation without discussing economic or business implications; 4) Studies not available in English.

Data processing - The processing of the corpus followed the SLR framework, resulting in a funnel-like distillation of sources. For the primary analysis (RQ1), the initial database search yielded approximately 150 records (Identification). A rigorous two-step screening followed: first, a title/abstract review led to the exclusion of 78 documents that did not meet discipline or quality criteria. Second, the remaining 72 records were assessed for conceptual relevance, where 57 studies were excluded for being purely technical or outside the conceptual scope. This resulted in a final corpus of 15 core publications selected for full-text review and synthesis for RQ1 (Eligibility and Inclusion). The corpus for the bioeconomy applications (RQ2) was processed independently following similar stringent criteria, focusing on 22 high-impact technical and economic sources. In total, 37 distinct publications were utilized for the final conceptual synthesis of findings (excluding methodological references), ensuring a robust foundation for addressing both research questions.

Analytical tools - The primary analytical tool employed for the literature synthesis was conceptual thematic analysis. This qualitative method involved a systematic, three-stage review process (similar to grounded theory methodology for conceptual analysis). The literature corpus was managed manually, prioritizing intellectual synthesis over automated mapping. First, key findings, concepts, and underlying mechanisms (e.g., data network effect, resource augmentation,

genetic editing, organizational agility, cost structure transformation) from the full text were subjected to open and inductive coding. This phase involved labelling text segments with codes that reflected their content, ensuring that the codes emerged directly from the analysed documents rather than being imposed externally. Second, these initial codes were critically reviewed, compared, and merged based on conceptual similarity. This process led to the formation of overarching conceptual clusters (e.g., AI as a Shift in Production Factors, AI and Sustainability in the Supply Chain) that represent the main research themes presented in the results section. Third, the conceptual clusters were validated against the defined Research Questions (RQ1 and RQ2) to confirm conceptual relevance and ensure that the synthesis effectively addresses the stated research aims. The explanation of how themes were identified and coded, explicitly detailing the inductive nature of the coding process, provides the necessary analytical depth and meets the reviewer's demand for methodological transparency.

Interpretation - The final stage involved the interpretation and conceptual synthesis of the developed clusters from both bodies of literature. This phase involved establishing explicit linkages and contradictions between the themes identified in the business economics stream (RQ1) and the bioeconomy application stream (RQ2). The interpretation focused on mapping the discovered relationships, trends, and future implications, such as confirming the transition from traditional factors of production to data-driven value creation across both fields. This process allowed for the mapping of the main research areas and practical applications connecting AI to general business innovation and specific sustainable development in the bioeconomy. The credibility of the findings rests on the transparency of the thematic synthesis process and the consistency of interpretation across the reviewed literature. The findings from this synthesis are presented in the "Research results" section.

3 Research results

The analysis of recent literature reveals several distinct, yet interconnected, research clusters. The presentation of these findings is structured to directly address RQ1 and RQ2 defined in the Introduction. The primary themes identified are (1) AI as a primary driver of business innovation and productivity, and (2) the application of AI in sustainable growth and the bioeconomy.

AI as a Driver of Business Innovation and Productivity

This research cluster, which represents the primary conceptual cluster derived from the inductive coding of the literature corpus (as detailed in the Methods section), confirms that AI is a fundamental driver of innovation and competitive advantage (Wamba-Taguimdje et al., 2020). Based on the codes related to 'new models of value creation' and 'enhanced managerial decisions', AI accelerates the development of new products and services while enabling firms to identify market opportunities and mitigate risks more effectively (Fu et al., 2025; Babina et al., 2024). Innovation is no longer confined to R&D departments; rather, it becomes embedded in daily operations through machine learning, natural language processing, and predictive analytics (Jia et al., 2024; Santhosh et al., 2024). This aligns with the view that AI innovation management is a key factor in organizational productivity and broader economic growth (Yi & Shirley, 2024). Zuo (2024) notes that AI not only enhances existing business processes but creates entirely new models for value delivery.

This innovation is directly linked to operational efficiency and overall firm performance (Wamba-Taguimdje et al., 2020). Analysis of codes related to 'real-time data feedback' and 'advanced resource allocation' highlights that traditional process optimization is now enhanced by intelligent automation, real-time data feedback, and advanced resource allocation algorithms (Santhosh et al., 2024). Wamba-Taguimdje et al., (2020) found a positive correlation between AI adoption and firm performance, particularly when combined with strong digital leadership. In financial management, AI-driven automation improves forecasting accuracy (Yubo & Ramachandran, 2020), while in manufacturing, it can minimize waste and manage inventory with unmatched precision (Qian & Feng, 2025). This dual impact on both innovation and efficiency represents a significant transformation of cost structures and productivity models (Santhosh et al., 2024; Yi & Shirley, 2024).

However, achieving these gains is not merely a technological challenge; it requires significant organizational adaptation (Machucho & Ortiz, 2025). The conceptual cluster identified recurring challenges related to 'skills shortages', 'ethical considerations', and 'regulatory compliance'. The literature highlights that AI adoption faces hurdles such as skills shortages, ethical considerations, and the need for regulatory compliance (Machucho & Ortiz, 2025). Enterprises must evolve their economic models from linear planning to adaptive, learning-based operations (Santhosh et al., 2024; Soni et al., 2020). This transition from research and innovation to full market deployment demands strong digital leadership and strategic foresight to manage the complex interplay between technological capabilities and organizational transformation (Soni et al., 2020).

At a deeper economic level, this transformation represents a fundamental shift in the factors of production (Acemoglu & Restrepo, 2018). This finding, central to RQ1, emerged from the coding and grouping of concepts concerning 'labour augmentation' and 'automation of cognitive tasks'. AI is altering the traditional balance between labour and capital, automating certain cognitive tasks while augmenting the capabilities of the human workforce (Acemoglu & Restrepo, 2018). This creates a new "production function" where data acts as a key asset and AI as the engine for converting that data into economic value (Chen et al., 2025). This transition to machine-supported decision-making ecosystems and data-driven productivity models is redefining how firms generate value and organizational performance is measured (Chen et al., 2025; Kassa & Worku, 2025).

Ultimately, AI reshapes the very nature of competitive advantage (Bruno, 2024). Consistent findings across the analysed corpus suggest a shift, coded as 'data network effect', away from traditional advantages based on scale or proprietary assets toward advantages based on data, algorithmic sophistication, and organizational agility (Zuo, 2024). Firms that successfully integrate AI are able to learn and adapt faster than their competitors, creating a "data network effect" that strengthens their market position (Bruno, 2024). This creates a dynamic competitive landscape where innovation cycles are shorter, and the ability to leverage intelligent systems becomes a primary determinant of long-term firm growth and survival (Babina et al., 2024; Fu et al., 2025).

To conclude this synthesis for RQ1, the synthesis reveals that AI acts as a holistic catalyst for business transformation (Bruno, 2024). It not only drives top-line growth through innovation (Babina et al., 2024) but also bottom-line performance through efficiency gains (Qian & Feng, 2025). Therefore, the successful integration of AI is less about a single technology and more about a new economic and organizational model (Chen et al., 2025). Moreover, these very principles of data-driven optimization and innovation are now being applied beyond traditional enterprise, serving as the foundation for advancements in sustainable development (Machucho & Ortiz, 2025).

AI in Sustainable Growth and the Bioeconomy

The analytical stream dedicated to RQ2 focuses on how AI-driven innovation extends into the complex biological and economic processes of the bioeconomy, where AI is used to optimize complex biological processes. Beyond the general applications, AI is also being leveraged for highly specific advancements, such as in the genetic editing of microorganisms like yeasts, which are critical for the development of next-generation biofuels. These applications demonstrate AI's capacity to connect digital computation with biological innovation. A cornerstone of the entire bioeconomy, however, remains agriculture, which is the focus of the following literature review. The conceptual review of the agricultural pillar (RQ2) confirms that AI is becoming a pivotal tool for global agricultural transformation.

Kisliuk et al. (2023) claim that the application and transfer of AI in agriculture has grown significantly in recent years. Moreover, AI may contribute to the worldwide agricultural change in response to the Sustainable Development Goals of the United Nations. Alexander et al. (2023) explain that agricultural systems face pressure due to factors including increasing regulations and deteriorating environmental conditions, which is creating opportunities for technological solutions. Similarly, Morkūnas et al. (2024) highlight that development toward innovative technologies is crucial for sustainability and efficiency of agriculture. As noted by Mana et al. (2024), AI is believed to contribute to global sustainability goals in multiple sectors by integrating, installing and retrofitting automated technologies, especially in the incorporation of renewable energy, and is expected to revitalize both new and existing agricultural areas. Zhang (2023) point out that the use of computer and electronics technologies in agriculture allowed farmers to collect relevant data digitally which made it possible to adopt AI technologies to automate this process. Likewise, Miller et al. (2025) claim that the integration of the Internet of Things as well as artificial intelligence has reshaped modern agriculture by providing precision farming, real-time monitoring and data-driven decision making. However, Jabber and Issa (2025) argue that AI technologies has been slowly adopted in agricultural sector because of concerns over unpredictability of AI and the inherent uncertainties within the industry itself. In this context, Hasteer et al. (2024) identify lack of skilled workforce and extreme climatic conditions as key barriers that prevent effective AI adoption in this industry.

Currently, artificial intelligence is being used in many areas of agriculture, such as crop surveillance, irrigation management, disease detection, fertilization techniques, task automation, image manipulation, and data processing, yield forecasting, supply chain optimization, decision support system implementation, weed control and resource optimization (Ahmad et al., 2024). For instance, Kamal et al. (2024) state that digital image processing techniques have been widely used in various AI applications, particularly in agriculture for identifying plant diseases. Furthermore, Rani et al. (2023) explain that AI methods like machine learning and deep learning have been applied in order to detect, predict and design recommendation systems for plant diseases.

In addition to agriculture, agricultural waste is a significant and underutilized resource with the potential to contribute to sustainable bioenergy production, and the use of conversion technologies for these wastes plays a crucial role in the bioenergy process (Egwuatu et al., 2024). In this context, Wang et al. (2021) highlight the potential and capabilities of AI to provide opportunities to advance a new generation of bioenergy and biofuels conversion technologies. Okolie (2024) claim that AI including machine learning has been important in the advancement of biofuel technologies due to its applications in prediction of product yield, optimization of process conditions and initial evaluation of economic and environmental impacts of biomass to biofuel technologies. Likewise, Balakrishnan et al. (2024) consider AI technologies as a drivers of innovation in the biomass energy sector, making an impact in almost all fields of biomass energy, from projecting nearly perfect energy yields to improving complex conversion techniques. According to Damian et al. (2024), Artificial Neural Networks (ANN) is one well-known AI technique that has several benefits for simulating the pre-treatment, fermentation and conversion phases of bioethanol production systems. Thus, AI modelling approaches are crucial for designing, managing, and optimizing bioethanol production (Owusu and Marfo, 2023). Notably, Culaba et al. (2021) believe that using artificial intelligence as a tool improves lignocellulosic biomass biorefineries in terms of decision support, classification, prediction, and optimization.

As noted above, AI including machine learning has been beneficial for many agricultural tasks such as crop health monitoring, yield prediction, price forecasting, yield mapping, problem detection and fertilizer usage optimization (Uzhinskiy, 2023). Pandey and Mishra (2024) also mention several significant advantages provided by AI technologies which include the following: 1) optimization of crop production practices; 2) support for predictive modelling and precision agricultural technologies; 3) improvement of crop monitoring and disease identification; 4) optimization of supply chain operations, storage management, transportation systems and quality assurance processes; and 5) reduction of food loss and waste through post-harvest loss reduction, predictive analytics and smart inventory management. Likewise, Cavazza et al. (2023) claim that AI represents a winning technology to support the key elements of the vertical farm business model, but it must be coupled with other devices such as robots, sensors and drones in order to collect enough data for continuous learning and improvement. In contrast, Hoseinzadeh and Garcia (2024) emphasize the dual nature of AI's impact in agriculture, particularly in greenhouse farming. Their study reveals AI potential in energy reduction, however, its effectiveness in lowering CO₂ emissions and reducing electricity and water usage are marginal in comparison to traditional farming methods. Furthermore, improvements in product quality and profitability achieved through AI are confirmed to be on par with conventional techniques.

To conclude the synthesis for RQ2, the findings demonstrate that AI bridges the gap between digital innovation and biological production. It serves as a critical technology for achieving sustainable growth by optimizing resource allocation and conversion efficiency across agriculture and bioenergy. Therefore, the application of AI in the bioeconomy is identified as a strategic determinant for sectoral sustainability and future competitiveness.

3.1 Summary

The thematic synthesis confirms that the established research clusters directly address the complexity outlined in the Research Questions. RQ1 (General Impact) is comprehensively addressed by the cluster AI as a Driver of Business Innovation and Productivity, which synthesizes the literature on how AI transforms economic fundamentals, productivity models (Acemoglu & Restrepo, 2018; Kassa & Worku, 2025), and competitive strategy (Bruno, 2024; Zuo, 2024). RQ2 (Bioeconomy Application) is covered by the cluster AI in Sustainable Growth and the Bioeconomy, which integrates findings on the role of AI in optimizing resource allocation and managing sustainable technologies in agriculture (Alexander et al., 2023; Miller et al., 2025) and biofuel production (Owusu & Marfo, 2023; Wang et al., 2021). The structured presentation of these findings directly ensures that the paper functions as a substantive academic contribution by providing clear, evidence-based answers to the specified research agenda.

The results of this hybrid conceptual analysis demonstrate that artificial intelligence is a significant driver of change in distinct but related domains. By systematically answering RQ1 and RQ2 through the PRISMA-informed selection process, in general business economics, AI is confirmed as a key enabler of innovation, productivity, and new value-delivery models. This same transformative potential is mirrored in the bioeconomy, where AI is a critical technology for advancing sustainability goals. The literature review highlights two key applications: first, in agriculture, where AI optimizes processes from crop management and disease detection to supply chain logistics, and second, in bioenergy, where AI is used to optimize biofuel conversion processes and manage bioresources. Collectively, these findings illustrate a clear trend: AI is the technological bridge connecting digital innovation with both general economic efficiency and sustainable biological production.

4 Conclusions

This article presented the results of a bibliographic and conceptual analysis on the role of artificial intelligence in business economics and the bioeconomy. Utilizing a rigorous, PRISMA-informed conceptual analysis framework, this study successfully answered the two defined research questions (RQ1 and RQ2). The findings confirm the growing interconnection between AI, innovation management, and sustainable development. The thematic synthesis identified primary research clusters: AI as a driver of enterprise innovation and efficiency (answering RQ1 by detailing the shift in factors of production and competitive dynamics), and AI as a key enabling technology for sustainable growth in the bioeconomy, with specific applications in agriculture and biofuel production (answering RQ2 by mapping technological and economic applications).

The practical implications of these findings are significant. For businesses, AI integration is no longer optional but a strategic imperative for maintaining competitiveness, optimizing cost structures, and enhancing productivity. For the bioeconomy, AI offers powerful tools to address pressing challenges in sustainability, food security, and renewable energy. The review of AI in agriculture and biofuels illustrates how these technologies can lead to more efficient and sustainable practices. The limitations of this study are its conceptual nature, which relies on a synthesis of existing literature rather than new empirical data.

Future research should move beyond conceptual analysis to empirical verification of these trends, particularly within the Central European context. Further studies are needed on the practical barriers to AI adoption, such as skill shortages and uncertainty, especially for SMEs. Additionally, more research is warranted on other facets of the bioeconomy, such as the use of AI in the genetic editing of microorganisms for biofuel production, to strengthen the long-term competitiveness and digital transformation of enterprises.

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Session: Economy Resilience:
Macroeconomic and Microeconomic Perspective

Economic Resilience: The Role of Monetary Policy and Firm Characteristics in Corporate Investment

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Abstract: This study examines how monetary policy influences corporate investment in China, emphasising how firm characteristics shape heterogeneous investment responses. Using a panel of 5,440 firms from 2000 to 2024, we analyse how interest rates, inflation, and firm-level attributes—such as size, leverage, and liquidity—interact to determine capital expenditure decisions. The results show that both interest rates and inflation exert positive and significant effects on investment, reflecting structural features of China’s financial system and firms’ adaptive behaviour under macroeconomic fluctuations. Larger and more leveraged firms invest significantly more, while liquidity has a negative effect, suggesting precautionary savings motives. Subsample regressions reveal meaningful heterogeneity: large firms respond more strongly to interest rates, while small firms face internal financial constraints and show minimal responsiveness to inflation. These insights highlight the importance of firm-level characteristics in understanding monetary transmission and corporate resilience.

Keywords: Monetary policy, corporate investment, firm heterogeneity, China

JEL Codes:

1 Introduction

Corporate investment is a key determinant of economic activity, with movements in capital expenditure contributing significantly to business cycle fluctuations (Bloom, 2014). Governments rely heavily on monetary policy—primarily through interest rate adjustments and credit conditions—to stabilise growth and manage inflation (Clarida, Galí, & Gertler, 1999). Understanding how firms respond to shifts in monetary policy is therefore crucial for anticipating investment patterns and designing effective policy interventions.

The classical neoclassical model establishes a direct relationship between the cost of capital and corporate investment (Jorgenson, 1963). However, empirical macro-level studies often report mixed or weak correlations. A major reason is heterogeneity across firms: aggregate estimates obscure differences between firms based on size, financial structure, dependence on external finance, and other characteristics. The credit channel literature (Bernanke & Gertler, 1995) shows that small, financially constrained firms are more sensitive to monetary tightening than larger firms (Gertler & Gilchrist, 1994; Oliner & Rudebusch, 1996).

As financial markets evolve (Boivin, Kiley, & Mishkin, 2010), the transmission of monetary policy increasingly depends on firm-level behavior. The Chinese context presents a unique laboratory for studying monetary transmission. A significant

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portion of the corporate sector, particularly large firms, consists of state-owned enterprises (SOEs) with soft budget constraints and preferential access to bank credit (Cong, Gao, Ponticelli, & Yang, 2019). This institutional framework suggests that the classical interest rate channel may be blunted or even reversed, as policy tightening could reallocate credit towards these strategically important firms. Consistent with recent evidence on credit misallocation in China (Hsieh & Klenow, 2009), large firms—especially SOEs—benefit from preferential lending conditions that weaken the effectiveness of the traditional interest-rate channel.

This paper contributes by empirically examining how monetary policy affects corporate investment in China and how firm characteristics moderate this effect. The analysis emphasises heterogeneity between large and small firms, providing micro-level insight into macroeconomic resilience.

2 Methodology

2.1. Research Design

The study uses a panel dataset of 5,440 Chinese firms from 2000 to 2024. Firm-level investment is measured using capital expenditure (CAPEX). Monetary policy stance is captured using the benchmark interest rate (IR) and inflation (INF). Firm characteristics include size (SIZE), leverage (LEV), and liquidity (LIQ). Panel data methods allow controlling for unobserved firm-specific heterogeneity (Baltagi, 2021).

2.2. Model Specification

The baseline fixed-effects model is:

$$\text{Equation 1: } CAPEX_{it} = \beta_1 IR_t + \beta_2 INF_t + \beta_3 SIZE_{it} + \beta_4 LEV_{it} + \beta_5 LIQ_{it} + \mu_i + \lambda_t + \epsilon_{it}$$

Where:

- $CAPEX_{it}$ = capital expenditure of firm i at time t
- IR_t = monetary policy interest rate
- INF_t = inflation rate
- $SIZE_{it}$ = log of total assets
- LEV_{it} = total debt / total assets
- LIQ_{it} = current ratio
- μ_i = firm fixed effects
- λ_t = time fixed effects

Macroeconomic variables (IR and INF) vary only across time, while firm characteristics vary across firms and time.

2.3. Monetary Policy Channels

To isolate the effects of individual monetary policy instruments, we estimate separate regressions for the interest rate and inflation channels. These specifications also serve as robustness checks for the baseline model.

(a) Interest Rate Channel

$$\text{Equation 2: } CAPEX_{it} = \beta_0 + \beta_1 IR_t + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \beta_4 LIQ_{it} + \mu_i + \epsilon_{it}$$

(b) Inflation Channel

$$\text{Equation 3: } CAPEX_{it} = \beta_0 + \beta_1 INF_t + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \beta_4 LIQ_{it} + \mu_i + \epsilon_{it}$$

In both cases, firm fixed effects (μ_i) are included to control for time-invariant unobserved heterogeneity. By comparing the size and significance of β_1 across the two channels, we can assess whether interest rates or inflation exert a stronger influence on firms' investment decisions. The empirical results of these models are reported in Table 2 (interest rate channel) and Table 3 (inflation channel).

2.4. Estimation Method

The main specification uses firm and time fixed effects with standard errors clustered at the firm level. For the separate channel regressions and subsample estimations, firm fixed effects are retained, while time effects are excluded where they would fully absorb time-varying macro variables (IR and INF). This avoids perfect collinearity between yearly dummies and macro indicators and allows the identification of monetary policy coefficients.

2.5. Variable Definitions and Descriptive Statistics

Table 1 Variable Definitions and Summary Statistics

Panel A Variable Definitions

Variable	Definition
CAPEX	Capital expenditure of firm i at time t . Measures investment activity (dependent variable).
IR	Benchmark monetary policy interest rate at time t (macro variable).
INF	Inflation rate at time t , included as an alternative monetary policy indicator.
SIZE	Natural logarithm of total assets of firm i at time t . Proxy for firm size.
LEV	Total debt divided by total assets for firm i at time t . Measures leverage.
LIQ	Current ratio (current assets $\div$ current liabilities) for firm i . Measures liquidity and short-term financial strength.

Source: Author's own definitions based on firm-level data from the China Stock Market & Accounting Research (CSMAR) database and Compustat, and macroeconomic data from the People's Bank of China (PBOC), the World Bank, the International Monetary Fund (IMF), and the National Bureau of Statistics of China (NBS).

Note: This table reports the definitions of variables used in the empirical analysis

Panel B Summary Statistics

Variable	Mean	Std. Dev.	Min	25%	50%	75%	Max	N
CAPEX	644.825	5322.574	-56.226	25.865	84.833	260.758	319,686.000	81,180
IR	4.9749	0.8269	4.350	4.350	4.350	5.600	7.470	88,483
INF	1.9837	1.4824	-0.73197	0.9810	1.9736	2.6195	5.9253	88,483
SIZE	7.9160	1.6951	-2.9759	6.8359	7.7313	8.7775	17.7037	88,217
LEV	0.2038	2.2334	0.0000	0.0324	0.1483	0.2907	459.8789	88,217
LIQ	0.2070	0.1689	0.0000	0.0851	0.1647	0.2894	1.0000	88,217

Source: Author’s own calculations based on firm-level data from the China Stock Market & Accounting Research (CSMAR) database and Compustat (2000–2024), and macroeconomic data from the People’s Bank of China (PBOC), the World Bank, the International Monetary Fund (IMF), and the National Bureau of Statistics of China (NBS).

Note: This table reports summary statistics for the main variables used in the empirical analysis.

3. Results

3.1. Main Model (Baseline Regression)

The baseline fixed-effects regression results are reported in Table 2. The interest rate (IR) enters with a positive and statistically significant coefficient ($\beta = 43.626$, $p < 0.01$). This implies that, on average, increases in the policy interest rate are associated with higher levels of corporate investment. Although counterintuitive in standard macroeconomic settings, this positive response is consistent with institutional features of the Chinese financial system, where tighter monetary conditions do not necessarily restrict credit to all firms equally. Instead, credit may be reallocated toward larger, state-affiliated, or strategically important firms, allowing aggregate investment to rise even in periods of higher rates.

Inflation (INF) also has a positive and significant effect ($\beta = 23.734$, $p < 0.01$), indicating that price-level movements carry information relevant for firms' investment decisions at the aggregate level. Firm-specific characteristics remain important determinants of investment: SIZE has a large positive effect ($\beta = 468.756$, $p < 0.01$), suggesting significant scale economies in investment capacity; LEV is positive and significant ($\beta = 10.690$, $p < 0.01$), indicating that more leveraged firms tend to invest more; and LIQ is negative and significant ($\beta = -506.604$, $p < 0.01$), which is consistent with firms holding higher liquidity buffers reducing long-term capital expenditure.

Overall, the results highlight that both monetary policy and firm-level characteristics play a significant role in shaping corporate investment decisions, with policy variables influencing investment through the broader macroeconomic environment, while firm-specific factors capture differences in internal resources and financing constraints.

Table 2. Baseline Fixed-Effects Regression Results

Variable	Coefficient	Std. Error	t-Statistic	p-Value	95% CI (Low)	95% CI (High)
IR	43.626	15.609	2.795	0.005	13.032	74.220
INF	23.734	6.937	3.421	0.001	10.137	37.331
SIZE	468.756	11.394	41.140	0.000	446.423	491.089
LEV	10.690	3.962	2.698	0.007	2.925	18.456
LIQ	-506.604	77.637	-6.525	0.000	-658.773	-354.435

Source: Author’s own calculations based on firm-level data from the China Stock Market & Accounting Research (CSMAR) database and Compustat (2000–2024), and macroeconomic data from the People’s Bank of China (PBOC), the World Bank, the International Monetary Fund (IMF), and the National Bureau of Statistics of China (NBS).

Note: This table reports baseline fixed-effects regression results. Standard errors are reported in parentheses. The dependent variable is capital expenditure (CAPEX).

3.2. Robustness Checks:

3.2.1. Interest Rate Channel

$$\text{CAPEX}_{it} = \beta_0 + \beta_1 \text{IR}_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 \text{LEV}_{it} + \beta_4 \text{LIQ}_{it} + \mu_i + \varepsilon_{it}$$

Table 3. Regression Results – Interest Rate Channel

Variable	Coefficient	Std. Error	t-Statistic	P-value	Significance
IR	65.815	14.199	4.635	0.000	***
SIZE	469.99	11.389	41.266	0.000	***
LEV	10.694	3.962	2.699	0.007	***
LIQ	−510.20	77.636	−6.572	0.000	***

Source: Author’s own estimations based on firm-level data from the China Stock Market & Accounting Research (CSMAR) database and Compustat, and macroeconomic data from the People’s Bank of China (PBOC), the World Bank, the International Monetary Fund (IMF), and the National Bureau of Statistics of China (NBS).

Note: This table reports fixed-effects regression results for the interest rate channel. The dependent variable is capital expenditure (CAPEX). Firm and year fixed effects are included. Standard errors are clustered at the firm level. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

As a robustness test, the model was re-estimated using only the interest rate as the monetary policy variable, excluding inflation. The results in table 3 remained consistent with the main model, confirming the robustness of the findings. The interest rate displayed a positive and statistically significant relationship with corporate investment ($\beta = 65.82$, $p < 0.01$).

This result suggests that higher interest rates are associated with increased capital expenditure among firms, which may reflect the presence of profitable investment opportunities that outweigh the cost of borrowing. It could also indicate that firms anticipate future economic expansion when interest rates rise moderately, prompting them to invest in capacity and growth. However, this interpretation should be treated cautiously, because the interest rate may be endogenous to investment activity, particularly in an economy where monetary policy reacts to underlying demand conditions

Firm-specific variables behaved as expected. Firm size (SIZE) remained strongly positive, implying that larger firms are better positioned to invest due to their financial capacity and economies of scale. Leverage (LEV) was positive and significant, supporting the notion that debt plays a complementary role in financing investment activities. Liquidity (LIQ), however, was negative and significant, suggesting that firms with higher liquidity levels may adopt a more cautious investment strategy, preferring to retain cash rather than engage in long-term capital projects.

Overall, these results demonstrate that the influence of firm characteristics on investment remains stable, while monetary policy—proxied by the interest rate—continues to play a relevant but complex role in shaping firms’ investment behaviour in China.

3.2.2. Inflation Channel

$$CAPEX_{it} = \beta_0 + \beta_1 INF_t + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \beta_4 LIQ_{it} + \mu_i + \varepsilon_{it}$$

Table 4. Regression Results – Inflation Channel

Variable	Coefficient	Std. Error	t-Statistic	p-Value	95% Confidence Interval
INF	31.790	6.310	5.038	0.000	[19.422, 44.159]
SIZE	452.140	9.720	46.516	0.000	[433.090, 471.190]
LEV	10.355	3.960	2.615	0.0089	[2.593, 18.117]
LIQ	-499.130	77.595	-6.433	0.000	[-651.210, -347.040]

Source: Author's own estimations based on firm-level data from the China Stock Market & Accounting Research (CSMAR) database and Compustat, and macroeconomic data from the People's Bank of China (PBOC), the World Bank, the International Monetary Fund (IMF), and the National Bureau of Statistics of China (NBS).

Note: This table reports fixed-effects regression results for the inflation channel. The dependent variable is capital expenditure (CAPEX). Firm and year fixed effects are included. Standard errors are clustered at the firm level.

As a robustness check, the regression model was re-estimated by replacing the interest rate with the inflation rate as the main monetary policy variable. The results remained consistent with the baseline model, indicating the stability of the findings. Inflation (INF) exhibited a positive and statistically significant relationship with corporate investment ($\beta = 31.79$, $p < 0.01$). This suggests that during periods of rising inflation, firms tend to increase their investment spending, possibly as a response to the anticipated rise in nominal revenues or as a strategy to hedge against the declining real value of money. This finding aligns with earlier empirical studies which argue that moderate inflation can stimulate investment by improving firms' profitability expectations and reducing the real burden of debt.

Firm-level variables also maintained their expected signs and significance. Firm size (SIZE) remained strongly positive, indicating that larger firms are more capable of undertaking investment projects due to their access to internal funds and credit markets. Leverage (LEV) was positively related to investment, implying that firms use debt as a means of financing growth opportunities, consistent with the pecking order and trade-off theories of capital structure. In contrast, liquidity (LIQ) showed a negative relationship with investment, suggesting that firms with higher liquid assets may prefer to hold cash or engage in short-term financial activities rather than committing funds to long-term capital expenditure.

Overall, the robustness results reinforce the reliability of the main regression findings. The persistence of the coefficients' signs and significance levels across model specifications indicates that the relationship between monetary policy variables, firm characteristics, and corporate investment is stable and not sensitive to changes in the macroeconomic indicator used.

3.3. Subsample Regression: Large Firms

Table 5. Subsample Regression Results — Large Firms

Variable	Coefficient	Std. Error	t-Statistic	p-Value
IR	241.890	45.581	5.307	0.000
INF	60.858	31.664	1.922	0.0546
SIZE	1657.800	177.270	9.352	0.000
LEV	-444.150	328.900	-1.350	0.177
LIQ	-1034.200	218.180	-4.740	0.000

Source: Author's own estimations based on firm-level data from the China Stock Market & Accounting Research (CSMAR) database and Compustat, and macroeconomic data from the People's Bank of China (PBOC), the World Bank, the International Monetary Fund (IMF), and the National Bureau of Statistics of China (NBS).

Note: This table reports fixed-effects regression results for the subsample of large firms. The dependent variable is capital expenditure (CAPEX). Firm and year fixed effects are included. Standard errors are clustered at the firm level.

Table 5 presents the regression results for the subsample of large firms, defined as firms with SIZE above the sample median. The interest rate remains strongly positive and highly significant ($\beta = 241.890$, $p < 0.01$). The magnitude of this effect is far larger than in the baseline model, indicating that large firms respond disproportionately to interest-rate movements. This pattern is consistent with China's institutional environment, where large firms—especially SOEs and firms with privileged access to regulated credit—continue to receive financing during periods of monetary tightening. As a result, their investment activity remains robust even when borrowing costs rise, reflecting preferential credit channels and softer budget constraints.

Inflation (INF) enters the model with a positive but only marginally significant coefficient ($\beta = 60.858$, $p = 0.0546$). This suggests that price-level dynamics exert, at best, a weak influence on large-firm investment, and the effect is not statistically robust. Firm size (SIZE) shows an extremely large and highly significant effect ($\beta = 1657.800$, $p < 0.01$), confirming that even within the group of large firms, scale differences remain a dominant determinant of investment behaviour. Liquidity (LIQ) is negative and significant ($\beta = -1034.200$, $p < 0.01$), indicating that firms with greater cash reserves invest less—possibly due to conservative financial management or the availability of fewer profitable investment opportunities. Leverage (LEV) is negative but statistically insignificant, suggesting that debt levels do not materially constrain investment for large firms, consistent with their stronger financial positions and stable access to credit markets.

Overall, these results indicate that large firms display strong resilience to monetary policy tightening. Their investment behaviour is driven less by macroeconomic constraints and more by internal characteristics—particularly scale and liquidity. Combined with the weaker responses observed among small firms, these findings demonstrate that large firms are the primary contributors to the strong positive interest-rate effect identified in the baseline regression.

3.4. Subsample Regression: Small Firms

Table 6. Subsample Regression Results — Small Firms

Variable	Coefficient	Std. Error	t-Statistic	p-Value
IR	10.124	0.6566	15.418	0.000
INF	0.3646	0.2332	1.563	0.118
SIZE	40.969	0.9702	42.229	0.000
LEV	0.6791	0.1209	5.619	0.000
LIQ	-38.272	3.4024	-11.249	0.000

Source: Author’s own estimations based on firm-level data from the China Stock Market & Accounting Research (CSMAR) database and Compustat, and macroeconomic data from the People’s Bank of China (PBOC), the World Bank, the International Monetary Fund (IMF), and the National Bureau of Statistics of China (NBS).

Note: This table reports fixed-effects regression results for the subsample of small firms. The dependent variable is capital expenditure (CAPEX). Firm and year fixed effects are included. Standard errors are clustered at the firm level.

Table 6 reports the results for the subsample of small firms. The interest rate continues to exhibit a positive and highly significant coefficient ($\beta = 10.124$, $p < 0.01$), but the magnitude is far smaller than for large firms. This indicates that small firms are much less responsive to interest-rate movements, reflecting financing constraints, limited collateral, and weaker banking relationships that restrict how monetary tightening or easing affects their investment capacity. Inflation (INF) is positive but statistically insignificant ($\beta = 0.3646$, $p = 0.118$), suggesting that price-level changes do not meaningfully influence investment behaviour among small firms.

Firm size (SIZE) remains strongly positive and significant even within this subsample ($\beta = 40.969$, $p < 0.01$), meaning that relatively larger small firms invest more than their smaller counterparts. Leverage (LEV) is positive and significant ($\beta = 0.6791$, $p < 0.01$), implying that access to debt financing is an important driver of investment for smaller firms. Liquidity (LIQ) is negative and highly significant ($\beta = -38.272$, $p < 0.01$), reinforcing the idea that firms with greater cash reserves prefer to maintain precautionary liquidity buffers rather than commit to long-term capital expenditure.

Overall, these results demonstrate that small firms are primarily constrained by their internal financial structure, with monetary policy variables playing only a limited role in shaping their investment decisions. This helps explain why the strong positive interest-rate effect observed in the baseline regression is driven largely by the behaviour of large firms.

3.5. Heterogeneity in Monetary Policy Transmission

The stark contrast in how large and small firms respond to economic variables, as detailed in Tables 5 and 6, is powerfully visualized in Figure 1. The coefficient comparisons reveal that the interest rate channel of monetary policy is overwhelmingly driven by large firms.

As shown in Figure 1(a), the coefficient on the interest rate for large firms is many times larger than that for small firms shown in Figure 1(b), underscoring the profound heterogeneity in the monetary transmission mechanism. This visual evidence strongly supports the hypothesis that large firms, often with preferential access to credit, maintain investment during tightening cycles.

Furthermore, the figures highlight how firm characteristics exert different influences across the two groups. The effect of firm size (SIZE) itself is vastly larger in the large firm subsample (Figure 1(a)), indicating strong scale economies, while the negative effect of liquidity (LIQ) is a dominant and consistent feature for both groups (Figure 1(a) and 1(b)), aligning with precautionary savings motives.

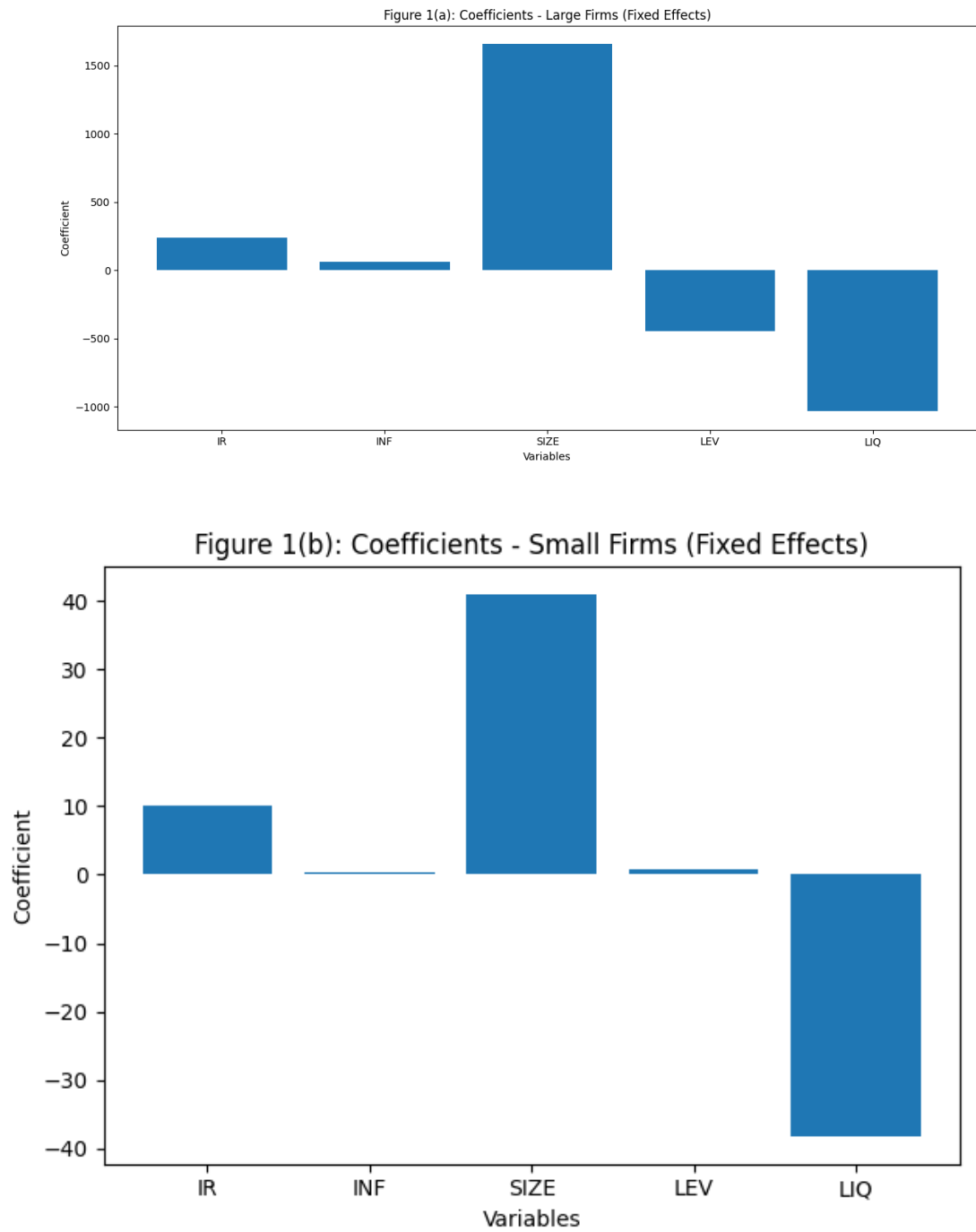


Figure 1. Coefficient Comparison between Large and Small Firms. 1(a) Large firms show strong sensitivity to monetary policy and firm characteristics. 1(b) Small firms exhibit much weaker responses, driven primarily by internal financial constraints.

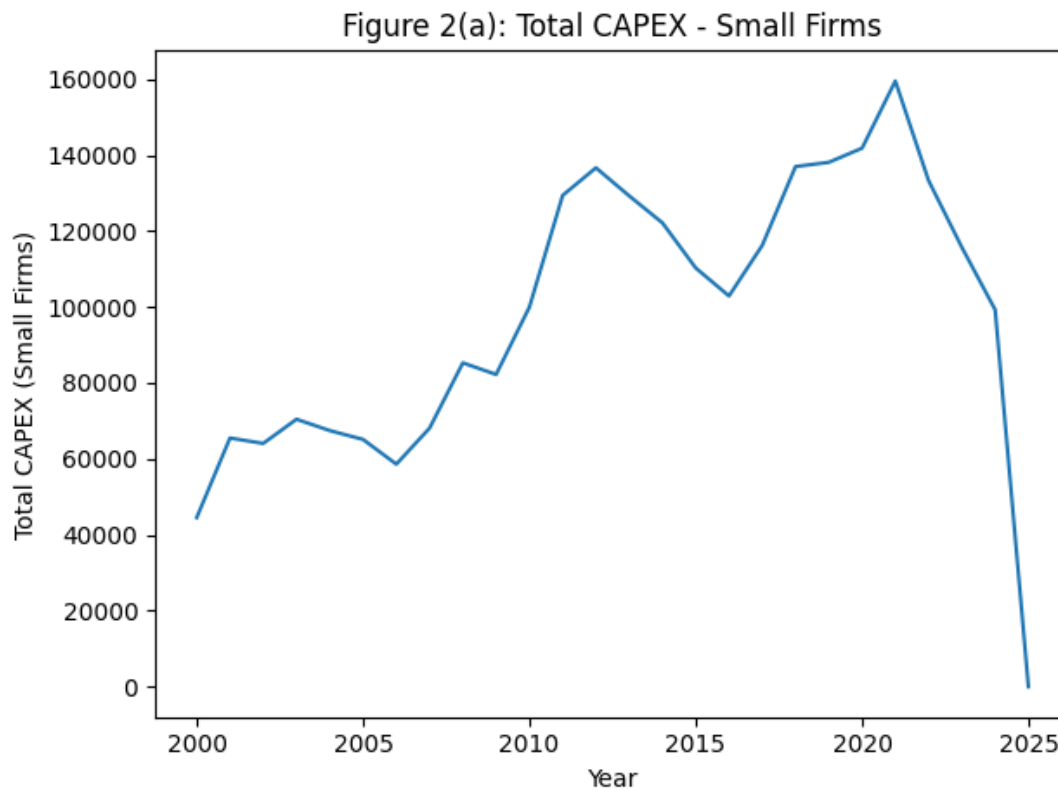
3.6. Trends in Capital Expenditure (CAPEX), 2000-2024.

The firm-level regression results find clear expression in the aggregate investment patterns of the Chinese economy, as depicted in Figure 2. A striking duality emerges between small and large firms.

As shown in Figure 2(a), the aggregate capital expenditure (CAPEX) of small firms exhibits a low but remarkably stable trajectory over time, devoid of dramatic spikes. This is further reflected in the low and smooth average CAPEX of small firms (see Appendix A), which suggests they invest at a stable but modest rate per firm due to persistent financing constraints. This visual evidence confirms that small firms are not the engine of aggregate investment fluctuations and that macro policy does not drastically alter their investment behaviour, directly corroborating the weak monetary policy coefficients found in our regressions.

In stark contrast, Figure 2(b) reveals that large firms dominate the economy's total investment dynamics, exhibiting pronounced CAPEX fluctuations. The pronounced spikes in their investment align closely with periods of government macro-stimulus, infrastructure expansion waves, and preferential lending policies. This pattern of aggressive investment expansion during both easy and tight monetary conditions provides visual, aggregate-level validation for the strongly positive interest-rate coefficient identified in our large-firm subsample regressions.

Together, these trends validate the central conclusion of this paper: the corporate investment landscape in China is a tale of two sectors. Monetary policy and aggregate investment dynamics are primarily a large-firm phenomenon, while small firms operate in a separate, financially constrained regime.



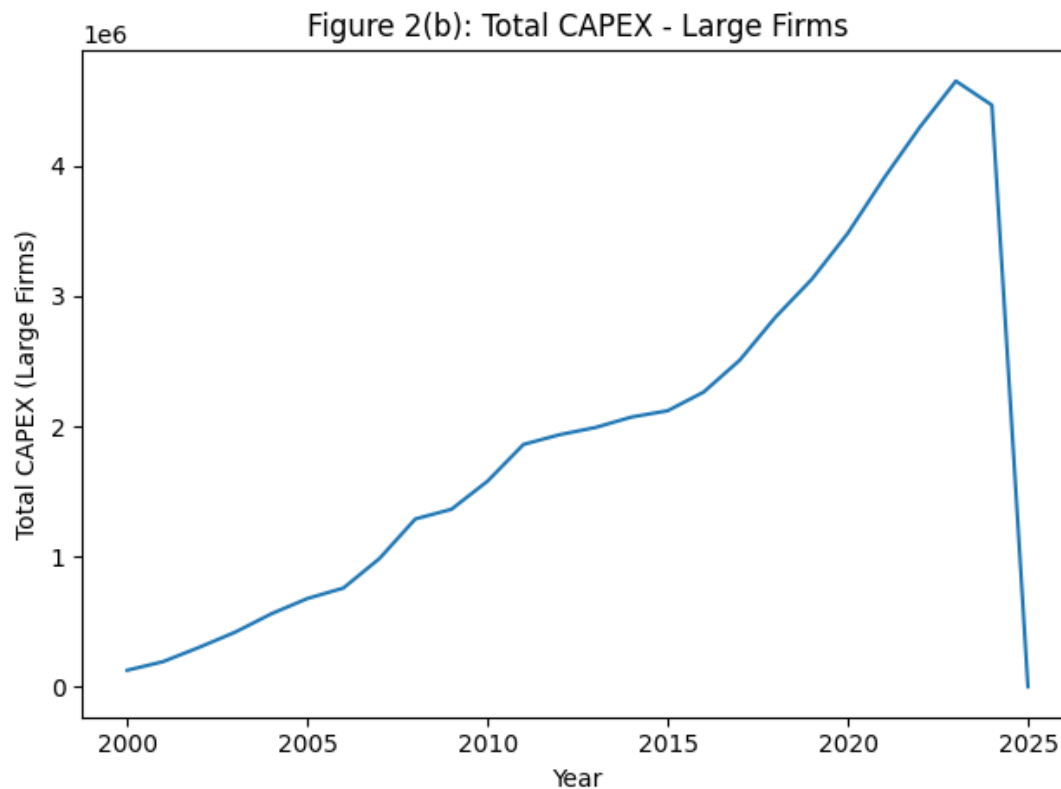


Figure 2. Aggregate Investment Trends by Firm Size. 2(a) Total CAPEX of small firms shows stable, low-volatility investment consistent with financial constraints. 2(b) Total CAPEX of large firms dominates aggregate investment with pronounced CAPEX fluctuations, corresponding to policy-driven cycles.

This visual stability is consistent with the regression findings, which show that although small firms do respond to monetary policy, the magnitude of their response is modest and therefore less visible in aggregate CAPEX patterns.

4 Discussion

The empirical results reveal a clear pattern of heterogeneity in how monetary policy affects corporate investment in China. While the baseline fixed-effects model shows that both interest rates and inflation are positively associated with capital expenditure, the subsample regressions demonstrate that these aggregate relationships mask substantial variation across firms.

4.1. Interest Rate Channel and Firm Size Asymmetry

The interest rate channel operates very differently across firm sizes. Large firms exhibit a strong positive response to interest-rate movements, consistent with their preferential access to bank credit, the presence of implicit guarantees, and generally softer budget constraints. These institutional advantages allow large firms to maintain or even expand investment during periods of monetary tightening, since credit allocation tends to remain favourable for them. In contrast, small firms display only a modest positive response to interest-rate changes, reflecting much tighter financial constraints, limited collateral, and greater reliance on internal funding sources. These differences indicate that the aggregate impact of interest rates on investment is shaped disproportionately by the behaviour of large firms.

4.2. Inflation Channel and Aggregate vs. Firm-Level Dynamics

Inflation is significant in the aggregate regression but loses significance entirely when the sample is divided by firm size. This pattern suggests that the inflation–investment relationship observed in the baseline model does not reflect a systematic behavioural mechanism at the firm level. Instead, the aggregate inflation effect may be capturing broader macroeconomic conditions—such as demand expectations or policy signals—that correlate with investment. Once firm heterogeneity is considered, inflation does not appear to directly influence capital expenditure for either small or large firms, indicating that price-level dynamics play a limited role in firm-level investment decisions.

4.3. Role of Firm Characteristics in Monetary Transmission

Firm-level characteristics meaningfully shape investment responses. Size consistently has a positive effect across all models, reflecting economies of scale, improved access to financing, and greater capacity to absorb risk. Leverage matters primarily for small firms, suggesting that access to external finance becomes a constraint mainly for financially weaker firms. Liquidity is negative and significant in every specification, implying that firms with larger cash reserves tend to behave cautiously, prioritizing liquidity buffers over long-term capital commitments. This pattern is consistent with firms operating under financial frictions, especially where future uncertainty is high.

4.4. Implications for Monetary Transmission in China

Taken together, the results indicate that monetary policy does not transmit uniformly across the corporate sector. The positive interest-rate effect observed in the baseline regression is driven disproportionately, though not exclusively, by large firms, whose preferential access to credit enables them to sustain investment even when borrowing costs rise. Large firms, particularly those with privileged access to the banking system, are the primary drivers of the positive interest-rate–investment relationship observed in aggregate data. Small firms remain financially constrained and are less responsive to macroeconomic policy signals, reducing their contribution to monetary transmission.

These findings carry several important policy implications. First, a monetary policy framework that relies heavily on aggregate tools such as interest-rate adjustments may reinforce existing structural advantages for large firms while having limited influence on smaller ones. Second, improving the transmission of monetary policy to small firms may require complementary measures, such as targeted SME credit facilities, credit guarantees, or differentiated reserve requirements. Finally, the presence of size-dependent transmission suggests that policymakers should consider firm heterogeneity when evaluating policy effectiveness and designing tools that promote more balanced investment behaviour across the economy.

5. Conclusion

This paper has examined how monetary policy and firm characteristics shape investment behaviour in China. The results show that both interest rates and inflation are positively associated with corporate investment, a pattern that departs from standard theoretical predictions. This finding reflects China’s institutional environment, where large and strategically important firms often continue to invest despite tighter monetary conditions, supported by preferential credit allocation, implicit guarantees, and expectations of strong nominal demand.

Firm characteristics play a central role in moderating these effects. Larger and more leveraged firms invest more aggressively, while higher liquidity is associated with reduced capital expenditure, consistent with precautionary motives in financially constrained settings. The subsample analysis highlights substantial heterogeneity: large firms account for

most of the positive aggregate response to monetary policy, whereas small firms—more financially constrained and reliant on internal funds—show limited sensitivity to inflation and only a modest response to interest-rate movements.

We recognise some important limitations. The positive correlation between interest rates and investment may partly reflect policy endogeneity, as the central bank may adjust rates in response to strong investment-led growth. While fixed effects mitigate some of these concerns, the results should be interpreted as robust correlations rather than strictly causal effects. Measurement error in capital expenditure (CAPEX) reporting may also introduce noise into firm-level estimates, and the macroeconomic variables (interest rate and inflation) are not firm-specific, which may understate variation in financial conditions across sectors.

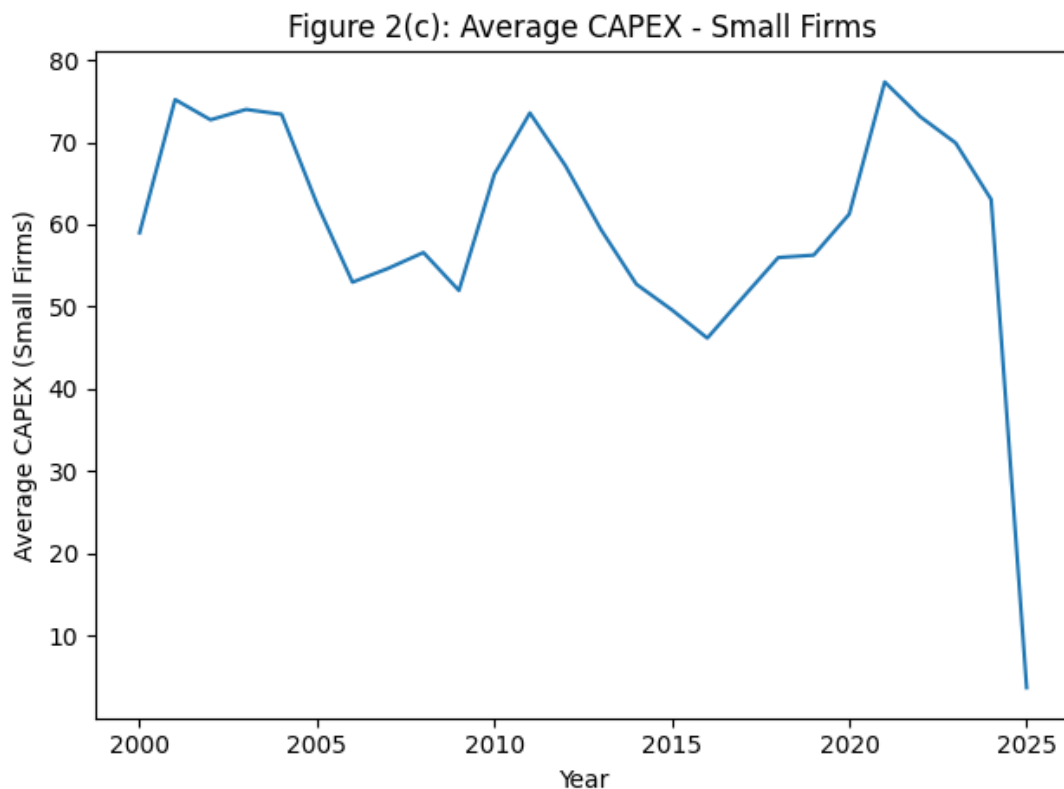
Despite these limitations, the findings clearly indicate that monetary policy in China is transmitted unevenly across the corporate sector. Large firms disproportionately shape the aggregate investment response, while small firms remain constrained primarily by internal financial factors rather than macroeconomic policy signals. These results underscore the need for policymakers to consider firm heterogeneity when evaluating the effectiveness of monetary policy. A more targeted policy framework—one that accounts for differences in credit access and financial resilience—may enhance the transmission of monetary policy and support more balanced investment behaviour across the economy.

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Appendix A. Additional Figures



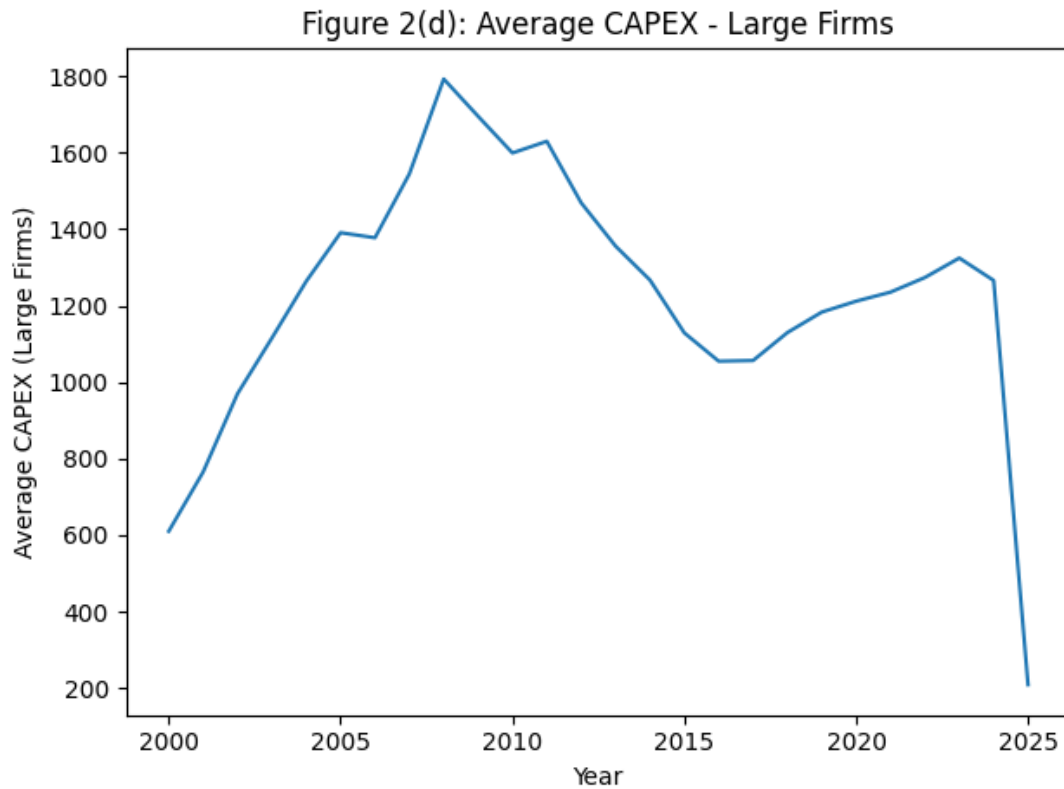


Figure A1. Average Capital Expenditure (CAPEX) per Firm.

- (a) Average CAPEX for small firms is smooth and low, confirming persistent financing constraints and stable, modest investment rates per firm.
- (b) Average CAPEX for large firms is higher and shows clear cyclicalities, indicating strong responsiveness to monetary policy, credit expansions, and external shocks at the firm level.

Figures 2(c) and 2(d) show a relatively smooth and stable pattern in the CAPEX of small firms over time. This visual stability is consistent with the regression findings, which indicate that although small firms respond to monetary policy, the magnitude of their response is modest and therefore less visible in aggregate CAPEX trends.

Economic Drivers of Sustainability in the Textile Industry

Pavla Herclíková¹, Martina Novotná², Tomáš Volek³

Abstract: The economic drivers of today's enterprises include the efficient use of resources (natural and other), while maintaining good economic results. This perspective is essential today for maintaining corporate competitiveness within the industry and internationally. This paper focuses on assessing the relationship between economic value added (EVA) and resource productivity. The textile industry is one of the most resource-intensive and globally interconnected industries. This industry is also facing growing pressure to integrate sustainability. An empirical analysis of companies in the textile industry in the Czech Republic has shown that companies with positive economic value added (EVA) not only achieve higher profitability but also exhibit a more sustainable long-term management style, as measured by resource productivity. Although average resource productivity values indicate different levels depending on EVA creation, this fact could not be statistically confirmed.

Keywords: Economic value added, companies, resource productivity, textile industry

JEL Classification: D24, E23, G01

1 Introduction

The textile industry is one of the most resource-intensive sectors in the global economy. High consumption of water, energy, and chemicals, extensive greenhouse gas emissions, and waste generation are common features of the manufacturing process. At a time when environmental regulations are tightening, consumer preferences are shifting toward sustainable products, and investors are placing increasing emphasis on environmental, social, and governance (ESG) criteria, companies in the textile sector are facing growing pressure to integrate sustainability not only as a mandatory component of compliance, but as a strategic element of their business activities. Reducing overproduction in the textile industry is inevitable. The textile industry, including the clothing industry, must start moving towards sustainability and adopt circular solutions. For companies in the textile industry, an effective solution may be to transition to a circular economy model that takes into account all stages of the production cycle – from working with renewable resources to providing transparent information to customers. The main effort is to implement sustainability criteria for textile production, but also to improve textile waste collection, sorting, and more efficient recycling. These activities are supported, for example, by the EU's LIFE grant program, whose subprogram "Circular Economy and Quality of Life" focuses precisely on "Improving the traceability of exports of used textiles/textile waste and improving the recycling of textile waste within the EU."

Existing research highlights various dimensions of sustainability: environmental (emission reduction, resource consumption, waste management), social (working conditions, fair wages), and economic, which in many cases is considered a barrier but also a key driver of change. Economic factors such as profitability, productivity (Blažková et al., 2020), input costs, innovation investment, and access to finance are key to understanding why and how companies are transitioning to more sustainable operations. This paper focuses on the economic drivers of sustainability in the textile industry. The analysis focuses on how they affect the economic performance of companies (profitability, productivity, costs). Although there is evidence of a positive relationship between sustainable innovation and the economic performance of textile companies, research still faces several limitations. There is a lack of uniform methodological approaches to measuring the economic benefits of sustainability, short-term analyses predominate, and most studies focus on selected regions (Dušek, 2018) outside Central Europe. Differences between small and large enterprises, the impact of financing availability, and the specifics of local markets are also insufficiently taken into account. Resource productivity is a basic indicator for assessing the efficiency of resource productivity.

Resource productivity is usually defined as the ratio of economic output to material and energy inputs. It is a key metric for assessing the "decoupling" of economic growth from raw material consumption. Higher material productivity, or

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resource productivity in general, indicates that a company or industry is creating more value with less input consumption, which is the goal of policies aimed at a circular economy (Setek et al., 2025) and sustainable growth. Empirical work at the country and sector levels shows that improvements in material productivity are consistently associated with increased competitiveness and better macroeconomic performance, with methodological approaches varying in the measurement of inputs and outputs (Flachenecker & Kornejew, 2018; Özbuğday et al., 2020).

There is growing empirical evidence that investments in increasing resource productivity (e.g., through material and energy savings, process innovations, or recycling) can lead to improved financial performance of companies. Studies in the field of environmental investment and corporate performance document positive relationships between resource efficiency and indicators of growth or company value; some studies also analyze the direct mechanism, i.e., lower operating costs, less exposure to commodity price risk, and better access to "green" financing. Together, these factors can increase the creation of corporate economic value added. These results support the hypothesis that higher resource productivity can translate into measurable economic value for a company, although the magnitude of the effect depends on the context, type of industry, and performance measurement (Özbuğday et al., 2020; Dangelico & Vocalelli, 2017; Wen et al., 2023).

In the context of the textile industry, where material and energy intensity and pressure to recycle are particularly high, theoretical and empirical work on the impact of circular practices suggests that targeted increases in resource productivity have the potential to improve value creation indicators such as EVA. At the same time, the literature on the circular economy and sustainable innovation in the apparel sector shows that benefits are often realized in the medium term and require support (both technological and political) to overcome barriers; This means that investments in resource productivity can increase the long-term economic value of companies if they are accompanied by systemic measures (e.g., financing, improved collection and recycling, technical standards). From this perspective, empirical research into the link between resource productivity and EVA in the textile sector is extremely relevant for both policy and practice (Triguero et al., 2023; Ramírez-Escamilla et al., 2024; Chen et al., 2023).

2 Methods

The article focuses on economic factors of sustainability in the textile industry, measuring EVA (economic value added) and resource productivity. Data was drawn from the Orbis database for the years 2022 and 2023. The empirical data set includes data on 136 companies from the textile industry in the Czech Republic (NACE 13), which was analysed using selected indicators assessing both economic success (EVA) and the efficiency of material resources used (resource productivity). The aim was to obtain information on whether the economic success of a company is also related to higher use of material resources. The authors assume that economically successful companies invest more in innovation, improve technology, and thus save both energy and material resources, leading to an improvement in the resource productivity indicator. The economic success of companies was assessed using the economic value added (EVA) indicator and profitability indicators (ROA = operating profit/assets; ROE = earnings after taxes/equity). The EVA (Economic Value Added) indicator was calculated using the entity approach, with NOA (Net Operating Assets) used to express invested capital.

$$EVA = NOPAT - NOA \times WACC, \quad (1)$$

where:

NOPAT (Net Operating Profit After Taxes): $NOPAT = \text{earnings before interest and taxes} \times \text{tax effect} = EBIT \times (1 - t)$

NOA (invested capital): Operating assets – Operating liabilities.

Operating assets mainly include tangible and intangible fixed assets, inventories, short-term and long-term trade receivables, and other assets used for the main business activity (e.g., receivables from operating relationships).

Operating liabilities include trade payables (short-term and long-term), liabilities to employees, liabilities to social security and health insurance institutions, tax liabilities (not related to interest), and other operating liabilities.

$$WACC \text{ (Weighted Average Cost of Capital)} = E/(E+D) \times r_e + D/(E+D) \times r_D \times (1 - t) \quad (2)$$

where

E = value of equity (from accounting); D = value of interest-bearing debt, r_e = cost of equity (estimated using CAPM, for example), r_D = cost of debt (effective interest rate), t = tax rate.

The cost of equity (r_e) was estimated using the CAPM (Capital Asset Pricing Model):

$$r_e = r_f + \beta(r_m - r_f) \quad (3)$$

r_f = risk-free rate of return (using the average half-yearly yield on Czech government bonds for the period 2014-2024, i.e. 2.27%)

β (beta) = sector risk – sector beta used for cyclical industries, which includes the textile industry in the Czech Republic 1.3

$r_m - r_f$ = market risk premium (8%).

Resource productivity at the company level was measured in the same way as at the national level, i.e., as the ratio of operating revenues to material and energy costs.

Companies were divided into two groups (companies generating economic value added, i.e., $EVA > 0$, and companies with negative economic value added, i.e., $EVA < 0$) and then analysed. The data were aggregated using contingency tables, and the average values of the analysed indicators were calculated for each group of enterprises. A two-sample t-test was used for static hypothesis testing, comparing the mean of the resource productivity variable between the two groups of enterprises.

$H_0 : \mu_1 = \mu_2$, where μ_1 is the average resource productivity of companies generating EVA,
 μ_2 is the average resource productivity of companies not generating EVA

$H_1 : \mu_1 \neq \mu_2$.

3 Research results

First, the analysis focuses on the development of the number of economic entities in the Czech Republic in sector 13 – manufacture of textiles, and sector 14 – manufacture of wearing apparel (Table 1), particularly on barriers affecting the introduction of innovations.

Table 1 Number of economic entities in the Czech Republic

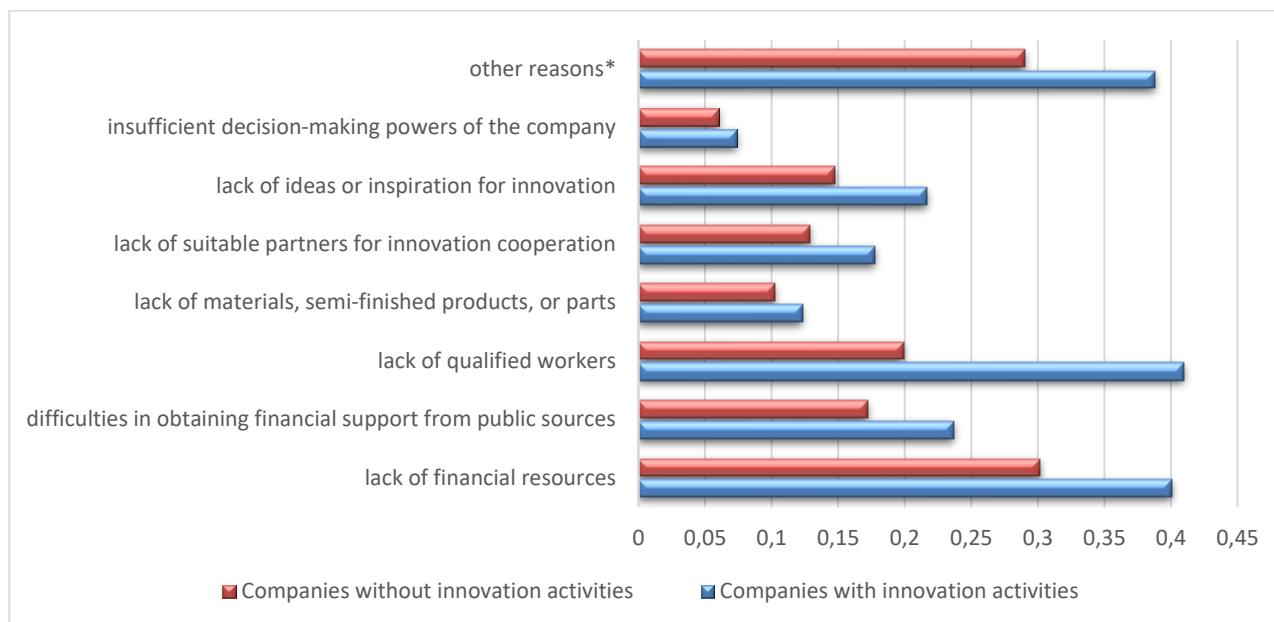
	Textile production		Clothing production	
	absolute	relative in %	absolute	relative in %
31.12.2021	3389	1.018	41662	12.521
31.12.2022	3210	0.950	42495	12.571
31.12.2023	2710	0.876	37396	12.571
30.06.2024	2656	0.857	37616	12.131

Source: own processing, Czech Statistical Office database

Table 1 shows that the number of economic entities classified as part of the textile industry in 2021–2024 is around 1% of all entities in the manufacturing industry and is declining in those years. A decline in entities can also be seen in the clothing industry. The reasons for this may include lower competitiveness (link to source), cheap products from third countries, etc.

Based on statistics (Eurostat, Czech Statistical Office) monitoring innovation activities, the impact of product innovations on the market in the textile and clothing industry was assessed (Figure 1). In this area, innovations were mainly focused on improving the quality of existing products and expanding the product range. Approximately 6% of innovations were primarily aimed at reducing negative environmental impacts. Chart 1 shows the factors that companies perceive as barriers to implementing or initiating innovation, both for companies that innovate and those that do not. Innovating companies consider the lack of skilled workers to be the biggest barrier, while non-innovating companies perceive the lack of financial resources as the biggest barrier.

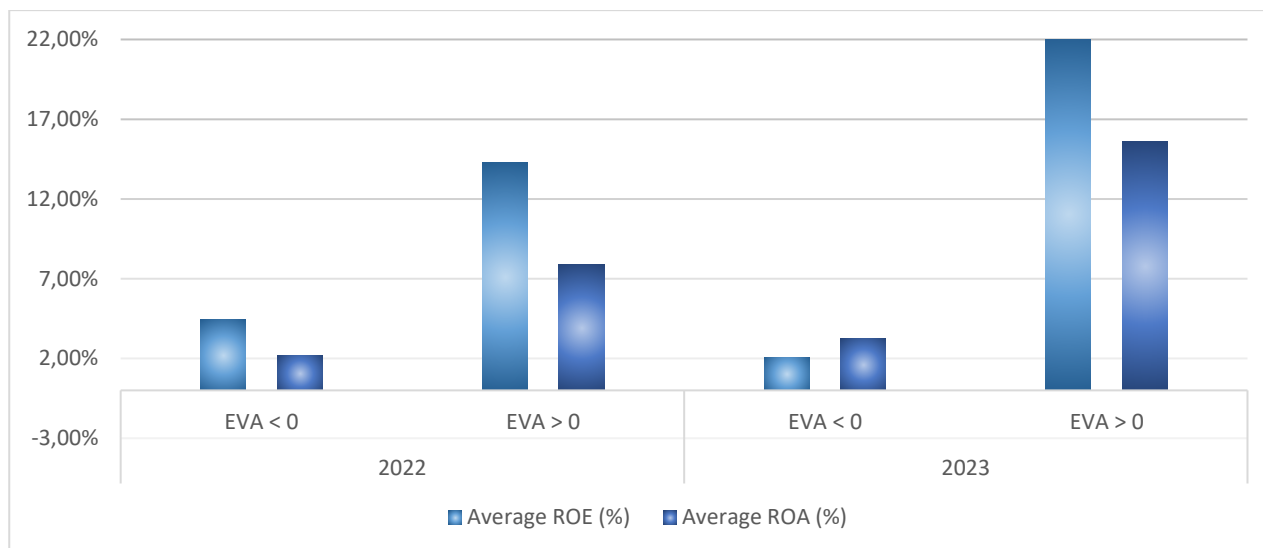
Figure 1 Factors limiting the implementation or initiation of innovation activities in the textile, clothing, and related industries (NACE 13-15) in 2020-2022



Source: Czech Statistical Office database

Analysis of the sample of company data revealed significant differences in performance and efficiency between the two groups of companies (those creating economic value added and those not creating economic value added). Differences were recorded in particular in profitability indicators (ROE, ROA) and resource productivity (Figure 2).

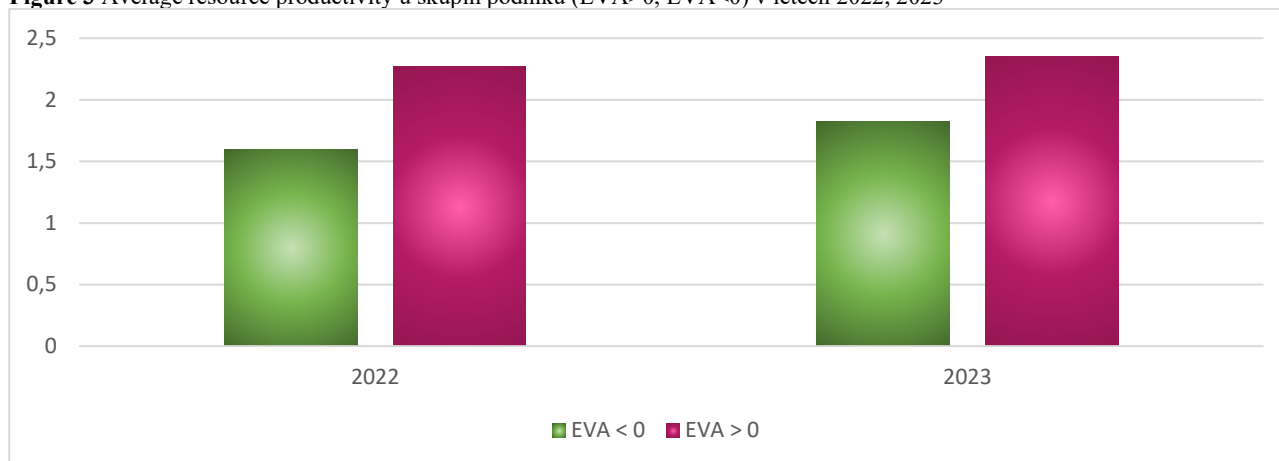
Figure 2 Profitability indicators for groups of companies (EVA>0, EVA<0) in 2022 and 2023



Source: own processing

In 2022, companies generating EVA achieved an average ROE of 14.27% and ROA of 7.88%, while companies not generating EVA had significantly lower indicators (ROE 4.43%; ROA 2.16%). In 2023, there was an overall improvement in profitability for both groups of companies (EVA-generating companies achieved ROE of 22.16% and ROA of 15.60%), which may be influenced by overall economic growth in the post-COVID period. The resource productivity indicator also shows differences between the two groups of companies (Figure 3).

Figure 3 Average resource productivity u skupin podniků (EVA>0, EVA<0) v letech 2022, 2023



Source: own processing

Figure 3 shows that resource productivity was higher in companies generating EVA (in 2022, it amounted to CZK 2.27 in revenue per CZK 1 in material costs and improved slightly in 2023). This difference can be interpreted as more efficient use of material and energy resources. The results suggest that EVA-generating companies should be able to make better use of available resources and respond more effectively to economic and operational challenges. In 2022, the lower values may have been partly influenced by the lingering effects of the pandemic crisis and increased energy costs. A t-test was then performed (Table 2).

Table 2 Student's -Test Two-sample t test

Variable	Average (EVA>0))	Average (EVA<0)	t	degrees of freedom	p-value	F-test (Variance)	p -value (Variance)
Resource productivity	12.74	7.90	1.17	270.00	0.24	1.31	0.13

Source: own processing

A t-test was then performed (Table 2). The group of companies creating economic value added achieves a higher average resource productivity (CZK 12.74) compared to companies not creating economic value added (CZK 7.90), equal variances assumed (F test, p-value 0.126 > 0.05).

Since the p-value is greater than 0.05, the hypothesis of equality of resource productivity averages cannot be rejected, i.e., the difference in averages cannot be considered statistically significant. Although it is possible to infer a significant difference based on the average resource productivity values, the t-test did not confirm this. The result would need to be verified on a larger sample of companies.

4 Conclusions

The paper focuses on assessing the link between economic value added and resource productivity. This perspective shows whether a firm not only creates economic value, but also does so efficiently and sustainably. Monitoring the link between these indicators is also important from the perspective of better strategic management and greater competitiveness in the international market. An empirical business analysis conducted on companies in the textile industry in the Czech Republic showed that companies with a positive EVA value not only achieve higher profitability, but also demonstrate a more sustainable long-term management style as measured by resource productivity. Their ability to convert consumed resources into economic value and maintain positive development of key financial indicators confirms that EVA creation is closely linked to the efficient use of resources and the principles of sustainable development. This conclusion is consistent with the results of a Spanish study by Córcoles and Triguero (2025), which found that investment in the circular economy and eco-innovation increases the performance of Spanish manufacturing companies. On the other hand, it should be noted that the importance of this type of textile industry in the overall economy is declining, with globalization and the liberalization of foreign trade being one of the significant factors, according to a study by Puig et al. (2023), one of the significant factors is globalization and the liberalization of foreign trade. Overall, it can be summarized that the results of the analysis confirm the hypothesis of a positive relationship between EVA creation and resource productivity. Companies that achieve positive EVA values not only generate higher profits for shareholders, but also demonstrate better environmental and operational

efficiency, which is a prerequisite for their long-term sustainability and competitiveness in the post-pandemic period. Although average resource productivity values indicate different levels depending on EVA creation, this fact could not be statistically confirmed. The primary limitation of the paper is the focus on only one sector of textile manufacturing with low number of observations, and the short time period when EVA was observed.

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Some Notes on Inflation in the Czech Republic between 2015 and 2025

Eva Kislingerová¹, Antonín Šmejkal², Lucie Vacíková³

Abstract: The inflationary burden and inflationary potential of a currency can be estimated either by analysing monetary policy and other macroeconomic data, or by using comparative analysis procedures in the case of identifying past inflationary burdens and estimating them on the basis of recent monetary policy actions in the case of future developments. This paper follows the latter method. Data for the Czech koruna compared to the Polish zloty, the Hungarian forint and the euro are used as comparative bases, and the US dollar and the Swiss franc are also examined in a partial way. The paper is designed as a set of notes on the subject. It cannot be seen as a comprehensive analysis based on sufficient research. However, it concludes that the Czech koruna has historically been burdened with an inflationary potential of roughly 0.5 to 1.5 percentage points relative to the major currencies. Thus, with the same monetary policy, inflation on the koruna reaches the higher values described above. The explanation for this phenomenon is historical and relates to the structural fundamentals of the Czech economy.

Keywords: fiscal policy, inflation, monetary policy, quantitative theory of money

JEL Classification: E31, E52, E62

1 Introduction

This paper is based on the following hypothesis in recognition of the full validity of the quantitative theory of money: the development of inflation in different countries may show considerable deviations from the development in other countries, however similar in terms of macroeconomic parameters and monetary policy parameters. Thus, in addition to the aspects described by quantitative theory, there are other aspects that can cause quite significant and long-term differences in inflationary developments in individual countries. By short-term we mean the Friedmanian outlook of six to nine months, and by medium-term we mean a period of up to three or five years, and by long-term we mean phenomena lasting longer than five years.

It should be stressed that this study collects only basic notes and observations on the subject. Both on a general or theoretical level and in the specific case of Czech inflation between 2015 and 2025, a full-fledged analysis would require, firstly, a much larger amount of data collection and, secondly, a considerable amount of calculations.

1.1 Quantitative theory of money

It is well known that the most common expression of the quantity theory of money is the standard transaction equation of exchange in the form

$$M * V = P * T.$$

Of course, we could also use one of the slightly or more different forms of this relationship. It would not make much difference to the following considerations. Indeed, from the point of view of the aim of this study, a discussion of subtle or greater differences and different perspectives within quantitative theory is not very useful.

Irving Fisher published the transaction equation of exchange in 1911 and 1912 (Fisher 1912, pp. 159-164) in a slightly different form, $M*V=p*Q$, but the content is identical. Here, too, M represents the money supply, V represents the velocity of circulation, p represents the price level, and Q represents the quantity of goods available. The detailed differences in the formulations are therefore of little importance. Despite the debate with the Cambridge school (Marshall 1923), despite the

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changes brought about by Keynes (Keynes 1923) and his later rejection of the quantitative theory of money, and even despite the subsequent fusion of Fisher and Keynes by Milton Friedman and the monetarism of the second half of the last century (Friedman 1956, pp. 51-67; Friedman and Schwartz 1963), the basic relationship remains almost untouched: money cannot influence real variables in the long run.

It should be added that the quantitative theory of money was established earlier in broad terms and basic relationships. We can find hints of it in treatises from the sixteenth century, and in a relatively comprehensive form in John Locke (1689, pp. 115-126) and, above all, David Hume (Hume 1752, pp. 28-39). David Ricardo used quantitative theory in a simple form, essentially in accordance with Hume.

Similarly, we will not discuss the various critical perspectives on quantitative theory. That being said, for the purposes of this paper we consider it valid in rough outline.

In the above equation, it represents:

- M the available money stock (or the amount of money held by entities as cash balances),
- V denotes the velocity of money circulation (or the transaction velocity of a monetary unit),
- P is the price level, and finally
- T the number of transactions in the economy (available goods, volume of product).

Very simply, according to the quantity theory of money, prices are a function of the money supply. If output is constant and money becomes scarce, the solution is not to change output but to change the price level. The latter will move exactly so that the equation once again expresses the equilibrium state. However, the process of finding equilibrium will be somewhat delayed beyond the change itself; prices will choose a certain reaction time. Logically, then, it should also be the case that, given roughly the same changes in output, similar changes in the money supply, and the same change in the velocity of circulation, the evolution of the price level should (with exaggeration, anywhere in the world) be the same relative to the original level. This necessarily implies, among other things, that the level of the original levels is irrelevant. What matters is the change, not the level of the base. This is an important comment in relation to the rather common notion of the need for less developed countries to "catch up" with developed countries, a notion that, while logical on its face, is clearly false. In other words: The desired effect of finding stability in output and productivity growth could be achieved by means other than inflation.

Empirically, at least, we suspect that there are some processes taking place in the real world where, in addition to the quantitative theory, it is necessary to supplement their explanation with further reasoning. At least the examples within the euro area, and indeed throughout its entire lifetime, raise considerable suspicions. We will deal with them later. However, let us stipulate that this will not be a full-fledged research, but only a comparison based on general data. This will include data for the Czech Republic and a comparison with some other countries.

It is therefore appropriate to add to the hypothesis stated at the beginning of the study. This supplement is the assumption that the overall economic environment, the economic system of each country, each state, has many different parameters that are capable of generating long-term asymmetries in the evolution of the price level and, therefore, in the evolution of inflation (consumer prices, but in a sense also producer prices and, consequently, the GDP deflator).

1.2 External shocks and fundamental differences versus systemic price instability

Let us now assume that both parts of the hypothesis are true. That is, first, that there are asymmetries in changes in the level of consumer prices even between otherwise comparable countries, even in the long run, and second, that these asymmetries are due to systemic circumstances within the economies of these countries.

The second part could be explained in other ways. For example, external shocks leading to cost pressures on producers could be such an explanation. However, we consider this attempt to be doomed to failure. Let us imagine a situation of an external price shock. First, a rise in price and a consequent fall in output, or a rise in price and a subsequent offsetting of this rise by an increase in the amount of money available, does not contradict the quantity theory. On the contrary, it confirms it. But then it should necessarily be the case that, given the fact that external shocks affect similar countries with similar intensity and timing, their effects will also be similar. However, and here we have fresh possibilities of comparison at hand thanks to the pandemic and its rupture into the energy crisis, this could be challenged quite successfully.

There is a second explanation for the different trends in price levels, which may be the different settings of the bases of these levels. However, it is already mentioned above that the basis is irrelevant from the point of view of quantitative theory. If we translate this into inflation in the Czech environment in the 1990s: the first transformation inflationary years were inevitable, as the sharp price increases were triggered by tax changes (primarily the abolition of the negative image tax on

a number of commodities) and exchange rate changes (devaluation of the koruna), which, with the liberalisation of trade (including foreign trade) and the change in the ratio of available goods (the growth of the share of imported product in household consumption), led to an inevitable price eruption. However, any further inflation above the usual level of Western European countries, which was often explained as "price level catching-up", no longer had this objective basis. The convergence of price levels in the Czech Republic and in the developed countries, as ascertained through exchange rates, did not have to have an inflationary solution; it could have had an exchange rate solution.

However, using the Czech Republic as an example and comparing it with other countries, we will show certain differences in the price level, differences that are very long-lasting and persistent despite changes in output. Although the other parameters already mentioned cannot be described as identical or very similar in the context of this comparison, we will propose that the different evolution of price levels is related to a phenomenon we will call inflation potential. In the context of this paper, this term is used to refer to the propensity of a currency, or more precisely of the economic environment, to behave inflationary, i.e. to raise consumer prices. It can also be summarised as systemic price instability. On the issue of the historical burden of asymmetries and imbalances on the Czech economy, see Kislingerová (2023).

We then use comparative analyses of data from different countries to make a basic assessment of whether it is indeed possible to find long-run divergent price level paths in some of these countries given relatively identical changes in important parameters.

2 Methods

As a basic source of information, we will first use Eurostat data on inflation (in relation to the above equation it is P), data from the same source on output growth (T) and fiscal government deficits (influenced by M), and then data from individual central banks on the development of key interest rates (also influenced by M). By comparing them analytically, mainly on the basis of trends, we will be able to evaluate the relationships of specific data for individual countries or regions, i.e. to make an appropriate comparison.

If the data move in the same or different relationships in the short and medium term, this may not (in line with quantitative theory) mean anything systemically significant. As has already been pointed out, in such limited periods (for various reasons) the theory partly resigns (in agreement with monetarists and Keynesians) to literal validity, since reality may be affected by a number of specific circumstances insufficiently captured by the variables included in the equation. However, over periods longer than five years, the trends in the movement of the price level should be consistent with the parameters, i.e. the equation should show an equilibrium found equal to that achieved in the real world.

However, the initial assumption of the paper, based on empirical observations, was that we would find some differences here as well. This is what happened (see below), so we will try to interpret them. The paths of this interpretation will be twofold. As is clear from what has been shown so far, there is no underlying basis for V (circulation velocity) in the data examined. This is a rather difficult variable to capture, the evolution of which can be revealed by such data as the volume of new credit in the economy or the ratio of credit extended relative to savings accumulated. That is, credit money issuance. The velocity of circulation is sometimes (mistakenly) assumed to be a constant. But then it would have no meaning in the transaction equation of exchange, because it would not enter into equilibrium in any way. Thus, the discussion of V is the first route to interpretation. The second is then to consider other influences that stand on their own outside the concepts with which quantitative theory works. These we collectively call the inflationary potential.

3 Research results

We will now attempt to briefly summarize the main findings from the data collection and analysis.

3.1. International inflation comparison

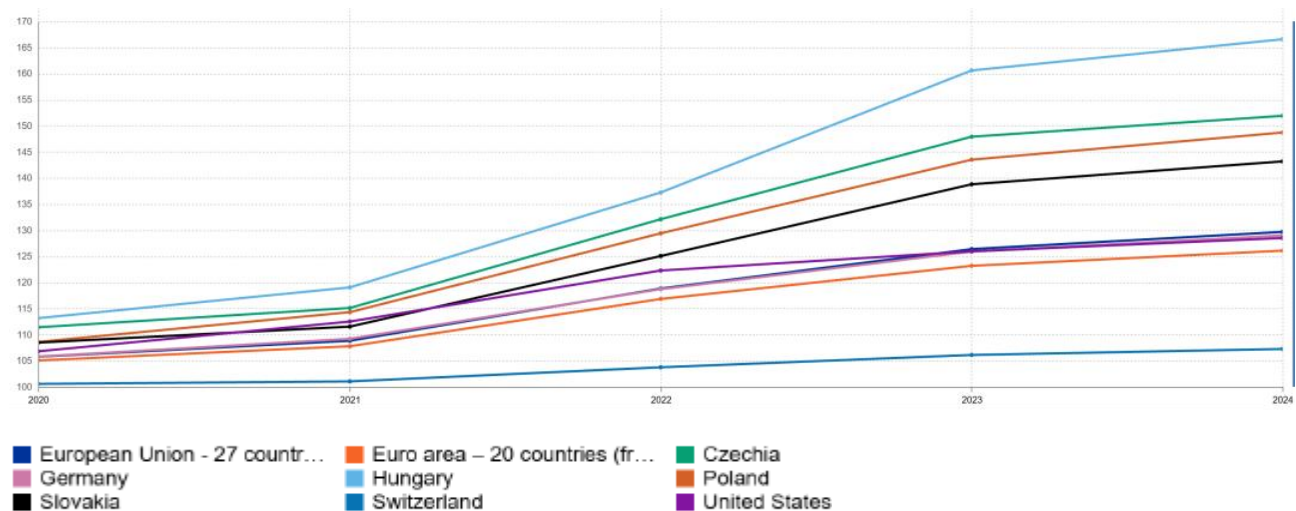
The key information base for us will be the evolution of the price level in the countries we want to compare. These are firstly the Czech Republic, which is the focus of our interest. Next, we will look at the European Union as a whole and the euro area as a whole, while in parallel we will also monitor data for Germany and Slovakia as countries that are close geographically and economically, but are nevertheless included in the euro area. Similarly, the chart shows data for Poland and Hungary, close trading partners, but with their own currencies. For a broader comparison, the graph also includes curves showing price level changes in Switzerland and the United States.

To understand the graph accurately, it should be noted that it is based on a comparison of developments up to 2024 with a baseline, which as a value of 100 is the average of 2015. While this is a comparison that does not make it very convenient to track year-on-year changes, it is ideal for projecting long-term (in this case 10-year) trends.

Another important feature is that the curves show the growth of the price level loaded over time. Thus, for the 2024 data, we see the total change over the whole period, although for better resolution and greater illustrative power the graphs themselves only show curves from 2020 onwards.

However, what does the graph actually show us: The country with the dramatically highest headline inflation within the group is Hungary by a wide margin, followed by the Czech Republic by a considerable margin, with Poland catching up quite dynamically in 2023 and 2024. Then Slovakia follows, still with a very high inflation rate, ahead of the rest of the sample. Substantially lower data are reported by the United States, wedged between the European Union and the euro area, with the EU achieving slightly higher price inflation during the years under review. In contrast, Switzerland comes out almost uninflated (compared to the rest) over the period.

Figure 1 HICP – annual data (average index and rate of change, 100 = 2015)



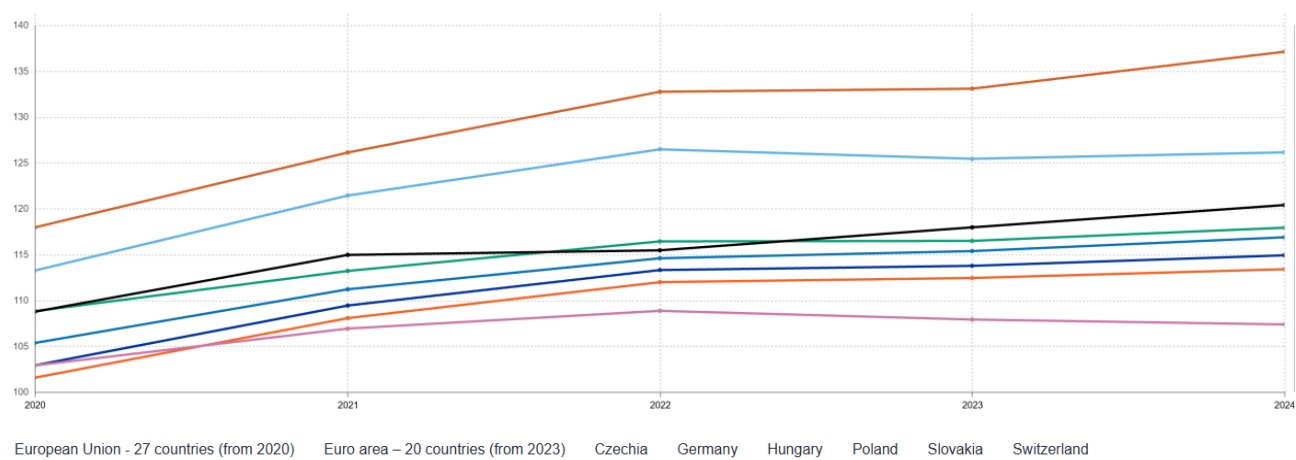
Source: Eurostat, https://ec.europa.eu/eurostat/databrowser/view/prc_hicp_aind/default/line?lang=en&category=prc.prc_hicp

The graph seems to indicate that there is convergence of price levels, calculated through the exchange rate value of domestic currencies, within the surveyed countries. In fact, it would be too easy to assess it in this straightforward way. Firstly, it is questionable why there should be such a divergence between Hungary and Slovakia, which are, moreover, neighbouring countries, and it would be similarly problematic to explain the disparities between Switzerland and Germany or the euro area as a whole.

3.2. Comparison of GDP development

Another comparison relevant for comparing the evolution of price levels is the evolution of product, i.e. the volume of available goods in some models. These concepts should not be confused, but they are indicators of the same facts.

Figure 2 GDP – annual data (average index and rate of change, 100 = 2015)



Source: Eurostat, https://ec.europa.eu/eurostat/databrowser/view/nama_10_gdp_custom_18431848/default/line?lang=en

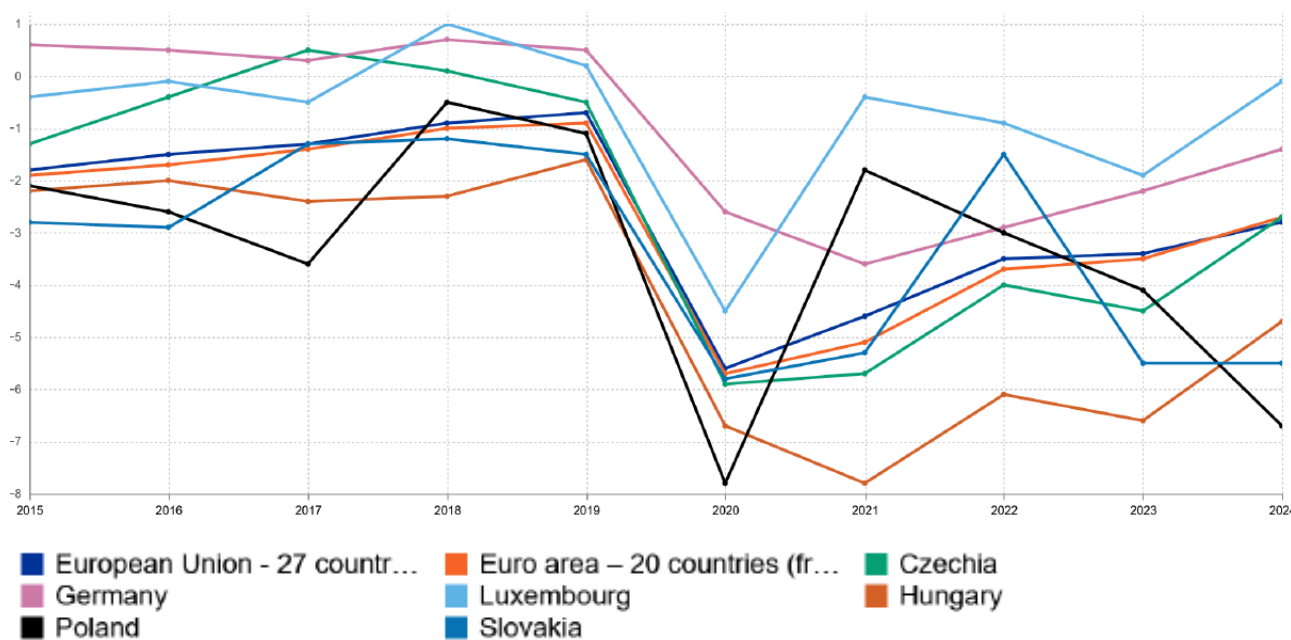
The second chart describes the change in gross domestic product for the same countries, again with a base of 2015 = 100. In this sense, the inflation and GDP curves in Graph 1 and Graph 2 are compatible. At first glance, some trends cannot be missed. First of all, an apparently successful anti-inflationary policy (although in this case not necessarily associated with a hawkish monetary policy) does not necessarily hinder economic growth, as the data for Switzerland show. The high Hungarian inflation is accompanied by relatively rapid output growth, but at first glance there is a disparity in the way price increases and output growth have taken place. The sharpest price increases correspond to a period of economic stagnation. The Hungarian economy (compared to 2015, it should be stressed) maintained growth in the metallic period, but completely failed in the energy crisis era. The chart also shows the demise of the German economy, and perhaps the German economic model, in an exceptionally illustrative way. The level of economic growth is quite tragic, which probably cannot be much offset by relatively low inflation.

Much more similar comments could be gathered, but without more data it is impossible to assess the situation of individual countries. What will be important is the extent to which the fiscal policies of individual countries have helped growth and inflation.

3.3. Deficits and rates

It is undeniable that the growth of debt (of the state, institutions, enterprises, citizens) promotes higher economic growth. After all, it finances consumption. But of course, this comes at a price. The growth of debt (the deficit of the state budget is, in the logic of the matter, practically necessarily covered by debt) means at the same time the next higher than necessary tax burden, unquestionably boosting inflation and, with it, increasing the inflation tax. This is a term used in the Czech environment (unfortunately) only rarely and, if so, in discussions that are more technical than usual. More on the topic, for example, Mach (2003).

Figure 3 Central Government deficit, percentage of gross domestic product (GDP)⁴



Source: Eurostat, https://ec.europa.eu/eurostat/databrowser/view/nama_10_gdp_custom_18435323/default/table

The graph shows very accurately the depth of deficits in recent years (downward direction = larger deficit, balanced budget occurs only at the second upper line of the orientation web). However, it is somewhat opaque and not very suitable

⁴ The attentive reader will notice the difference between the data in the graph and those often reported in the Czech environment. To illustrate, in the chart, the Czech government's two-year deficit for 2020 and 2021 is about 11.5 per cent of GDP; in the Czech environment, a figure closer to 13 per cent is often quoted. The difference is due to what all is included in the deficit. Thus, the higher deficit refers purely to the results of the state budget as such; the chart captures the deficit of the central government and therefore includes some institutions that stand outside the budget as such. In the Czech environment, then, the result is slightly better. On the contrary, it is worse compared to the result of the state and public institutions, where the figures are improved by the surpluses of cities and municipalities.

for further interpretation. Therefore, for an overall comparison of the countries (and groups of countries) over the years in question, we will use the somewhat unorthodox cumulative deficit method.⁵ The result is shown in Table 1.

Even a glance at its last column (Sum) shows that Hungary, followed by Poland and Slovakia, has been pursuing the most diluted fiscal policy throughout the period under review. Despite the usual feeling in Czech public debates, the data for the Czech Republic are moderate in principle and compared to other post-communist countries and better than the EU and euro area average. However, when compared with Germany or Luxembourg, one cannot help but conclude that even so, the approach to state budgets has been relatively irresponsible in relation to the currency and inflation.⁶ In other words, the Czech Republic's fiscal policy in the period in question (in its entirety, it is not an assessment of individual years) was inflationary, albeit more responsible compared to most of its neighbours.

Table 1 Central Government deficit, percentage of gross domestic product (GDP)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	summa
EU - 27 countries	-1,8	-1,5	-1,3	-0,9	-0,7	-5,6	-4,6	-3,5	-3,4	-2,8	-26,1
Euro area - 19 countries	-1,9	-1,7	-1,4	-1,0	-0,9	-5,7	-5,1	-3,8	-3,5	-2,7	-27,7
Czechia	-1,3	-0,4	0,5	0,1	-0,5	-5,9	-5,7	-4,0	-4,5	-2,7	-24,4
Germany	0,6	0,5	0,3	0,7	0,5	-2,6	-3,6	-2,9	-2,2	-1,4	-10,1
Luxembourg	-0,4	-0,1	-0,5	1,0	0,2	-4,5	-0,4	-0,9	-1,9	-0,1	-7,6
Hungary	-2,2	-2,0	-2,4	-2,3	-1,6	-6,7	-7,8	-6,1	-6,6	-4,7	-42,4
Poland	-2,1	-2,6	-3,6	-0,5	-1,1	-7,8	-1,8	-3,0	-4,1	-6,7	-33,3
Slovakia	-2,8	-2,9	-1,3	-1,2	-1,5	-5,8	-5,3	-1,5	-5,5	-5,5	-33,3

Source: Eurostat, https://ec.europa.eu/eurostat/databrowser/view/nama_10_gdp_custom_18435323/default/table, own calculations.

Even more illustrative is a comparison of the percentage of debt to GDP by selected countries and years.

Table 2 Gross debt, General Government, percentage of gross domestic product (GDP)

	2015	2019	difference 2015/19	2021	difference 2019/21	2024	difference 2021/24	difference 2015/2024
EU - 27 countries	85,1	77,4	-7,7	86,8	+9,4	81,0	-6,8	-4,1
Euro area - 19 countries	91,1	83,7	-7,4	93,9	+10,2	87,6	-6,3	-3,5
Czechia	39,5	29,6	-9,9	40,7	+11,1	43,6	+2,9	+4,1
Germany	71,2	58,7	-12,5	68,1	+9,4	62,5	-5,6	-8,7
Luxembourg	21,1	22,3	+1,2	24,2	+1,9	26,3	+2,1	+5,2
Hungary	75,7	65,0	-10,7	76,2	+11,2	73,5	-2,7	-2,2
Poland	51,1	45,2	-5,9	53,0	+1,9	55,3	+2,5	+4,2
Slovakia	51,6	48,0	-3,6	60,2	+12,2	59,3	-0,9	+7,7

Source: Eurostat, https://ec.europa.eu/eurostat/databrowser/view/gov_10dd_edpt1_custom_18469292/default/table, own calculations.

Of course, a percentage reduction in debt does not necessarily imply a nominal reduction, so even though government debt measured in this way may be falling, servicing the debt is likely to become increasingly challenging. More importantly, however: The last column essentially distinguishes those countries that have better debt relative to GDP at the end of a given decade and vice versa.⁷

As for rates, we use central bank key rate data for the euro, the Polish zloty, the Hungarian forint and the Czech koruna, while adding basic information on the US dollar and the Swiss franc. Their changes are reported in the following table. Let us note a very interesting circumstance. Countries or areas that can now live quite comfortably with low rates have had this ability throughout the period, regardless of boom or crisis, even to some extent irrespective of the fiscal policies of the respective governments and the evolution of government debt.

⁵ We are aware of the difficulty of adding up the percentage of deficits to GDP in individual years, as these values are of course affected by the volume of GDP at market prices over time. Thus, percentages are added on different bases, which is of course very non-standard. On the other hand, however, this sum shows what is needed for further consideration, namely the degree of fiscal policy easing over the period. Of course, this is without the weighting of individual years and other contexts, which must be taken into account when interpreting the figures.

⁶ In this comparison, Luxembourg is used as a proxy for Switzerland, where data are not available in a comparable structure and obtained by the same method. This is also the case for the United States, which appears in some of the previous data bases.

⁷ Beware of simplistic comparisons between Table 1 and Table 2, it is necessary to perceive the difference between Central and General Government. Further, not necessarily the entire deficit must be covered by debt. Reserves or extra-budgetary resources can be used; for example, some countries do not include one-off government revenues (e.g. from the sale of assets) in budget revenues.

Table 3 Key rate developments (year-end position, 2025 year-end position at end-September)

Měna	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Czech koruna	0,05	0,05	0,50	1,75	2,00	0,25	3,75	7,00	6,75	4,00	3,50
Euro	-0,30	-0,40	-0,40	-0,40	-0,50	-0,50	-0,50	2,00	4,00	3,00	2,00
USD	0,50	0,75	1,50	2,50	1,75	0,25	0,25	4,50	5,50	4,50	4,25
Swiss franc	-0,75	-0,75	-0,75	-0,75	-0,75	-0,75	-0,75	1,00	1,75	0,50	0,00
British pound	0,50	0,50	0,50	0,75	0,75	0,10	0,25	3,50	5,25	4,75	4,00
Polish zloty	1,50	1,50	1,50	1,50	1,50	0,10	1,75	6,75	5,75	5,75	4,75
Hungarian forint	1,35	0,90	0,90	0,90	0,90	0,60	2,40	13,00	10,75	6,50	6,50

Source: ECB, ČNB, SNB, FED, Bank of England, <https://www.lynxbroker.cz/investovani/burzovni-trhy/burzovni-informace/urokove-sazby-centralnich-bank/>

Thus, in addition to the circulation rate issue, we have collected some data on all the items contained in the standard exchange transaction equation. Now comes the necessity to analyse these data and to draw some conclusions from their relationships towards the above hypothesis.

4 Research results

The method of clustering data into related groups was used for comparison. These were then rated separately within each parameter on a scale from 1 (best group in the area) to 5 (negative rating).⁸ The stratification is created only within the group, it has no relation to other countries, which are not discussed here. Data unavailable by structure and method (for example, some data for Switzerland) have been supplemented by using the nearest comparable data.

Table 4 Comparison of regions and countries

	Czechia	Poland	Hungary	Switzerland	Slovakia	Luxembourg	Germany	Euro area
Inflation	4	4	5	1	4	2	2	2
GDP	3	1	2	3	3	3	5	4
Deficit	3	4	5	1	4	1	2	3
Debt	2	3	4	1	3	1	3	4
Rates	3	4	5	1	2	2	2	2
Results	3,0	3,2	4,2	1,4	3,2	1,8	2,8	3,0

Source: Own calculations.

The higher the figure in the bottom row, the riskier the country is from the point of view of monetary and budgetary stability, taking into account GDP dynamics. Of course, this is a rather crude and rather superficial comparison, but it is nevertheless possible to assume that the hypothesis has been confirmed, at least in general terms.

For example, compare the Czechia and Germany columns. Germany performs better overall, mainly due to low inflation and the possibility of low rates on the euro combined with better deficit data. However, the overall government debt (including its evolution) and, above all, the utterly lacklustre GDP growth are pushing Germany towards instability. Overall, it cannot be said that Germany is more stable when, for example, total debt to GDP is much higher than in the Czech Republic. However, and this is precisely the key point, the Czech National Bank still has to pursue (and historically, not just currently) a much tighter monetary policy to maintain at least a level of inflation that is even within sight of German inflation. In doing so, we have previously rejected as unfounded the theory of a necessary catch-up in price levels.

The same is evident in the comparison with the euro area, especially when compared with Slovakia. Compared to the whole group of euro-paying countries, the data on economic growth, deficits and debt are significantly better on the Czech economy side, yet the long-term inflation of the koruna is higher, with (one could say) a multiply tighter monetary policy (as shown very consistently in Table 3). While this could be temporarily explained by a change in the velocity of circulation, it would hardly be explained in the same way over a ten-year period.

5 Conclusions

All of the procedures and conclusions outlined (it must be emphasized again that these are really only sketches and notes) will need to be reviewed and significantly supplemented in terms of the volume and type of data examined in order to verify them in future research. We are fully aware of the partial nature of the evidence provided. In particular, it would be necessary

⁸ Of course, it would be useful to describe this process in more detail, but the limited space of the paper does not allow it. However, the evaluation can be verified by looking back at the graphs and tables.

to examine in more detail the money supply,⁹ whose representation by fiscal and monetary indicators is necessarily only partial. As highlighted above, the fundamental issue remains the velocity of circulation. We point out before the parenthesis that this problem concerns the whole quantitative theory of money, and that, however much we do not consider the velocity of circulation as a constant (see above), for the present investigation we assume a synchronic evolution of the indicator at least in the countries under study. If we accept this simplification, however, then the velocity of circulation has effectively the same effect on the outcome of the standard transaction equation of exchange as if it were a constant.¹⁰

In any case, however, some quite strong arguments were put forward for continuing to work with the idea that the Czech economy was performing worse in terms of inflation and, through this, necessarily in terms of key interest rate settings than other macroeconomic data and the overall economic set-up would justify. However much this issue needs to be further elaborated, we see a certain inflationary potential within the Czech currency, a certain tendency towards higher inflation. This puts the koruna at a disadvantage compared to more robust and stable currencies, in particular the euro in this comparison.

The reason for the existence of the potential can be widely disputed, and it could certainly be argued that it is a tax on imperfect markets and an imperfect business environment. However, this does not rule out the possibility of a much broader explanation. Of course, the value of inflation potential is a very interesting question. This handicap could be estimated at between 0.5 and 1.5 percentage points. This means that inflation on the koruna (all other parameters being equal) would be higher than on the euro by this amount. The estimate is based on a comparison of the 10-year series of key koruna and euro inflation rates and the 10-year series of euro area inflation, i.e. the relationship between the setting of rates and consumer price developments.

Acknowledgement

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⁹ However, one of the problems with the monetary stock is the extreme difficulty of correctly distinguishing between data within the euro area (meaning internally) and data comparability externally (with economies outside the euro area). However, this is true for all advanced economies, more precisely for all major fiat currencies, as they have many specificities. Local differences in the structure of financial products, in the financing of the economy (credit versus other external sourcing practices versus investments with some characteristics of credit), among others, pose a problem.

¹⁰ For it is true that, given the same change within the systems being compared, it does not affect the outcome of the comparison.

Does Redistribution Promote Human Development? The Role of Migration and Inequality

Vít Kubal¹, Ivana Faltová Leitmanová²

Abstract: This paper revisits the long-standing debate on whether fiscal redistribution hinders or supports economic development. Utilizing data from a diverse sample of more than 70 countries over the last three decades since 1993. The analysis explores the relationship between redistribution policies and national income levels, which represents the material basis for human development and its sub-aspects. Contrary to traditional efficiency-loss arguments, the findings suggest a positive and statistically significant association between higher redistribution rates and higher per capita income. In addition to income levels, the study examines how redistribution relates to income inequality and to migration. While initial correlation analysis suggested that countries with more migrants tend to be more equal, panel regression reveals a reversed relationship: an increasing migrant population is associated with rising inequality in host countries. Ultimately, the impact of migration on inequality, as well as on other aspects of economic development, depends on how well destination countries are able to integrate migrants into their social and economic systems.

Keywords: redistribution, economic development, inequality, migration

JEL Classification: D12, I32, O44, Q56

1 Introduction

The relationship between income redistribution and economic growth has long been a central but unresolved issue in both theoretical and empirical economics. Based on Okun's seminal work (1975), the "leaky bucket" hypothesis defines redistribution as a process that inevitably reduces economic efficiency. This framework assumes that any transfer of resources from higher-income individuals to lower-income individuals involves administrative leakages, behavioural distortions, and reduced incentives for productivity, thereby limiting overall growth. Despite its intuitive appeal, this trade-off model is increasingly being subjected to critical scrutiny. Recent empirical evidence challenges this conventional wisdom and suggests that, under certain institutional and macroeconomic conditions, redistribution may not only be compatible with sustainable economic growth but may even promote it (Berg & Ostry, 2011; Cingano, 2014; Cerra et al., 2021). These studies argue that high levels of inequality can hinder growth through several channels, including insufficient investment in human capital, reduced social cohesion, and increased political instability. From this perspective, redistribution can play a corrective role by addressing market failures and increasing aggregate demand, especially in economies with large differences in inequality. This article builds on this line of research and examines the empirical relationship between income redistribution and national income levels across a large and diverse sample of countries. Specifically, we examine whether countries with higher levels of fiscal redistribution measured as the difference between market and disposable income inequality tend to achieve higher per capita income over time. Our study extends this line of research by conducting a cross-country analysis covering more than 70 countries over the last three decades. This long-term, comparative perspective enables us to examine how redistribution policies are associated with national income levels across a wide range of economic and institutional contexts.

At the same time, it is clear that economic growth is only one aspect of economic development. Composite indicators are constructed using other indicators that are used to monitor economic development. One of these, the Human Development Index (HDI), also allows the impact of redistribution and migration to be examined. The fact that people migrate in search of a better life is the subject of a number of studies and, subsequently, political measures (World Migration report, 2024, McAuliffe et al., 2024). Migration has increased significantly over the past two decades, from 2.8% of the world's population in 2000 to 3.6%. Empirical research (Khan, 2025) confirms that remittances have a significant impact on education, especially in low-income countries, and on health, especially in upper-middle-income countries. Nikolova

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(2025) and Gupta and Bapuji (2024) also paid attention to aspects related to the varying levels of human capital among migrants.

A distinctive feature of our study is the inclusion of international migration as a mediating factor. Migration has become an increasingly important element of the global economic environment, affecting labour markets, fiscal balances, and social cohesion in both countries of origin and host countries. Migrants are not randomly distributed among destinations; rather, their decisions are influenced by a combination of economic opportunities, institutional quality, perceived inequality, and redistribution regimes (Clemens & Mendola, 2024; McKenzie & Rapoport, 2007). This suggests a potential two-way interaction: redistribution can attract or repel migrants, while migration can affect both the effectiveness and political sustainability of redistributive policies. The integration of migrants into host societies further complicates this relationship. On the one hand, an inclusive labour market that allows for social mobility can reinforce the economic and social benefits of redistribution. On the other hand, if migrants disproportionately occupy low-income, precarious jobs or face barriers to accessing social security systems, their presence may contribute to growing inequality and social fragmentation (Leal & Harder, 2023). This interdependence raises important questions about the long-term compatibility of open migration regimes with egalitarian models of redistribution, particularly in high-income democratic countries facing demographic pressures and fiscal constraints.

The need for a systematic approach to migration is therefore emphasized by Tagliacozzo et al. (2024), Zickgraf et al. (2024), and Triandafyllidou et al. (2024). The results of research by Charles-Edwards et al. (2025) already suggest a certain systematicity when it comes to shifts in both the level and pattern of flows, which become more intense and balanced with higher levels of human development. This is closely linked to the need for adequate infrastructure (McAuliffe and Triandafyllidou, 2022, Sun et al., 2024, Pandey et al., 2025).

By placing redistribution within a broader socioeconomic framework, this study aims to contribute to a more comprehensive understanding of the mechanisms through which fiscal policy relates to economic development. Rather than presenting a single causal explanation, we provide empirical evidence on how redistribution correlates with national income levels, while also considering how migration and inequality interact with these dynamics. Migration is not considered a central explanatory variable, but rather a relevant contextual factor that can amplify or mitigate the effects of redistributive efforts. In particular, we examine whether countries with higher levels of redistribution tend to attract larger numbers of migrants and how this may affect domestic inequality. From this perspective, the study engages with broader debates in political economy concerning the compatibility of equality-oriented fiscal policy with the challenges of global mobility, demographic change, and institutional diversity.

2 Methods

As briefly explained in the introduction section. Our paper deals mainly with the potential relationship between national income levels represented and the income redistribution using a cross-country analysis covering more than 70 countries over the last three decades (1993 - 2022). The income levels are represented by GNI per capita, which allows us to compare countries that would not be possible to compare without converting to per capita figures. The degree of redistribution can be calculated in various ways, so it is important to consider possible minor differences in methodology when comparing with other studies. In our case, we chose to calculate the difference between the original Gini coefficient, known as the Gini market, i.e., after the initial distribution based on market mechanisms, and the subsequent Gini disposable, which represents the value of the inequality coefficient after subsequent redistribution and thus after state intervention in the market environment. Based on our choice of data, we can use the Gini coefficient to compare its value before and after redistribution, which gives us the redistribution rate, but the Gini coefficient value after redistribution can be used for analysis as a separate variable in the form of inequality. This value shows us the inequality after redistribution. Not only the degree of redistribution, but also the value of separate inequality. It is important to mention that the data for both variants of the Gini coefficient were taken from the Standardized World Income Inequality Database (SWIID). As for the GNI per capita data, it was taken from the World Bank database, which uses its own method called the Atlas method. This method specifically ensures international comparability by adjusting for inflation and exchange rate fluctuations.

The preliminary stage of the analysis, conducted in Microsoft Excel, involved computing correlation coefficients and graphical exploration of the relationship between redistribution and income levels. This graphical exploration can be observed in Figure 1 (see Research results) where there are two figures next to each other. The first follows the relationship for the year 1993 and the latter represents the relationship for the end of the period (2022). The reader can see that the colour of the data points corresponds to the income group. Green dots are the High-income countries. Blue diamonds represent the Upper middle-income countries, orange squares represent the Lower middle-income countries and lastly, the red triangles represent the Low-income countries. These steps provided initial insights into the direction and magnitude of

the association. Subsequently, more advanced analyses were conducted in RStudio, using a panel data framework with country fixed effects to control for unobserved heterogeneity across nations. In addition to the main specification focusing on redistribution and income, the models also incorporate migration. For our purposes, we used the percentage of migrants in the total population (stock of migrants) to compare the impact of migration on inequality in a given country. If we had used absolute values, this would not have accurately reflected the number of migrants in specific countries. This is logical, as the same number of migrants will appear differently in absolute terms in a country with a population of one million and in a country with ten times that population. In order to achieve the highest possible informative value, we therefore used the percentage of migrants in the total population as previously stated. Given the scope of this article, we decided to formulate a single null hypothesis, which we tested through analysis. This hypothesis is as follows:

- (1) Null hypothesis (H0): *"There is no statistically significant association between a country's income level and the extent of its income redistribution."*

However, we supplement this single hypothesis with an analysis of the relationship between migration and inequality and, more generally, the role that migration can play in relation to redistribution. Based on the results of this supplementary analysis, we are then able to draw certain conclusions about the extent to which migration can play a role in these relationships, thus laying the groundwork for a more detailed analysis in the future.

Despite limited space, we tried to focus even more on migration and its impact on economic development, and we also attempted to test the relationship between the number of migrants and age in a given country as part of a supplementary analysis. To best represent the average age in a given country, we chose the "median age" indicator from the Our World in Data database. The reason for examining this relationship stems from an effort to map the age of migrants traveling to host countries. Under certain assumptions, it could be expected that a large increase in migrants as a percentage of the total population would lower the average age, or more specifically the median age in a given country, as it is often younger migrants who are looking for better conditions for their families. If, on the other hand, the analysis found an increase in the median age, the question would arise as to whether the reason for this is the migration of older migrants, who raise this average, or some other factor.

Since this study addresses not only economic growth but also human development, that is, growth in a broader societal context, the analysis includes not only the relationship between migrant stock, meaning the percentage of migrants in the total population of the host country, and the median age, but also education. Education is an essential component of human development and should be included when analysing its determinants. A wide range of indicators measure educational attainment across countries worldwide, yet for the purposes of this study it was necessary to select an indicator with global coverage and consistent time-series data. Therefore, data were obtained from the Barro-Lee Educational Attainment Dataset (2021), which provides harmonized data on the educational composition of the population by age and gender for most countries in five-year intervals since 1950. Although the dataset also includes projected values beyond 2020, only empirically observed data were used in this analysis. Consequently, the values for 2020 were used as the closest possible estimate for 2022, and the values for 1995 were used as a substitute for 1993 in order to maintain consistency across variables and time intervals. In particular, the indicator "Completed tertiary education (% of population aged 15–64)" was used. It expresses the share of the population who have completed tertiary education (ISCED 5–8). This variable was chosen as a proxy for human capital because tertiary education represents the highest level of formal education and is considered a key determinant of economic growth, productivity, and innovation capacity (Barro & Lee, 2013). We also considered using the secondary education level as an alternative, but in most high-income countries the proportion of individuals with completed secondary education is already very high, which would likely obscure any meaningful variation. The tertiary education indicator was therefore considered more suitable for capturing differences in educational attainment across countries, particularly between high-, middle-, and low-income economies.

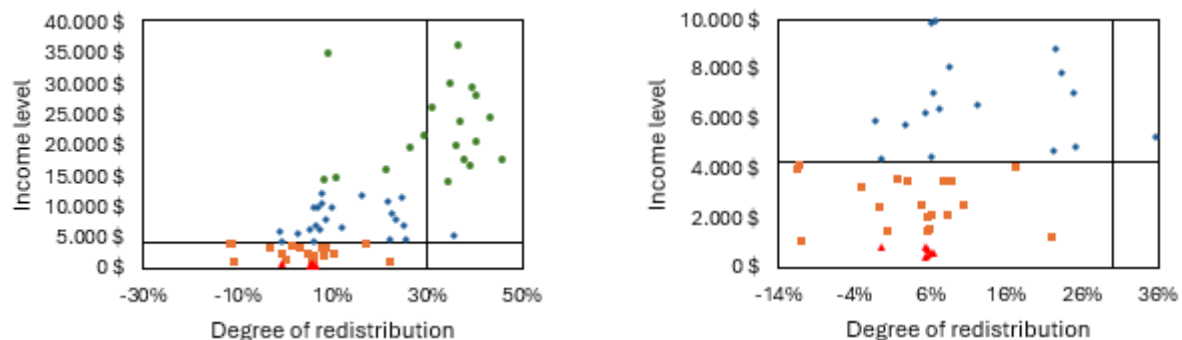
It should be acknowledged that tertiary education has expanded in most countries over the past three decades regardless of migration trends. However, migration motives are often linked to opportunities for a better life, which commonly include access to higher education or the use of skills acquired abroad. If the results indicate that migration contributes to the rejuvenation of host countries or at least slows population aging, this could be related to the fact that young individuals often migrate to take advantage of educational opportunities in destination countries. For this reason, the final part of this supplementary analysis explores the relationship between the share of migrants in a country's population and educational attainment, specifically tertiary education as defined above. The results of this analysis are presented in Chapter 3 (see Research results). Again, this part of the study is based on a linear model examining the relationship between the change in the share of migrants in the total population and the percentage change in tertiary-educated individuals aged 15–64. Since

income levels are closely related to both education and migration, the model also includes initial per capita income as a control variable to eliminate the influence of economic development on the estimated relationship. By controlling for income, we aim to isolate the effect of migration on educational attainment from that of general economic prosperity, ensuring that the observed associations reflect social and demographic mechanisms rather than differences in wealth across countries.

3 Research results

The results of our analysis reveal a statistically significant and positive association between income redistribution and income level of countries, represented as GNI per capita. Countries with higher levels of redistribution (measured as the difference between market and disposable Gini coefficients) tend to exhibit higher values of Gross National Income (GNI) per capita. This relationship holds across the observed sample of more than 70 countries from 1993 to 2021 and is consistent with a growing body of literature that views redistribution not merely as compatible with economic growth, but as a potential driver of long-term development through its effects on equity, stability, and social investment. This finding is visually supported by a clear positive trend in the graphical representation of the relationship between redistribution and income (see Figure 1), where countries with sustained redistributive efforts are clustered at higher income levels. While the relationship is not strictly linear, the general pattern indicates that greater income equalization through taxation and transfers does not impede, and may in fact facilitate, higher income levels at the national scale. We are well aware that correlation does not equal causation, and so a much deeper analysis will be needed in the future. At the same time, many countries already had high income values at the beginning of the period under review, but these countries continued to grow and remained at high values. This is despite the fact that the scale for 2021 has changed in line with the change in the threshold for individual income groups according to the World Bank methodology (Atlas method). It can therefore be said that countries that maintained a high level of redistribution throughout the period under review did not suffer in any way and grew throughout the period. At the same time, many countries that started with very low-income values grew, and in most cases this growth was accompanied by high levels of redistribution. There are exceptions, such as Korea, which grew during the period under review with relatively low redistribution rates, but the situation here is very specific, as this country grew mainly on the basis of its brands such as Samsung, etc.

Figure 1 Income level and Degree of redistribution 1993 & 2022



Source: Authors calculations

Certainly, there were also countries that did not grow despite relatively high levels of redistribution, but in that case many other external factors often play a role, which could not be analysed in depth here. Countries that had low-income levels at the beginning and showed low or even negative redistribution values during the period under review, with a few exceptions such as the aforementioned Korea, grew only marginally in less than 30 years. Negative redistribution values in this regard indicate the centralization of power among just a few individuals who extract wealth from others, which is more typical of regimes far removed from democracy. At the same time, countries with very low redistribution rates indicate poorly functioning state institutions that do not seek to help those at the very bottom of the distribution ladder. The ideal level of redistribution and solidarity is very difficult to determine and is highly specific to the particular situation of each country. This sensitive issue requires increased attention in the future as it becomes increasingly relevant.

This relationship between income level and redistribution isn't obvious merely using graphical representation. It is also supported by analysis which confirms statistical significance of this relationship. As for the role of migration, the analysis using fixed effects models reveals that there is statistically significant positive relationship between percentage of migrants in country's population and its level of inequality. From this finding we can derive that countries are often unable to absorb these migrants and to integrate them into society in a way that does not increase inequality. Although it is not possible to

determine the causality of this relationship with certainty on the basis of such a superficial analysis, and conclusions must be treated with caution. These results suggest that migrants coming to these countries (mostly to high-income countries) are unable to find jobs other than the lowest-paid ones, or even do not work at all, but are registered in the system so that they can take advantage of the solidarity of the system in the given country and receive social benefits. It is terribly important to be cautious with these conclusions, and we are aware that a much more detailed analysis is needed, but the increase in inequality does indeed indicate that this may be one of the reasons.

The supplementary analysis regarding migrants consisted of an additional part, the purpose of which has already been described in Section 2 (see Methods). Here, we tested how the change in the share of migrants in the host country's population over the last three decades was reflected in the change in the age structure. Specifically, we compared it with the change in the median age. It can be expected that mainly younger people migrate, which could lower the median age in the host country. The results of testing this relationship are interesting. First, we compared the percentage change in the number of migrants and the median age. However, the result did not show anything statistically significant. A closer look at the data, however, revealed that the median age has increased in almost all countries over the past 30 years. It is therefore very difficult for the regression to determine whether this is due to an increase in the number of migrants, as this is happening everywhere. For this reason, we adjusted the linear model to also include the initial value of the median age. The model subsequently shows that countries with a higher initial median age have experienced a greater increase in median age. However, countries with a higher increase in the number of migrants have experienced slower population aging. Therefore, we cannot directly speak of rejuvenation, but these migration flows at least counteract the demographic trend of population aging in developed countries to some extent. Although the relationship is very complex, the model shows statistical significance, which indicates that a certain connection exists.

Building on these findings, the supplementary analysis was further extended to include education as another essential dimension of human development. In this part, the models examined how changes in the share of migrants are related to changes in tertiary education attainment. The results show a positive and moderately strong relationship between these two variables. The coefficient for is positive and statistically significant at the 10% level ($p = 0.085$), suggesting that countries with a faster increase in the migrant population tend to record a faster growth in the share of tertiary-educated individuals. After controlling for the initial income level, the relationship remains positive, although slightly weaker, which implies that migration may contribute to human capital accumulation even beyond the influence of economic prosperity itself. The results also indicate a pattern of convergence in education. The coefficient of initial tertiary education is negative and statistically significant ($p = 0.012$), confirming that countries starting with a lower level of tertiary attainment have experienced a faster growth in educational attainment. This supports the hypothesis of conditional convergence in education, suggesting that less educated countries are catching up with more advanced ones over time.

Finally, the relationship between inequality and education is negative and statistically significant when considering the direct association between the education indicator and the Gini coefficient after redistribution ($p = 0.000251$). A similar level of statistical significance is found for the relationship between the degree of redistribution and tertiary education attainment, where the coefficient is positive as expected, indicating that a higher degree of redistribution is associated with higher levels of education ($p = 0.000582$). However, income plays a crucial role in this context. Once income is included in the model and the change in education is analysed in relation to inequality and redistribution, the previously significant relationships lose their statistical significance. This suggests that cross-country differences in tertiary education attainment are more strongly linked to income levels than to the redistribution of income inequality itself. In other words, variations in national wealth appear to be a more powerful determinant of educational outcomes than differences in redistributive intensity. It should be emphasized that this part of the analysis is supplementary, and further, more detailed research would be required to better understand the causal mechanisms underlying these relationships.

4 Conclusion

The results of our study indicate that income redistribution and economic prosperity are not mutually exclusive. Countries that maintained higher levels of redistribution throughout the observed period generally achieved and sustained higher income levels. Rather than constraining efficiency, redistribution appears to contribute to long-term stability, social cohesion, and overall economic resilience. At the same time, the findings underline that there is no universal pattern. Some economies experienced only limited growth despite extensive redistribution, while others such as South Korea achieved rapid expansion even with modest redistributive policies. These contrasting examples point to the importance of institutional quality, industrial structure, and historical context in shaping outcomes. The positive association between migration and inequality further reveals that economic openness brings new challenges. Migrants, who mainly move to high-income countries, often contribute to higher inequality, although the underlying mechanisms are complex. One

possible explanation is that many migrants arrive with a limited skillset, language proficiency, or social capital, which makes integration into the labour market more difficult and can lead to concentration in low-paid sectors. As a result, inequality may rise even in economies with otherwise strong redistributive systems. According to our findings, however, migrants slow down the aging of host countries' populations, so it will be interesting to include their level of participation in the labour market in these countries in future research. Although lowering the age is a positive factor, it is crucial to determine the relationship between migrants and work participation. In other words, whether they contribute to the system and what positions they occupy. To better understand what types of jobs migrants are likely to hold, we examined how migration is related to education, that is, whether migrants tend to be more or less educated. The analysis shows that an increase in the share of migrants is positively associated with the growth of tertiary education attainment, suggesting that migration may indirectly support the accumulation of skilled labour. However, this relationship weakens once income levels are considered, indicating that differences in education are more closely linked to national wealth than to migration or redistribution alone. Overall, redistribution should not be viewed as a barrier to growth but as one potential channel through which economies achieve greater balance and inclusiveness. Future research should focus on the interplay between redistribution, migration, and governance to better understand how policy design can foster both equity and sustainable development. A deeper understanding of these interconnections could help policymakers design welfare and migration systems that reinforce each other rather than compete. Integrating educational and labour market policies within redistributive frameworks may thus be essential for achieving sustainable and inclusive growth in the long term.

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Challenges of Czech Defense Policy: Integrating Sustainability and Economic Resilience

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Abstract: Defense expenditures in the Czech economy reached 1.5% of GDP in 2023 and 2.08% of GDP in 2024, amounting to approximately CZK 160 billion. Meeting the new commitment to allocate 5% of GDP to defense (3.5% for military spending and 1.5% for support expenditures) would require over CZK 450 billion annually, placing significant pressure on the state budget and the economy. In this context, it is advisable to direct part of the funds toward security projects based on the principles of the Copenhagen School of Security Studies. These projects integrate sustainability with state security, encompassing environmental protection, energy self-sufficiency, transport infrastructure, and other strategic sectors. The goal is to develop a comprehensive approach that combines military readiness with the long-term resilience of the state against risks related to climate, energy, and infrastructure, while minimizing negative impacts on the economy.

Keywords: defense expenditures, economic resilience, sustainability, copenhagen school of security studies, strategic infrastructure

JEL Classification: H56, H77, Q01

1. Introduction

In recent years, the defense policy of the Czech Republic has found itself at a critical crossroads between traditional military priorities and the growing demands for economic and environmental sustainability (Černý, 2022; OECD, 2023). Defense spending has long represented a key element of national security; however, its dynamics and structure increasingly reflect the broader framework of the state's socioeconomic and environmental resilience (Boin & van Eeten, 2013; Linkov & Trump, 2019).

According to data from the Ministry of Defence of the Czech Republic, defense expenditures increased from 1.5% of gross domestic product (GDP) in 2023 to 2.08% of GDP in 2024, which corresponds to approximately 160 billion CZK (Ministry of Defence of the Czech Republic, 2024). The new commitment to the North Atlantic Treaty Organization (NATO), under which the Czech Republic is to allocate 5% of GDP to defense - 3.5% for direct military spending and 1.5% for supporting expenditures - raises questions regarding financing, fiscal sustainability, and the long-term stability of the state budget (European Fiscal Board, 2023; World Bank, 2022). Meeting this target would require annual expenditures exceeding 450 billion CZK, which represents a significant budgetary burden with implications for other public policy sectors (OECD, 2023).

The current security context therefore calls for a comprehensive and integrated approach that links military preparedness with the state's ability to adapt to economic, energy, and environmental risk factors (European Defence Agency, 2023; Veselý & Novotná, 2024). The integration of sustainability principles into defense projects - drawing inspiration from the Copenhagen School of Security Studies - broadens the concept of security beyond traditional military threats (Buzan, Wæver, & de Wilde, 1998; Boin & van Eeten, 2013).

2. Methodology

The study employs a combination of qualitative and quantitative methods to analyze the development of defense expenditures in the Czech Republic and the possibilities for integrating the principles of economic, environmental, and social sustainability into defense policy. Data were obtained from official sources of the Ministry of Defence, the state budget, and NATO statistics, covering the period from 2010 to 2024.

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The qualitative part of the analysis includes a document study of strategic and policy materials and the application of theoretical frameworks of the Copenhagen and Paris Schools of Security, which expand the concept of security beyond traditional military threats. The quantitative assessment includes trend analysis of defense expenditures, comparison with other NATO member states, and evaluation of the impacts of high defense spending on the state budget, infrastructure, and socioeconomic stability. The integrative approach focuses on identifying strategic projects that support military preparedness while simultaneously enhancing the economic, environmental, and social resilience of the state. The analysis evaluates the multiplicative benefits of projects and mutually positive externalities, with a key emphasis on inter-ministerial coordination, cooperation with academia and the private sector, and the institutional assurance of long-term implementation.

3. Research results

3.1 Development of Defense Expenditures in the Czech Economy

The historical development of defense expenditures in the Czech Republic from 2010 to the present reflects the dynamics of geopolitical, economic, and political factors that have influenced the state's security policy. Between 2010 and 2020, the share of defense spending ranged mostly between 1.0% and 1.3% of GDP, reflecting limited fiscal capacity, a stable regional security environment, and NATO commitments that were less ambitious than today's targets. During this period, investments were primarily directed toward equipment modernization, troop training, and maintenance of existing infrastructure.

The years 2021–2022 brought a moderate increase in expenditures in response to the deteriorating geopolitical situation in Europe and NATO's pressure to raise military budgets. Spending reached approximately 1.4% of GDP, corresponding to around 120 – 130 billion CZK annually (OECD, 2023). However, this increase remained insufficient to meet alliance readiness standards and modernize the armed forces in line with technological developments. The year 2023 marked a significant shift as defense spending rose to 1.5 % of GDP, equivalent to roughly 160 billion CZK (OECD, 2024). This growth was driven by a combination of domestic political decisions and external pressures, particularly from NATO. At the same time, discussions began on optimizing resource allocation to combine military readiness with the state's long-term resilience to economic and environmental risks.

The year 2024 brought a further increase to 2.08 % of GDP, which in absolute terms represents a significantly heavier burden on the state budget. This increase reflects not only the commitment to higher defense spending but also the need to respond to current geopolitical threats and to secure modern military infrastructure. Achieving the 5 % GDP target—divided into 3.5 % for military expenditures and 1.5 % for supporting expenditures—would require annual allocations exceeding 450 billion CZK, placing a considerable strain on public finances and demanding careful prioritization and planning.

A comparison with other NATO member states shows that the Czech Republic falls within the medium-burden range, while countries such as the United States and Poland already reach or exceed the 3 – 4 % GDP threshold. This context highlights the pressure on Czech defense policy to find a balance between fulfilling alliance commitments and maintaining economic stability and public services. Higher defense spending should not be viewed solely as a military necessity but also as part of a broader strategy for the state's long-term security. From this perspective, there is growing recognition that defense expenditures should be combined with strategic investments supporting sustainability and economic resilience. Examples include projects focused on energy self-sufficiency, modernization of transport infrastructure, cybersecurity, and environmental protection—all of which not only enhance military preparedness but also strengthen the overall stability and resilience of the state in times of crisis. This shift implies that modern Czech defense policy must consider not only the quantity of allocated resources but also their quality and long-term contribution to the nation.

3.2 Integration of Sustainability Principles into Defense Policy in the Context of the Copenhagen and Paris Schools of Security Studies

The adverse global forecasts formulated in the 1960s - particularly regarding environmental threats and the depletion of natural resources (Meadows et al., 1972) - and the subsequent effects of the oil shocks of the 1970s and early 1980s provided a major impetus for a fundamental transformation in the theoretical framework of security studies. In 1985, the Copenhagen Peace Research Institute was established in response to these developments, becoming the foundation of the so-called Copenhagen School of Security Studies (Buzan, 1991). Methodologically grounded in structural realism, the English School, and social constructivism, this school represented a significant reform of the prevailing approach to security analysis and laid the foundations for modern security theory (Buzan, Wæver, & de Wilde, 1998). The founder and leading representative of the Copenhagen School, British political scientist Barry Buzan, made a crucial contribution by expanding and deepening the theoretical framework of security studies. A key element of this reform was the development of the concept of new threats and new referent objects of security, along with a new analytical approach to their interpretation

through securitization. This concept, systematically formulated by Danish political scientist Ole Wæver in 1995 (Wæver, 1995), represented a theoretical breakthrough in understanding the processes through which certain phenomena become subjects of security policy.

At the turn of the 1980s and 1990s, growing global interconnectedness and interdependence of regions led to the development of the concept of common security (Palme Commission, 1982). This approach emphasized the necessity of international cooperation and overcoming the classical security dilemma (Booth, 1991; Booth & Wheeler, 2008). After the end of the Cold War, the redefinition of security became the subject of extensive academic debate, significantly shaped by the representatives of the Copenhagen School. The central questions concerned how to broaden and deepen the concept of international security without compromising its theoretical consistency and how to integrate non-military (non-traditional) threats into the analytical framework without losing conceptual coherence (Buzan & Hansen, 2009). Empirical analyses of the Copenhagen School highlighted the need to extend the narrowly defined concept of military security to include political, economic, environmental, and social dimensions, which together form a comprehensive framework for both national and global security (Buzan et al., 1998). Since that period, the broadened concept of security - encompassing five basic sectors: military, economic, political, societal, and environmental- has become established in the literature (Baldwin, 1997).

In the first half of the third decade of the 21st century, following the combined impacts of the COVID-19 pandemic (since 2020) and the war in Ukraine (since February 24, 2022), scholars have identified the emergence of a multi-attributive crisis (Boin & Lodge, 2021; Nye, 2023). This complex crisis includes simultaneous pandemic, military, energy, and migration factors that heavily burden both national and international security systems. The result is increased vulnerability of business, institutional, and state structures to short and long-term risks. These circumstances confirm the validity of the broader concept of security, integrating military preparedness, economic resilience, and environmental sustainability into a unified framework of strategic risk management (Baldwin, 1997; Boin, 2020). Building upon the theoretical conclusions of the Copenhagen School, the Paris School of Security Studies extends its framework by introducing a practical dimension of strategic integration of security, economic, political, and environmental factors (Bigo, 2002; Huysmans, 2006). This school presents an innovative approach linking sustainability principles with the planning and implementation of defense and security projects. Key areas of integration include energy self-sufficiency of military facilities, use of renewable energy sources, deployment of hybrid systems and smart grids that reduce dependence on external suppliers and increase infrastructure resilience to crises and geopolitical pressures (Tsoukala, 2011). The Paris School further develops the concept of security by emphasizing the micro-level of everyday practices that shape the real forms of security processes. Its leading figures—Didier Bigo, Jef Huysmans, Anastassia Tsoukala, and Emmanuel-Pierre Guittet—argue that security is not merely the outcome of political decisions but emerges within everyday procedures, technological systems, and bureaucratic mechanisms (Bigo, 2014; Guittet & Bigo, 2013). Bigo analyzes how surveillance and border regimes respond to environmental crises, while Huysmans examines how public discourse on climate and energy security affects the legitimacy of political decisions (Huysmans, 2014). Tsoukala highlights the role of diplomatic and humanitarian actors whose daily practices are shaped by environmental factors that directly influence the formulation of security strategies and operational decisions (Tsoukala, 2011).

Moreover, emphasis is placed on minimizing the ecological impact of military operations, particularly through modernization of materials with regard to recyclability, reduction of greenhouse gas emissions, and environmentally sensitive planning of military exercises (NATO, 2022). The modernization of transport and logistics infrastructure not only enables rapid mobilization of units and distribution of supplies but also supports the civilian sector and contributes to the socio-economic stability of regions. Thus, the principles of sustainability can be linked to the social and economic dimensions of security. Projects that create jobs, foster innovation, and promote regional economic development increase the legitimacy of defense policy and strengthen societal resilience to crises. Investments of this type also have multiplicative effects across multiple sectors and align with the concept of mutually positive externalities (Porter & Kramer, 2011). Successful implementation of such a framework requires coordination among the ministries of defense, finance, environment, health, transport, and other relevant institutions. Cooperation with academia, research institutions, and the private sector is also crucial, as it enables effective use of know-how, technology sharing, and the long-term viability of projects.

3.3 Economic and Environmental Resilience within the Framework of State Defense Policy

Economic and environmental resilience represents the complex capacity of a state to adapt to crises and restore its functionality under conditions of military, energy, infrastructural, or climatic disruption (Boin & van Eeten, 2013; Linkov & Trump, 2019). The expanded security perspective enables the conception and implementation of projects that synergistically support military readiness, environmental stability, and economic resilience (Černý, 2022; OECD, 2023). Strategic projects within the defense policy of the Czech Republic must therefore simultaneously emphasize the dimensions

of military preparedness, long-term structural stability, and efficient resource management (Ministry of Defence of the Czech Republic, 2024).

An interdisciplinary understanding of security enables the identification of areas in which defense investments generate multiplier effects with impacts across multiple sectors of public policy (NATO, 2021). Energy and material self-sufficiency constitute essential preconditions for the state's strategic autonomy; military bases and logistical facilities equipped with renewable energy technologies and intelligent consumption management systems contribute to reducing operational costs, strengthening regional resilience, and promoting circular use of materials (European Defence Agency, 2023; Veselý & Novotná, 2024).

Transport and logistics infrastructure ensure rapid mobilization of forces, supply distribution, and support to the civilian sector. Its modernization with regard to energy efficiency and environmental sustainability brings new employment opportunities and strengthens the regional economic structure (World Bank, 2022). Investments in low-impact technologies simultaneously enhance operational efficiency and minimize the ecological footprint of military activities (UNEP, 2021; Linkov et al., 2018). Maintaining critical reserves and optimizing material flows ensure continuity of state functions during crises and integrate military, civil, and environmental goals within a unified resilience framework (OECD, 2022).

Environmental protection is an essential component of all strategic projects. Minimizing ecological burdens and promoting sustainable production and operational processes contribute to long-term stability and societal acceptance of defense policy (UNDP, 2020). The modernization of medical infrastructure and the development of mobile crisis units strengthen the state's ability to respond to pandemics, natural disasters, or technological accidents, thereby enhancing the socio-economic resilience of regions (WHO, 2023).

Energy self-sufficiency is one of the pillars of national resilience. Projects focusing on the use of renewable resources within both military and civilian infrastructure reduce dependence on fossil fuel imports, thus lowering economic vulnerability to international market fluctuations and geopolitical pressures (IEA, 2023). Intelligent energy management systems ensure efficient resource use even in crisis scenarios (European Energy Agency, 2024).

Infrastructure resilience is based on the modernization of transport networks, storage capacities, and strategic logistics hubs. These components enable rapid mobilization of armed forces while also supporting the civilian sector during emergencies such as natural disasters, cyberattacks, or energy outages (Boin et al., 2016; Ministry of Transport of the Czech Republic, 2024). Strategic infrastructure planning therefore links military preparedness with the principles of sustainable development (UNDRR, 2022).

Environmental resilience includes the protection of natural resources, emission reduction, and the promotion of circular material flows (European Environment Agency, 2023). Projects focused on sustainable management of land, water, and energy resources contribute to environmental stability and economic efficiency by reducing costs associated with the restoration of ecological damage (Meadows et al., 2019).

Economic resilience requires the diversification of strategic investments and the creation of reserves of critical commodities to ensure continuity of state functioning during external shocks (World Economic Forum, 2023). At the same time, it supports long-term economic growth through investments in innovation, modern technologies, and efficient logistics infrastructure (OECD, 2024).

Healthcare resilience represents an integral component of overall resilience. The modernization of military and civilian healthcare facilities, development of mobile units, and provision of access to critical medicines increase the state's ability to respond to pandemics, mass accidents, and crisis situations (WHO, 2023; European Centre for Disease Prevention and Control, 2022).

Institutionalization and coordination are prerequisites for effective implementation of strategic projects. The establishment of inter-ministerial coordination structures, strategic planning with a 10–15-year horizon, and monitoring mechanisms evaluating project impacts in terms of economic, environmental, and security efficiency ensure policy continuity regardless of shifts in governmental priorities (OECD, 2021). Successful implementation of these measures requires inter-ministerial coordination, cooperation with academic and research institutions, engagement of the private sector, and integration of international NATO and European Union standards (European Commission, 2022; NATO, 2023). This interconnectedness maximizes the long-term benefits of defense expenditures and reinforces the legitimacy of strategic security governance (Bailes & Frommelt, 2004). Sophisticated public finance management requires the application of tools for prioritization and resource allocation with respect to long-term returns and multiplier effects of individual projects (European Fiscal Board, 2023).

The phenomenon of positive externalities allows measures that strengthen military readiness to simultaneously promote socio-economic and environmental stability (Bačová, 2024). The conflict between short-term efficiency and long-term sustainability can thus be partially mitigated, as synergistic effects enhance the legitimacy and acceptability of strategic decisions (Kleibrink et al., 2022). Integrating economic and environmental resilience into state defense policy therefore represents a key factor in the ability to confront not only traditional military threats but also new risks associated with climate change, energy transformation, and infrastructural vulnerability (Linkov & Trump, 2019; European Defence Agency, 2023). This approach maximizes long-term benefits for the economy, society, and the environment, ensuring strategic stability of the Czech Republic in a volatile global security environment.

4. Conclusion

Rising defense expenditures in the Czech Republic represent a complex challenge that transcends traditional military priorities and encompasses economic, environmental, and social dimensions. It can be stated that an increase in budgetary resources alone is insufficient to ensure long-term security; it is essential to strategically combine projects with measures that enhance state resilience, environmental sustainability, and socio-economic stability (Báčová, 2024). From the perspective of economic theory, strategic projects that generate mutually positive externalities simultaneously reduce the state's vulnerability to crises, minimize negative impacts on the economy, and strengthen the legitimacy of political decisions. The phenomenon of mutually positive externalities emerges as a key instrument for aligning military, economic, and environmental objectives. Economic and environmental resilience is essential for adapting to new threats, including climate crises, energy outages, and infrastructural failures. Projects that strengthen the resilience of critical systems and diversify strategic reserves enable the state to maintain functionality even in crisis scenarios. Healthcare capacity plays a role not only in military operations but also in addressing pandemics and civil crises, thereby supporting the socio-economic stability of regions (Černý, 2022).

For effective implementation, it is necessary to establish institutionalized mechanisms of planning and coordination, strategic planning, and monitoring systems. The conflict between short-term efficiency and long-term sustainability represents a significant political challenge that can be partially mitigated through projects with multiple benefits. The integration of sustainability principles, inspired by the Copenhagen and Paris Schools of Security, enables the formulation of a comprehensive framework linking military readiness with long-term state resilience. In conclusion, Czech defense policy must find a balance between fulfilling alliance commitments and maintaining long-term economic and environmental stability. Strategic, sustainable, and integrated projects represent key tools for maximizing the benefits of defense spending and strengthening the legitimacy of political decisions.

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Dynamics of Nonprofit Organizations under Economic Pressure: Institutional Responses and Long-Term Sustainability

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Abstract: Nonprofit organizations constitute an integral part of civil society, as they contribute to the provision of public services, the promotion of social cohesion, and the representation of disadvantaged groups. In recent years, however, they have faced increasing economic pressures that threaten their stability and long-term sustainability. Rising inflation, growing labor and energy costs, limited availability of public funding, and changes in the structure of private donors create an environment in which nonprofit organizations must fundamentally redefine their financial and organizational strategies. This article analyzes the institutional responses of the nonprofit sector to these challenges, with particular emphasis on resource diversification, internal process optimization, and strengthening strategic management. It also discusses the risks associated with reliance on limited funding sources and presents examples of best practices that can enhance sector resilience. The study aims to deepen understanding of the dynamics of nonprofit organizations in a changing economic context and to highlight factors that may support their long-term institutional sustainability.

Keywords: nonprofit organizations, economic pressure, financial sustainability institutional responses resource diversification

JEL Classification: L31, H84, M14, O35

1. Introduction

Nonprofit organizations represent a key pillar of civil society. Their role goes beyond providing public services—they act as intermediaries between citizens, the state, and the market, contributing to social cohesion, solidarity, and democratic participation (Anheier, 2014). In the Czech context, the nonprofit sector underwent significant transformation after 1989—from limited volunteer activities to a developed network of professional organizations with diverse legal forms, from associations to public-benefit corporations (Frič & Goulli, 2010). This structural diversity reflects the plurality of the sector's functions, increasing professionalization, and growing social significance.

Based on the aforementioned facts, this article analyzes the transformations and adaptation strategies of nonprofit organizations in the Czech Republic in the context of growing economic pressures and technological changes. Using theoretical approaches from civic participation, institutional economics, and social capital, the study examines the role of the nonprofit sector in civil society, the impact of economic constraints on its activities, and the main directions of institutional adaptation.

The main goal of this article is to analyze the current dynamics of the Czech nonprofit sector, identify economic and institutional pressures it faces, and evaluate strategies for adaptation and long-term sustainability.

2. Methodology

The analysis of the Czech nonprofit sector was carried out using a combined approach, including qualitative and quantitative methods. The qualitative part focused on identifying institutional adaptation strategies, optimization of internal processes, digitalization, and fundraising practices in selected nonprofit organizations. Primary data sources included annual reports,

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strategic plans, publicly available documents, and case studies of selected organizations, such as Caritas Czech Republic, People in Need, and the Institute for Liberal Studies. These case studies provided deeper insights into practical adaptation mechanisms to economic and non-economic pressures, allowed assessment of organizational capacity and flexibility, and demonstrated differences in approaches between smaller and larger entities (Anheier, 2014; Frič & Goulli, 2010). Qualitative data were analyzed using content analysis, systematically identifying strategies, procedures, and practical impacts of adaptation.

The quantitative part of the study focused on structural composition and economic stability of the sector. Main data sources included STEM statistical reports (STEM, 2025), data on income and financing structures of nonmarket nonprofit institutions, volunteer work information, and development of operating costs and organizational investments. The analysis included calculation of the share of public vs. private funding, income diversification, and financial vulnerability measurement through indicators of dependency on key sources. Secondary data from literature (Salamon, 2012; Hansmann, 1980; Billis, 2010) provided a framework for interpreting empirical results and linking them with theoretical approaches to the roles and functions of nonprofits, social capital, institutional economics, and the third sector. The combination of qualitative and quantitative methods allowed a comprehensive assessment of institutional adaptations, structural vulnerability, and long-term sustainability strategies of the Czech nonprofit sector under growing economic, social, and technological pressures.

3. Research results

3.1 Theoretical framework: roles and functions of nonprofit organizations

Nonprofit organizations constitute a crucial subsystem of modern society, complementing the state and market in providing public goods and services. Their theoretical foundation is linked to the third-sector concept (Salamon & Anheier, 1997), civil society (Putnam, 2000), and public goods theory (Weisbrod, 1977). According to Salamon's "third revolution" concept in social organization, nonprofits respond to market and state failures - where the market cannot efficiently provide public goods and the state responds slowly or rigidly.

From an economic perspective, nonprofit activity can be seen as part of a hybrid economy, mixing market and nonmarket relations. Hansmann (1980) notes that a key characteristic is the non-distribution constraint, ensuring all surplus is reinvested into organizational activities rather than distributed to owners or investors. This principle fosters trustworthiness and legitimacy.

Sociological approaches emphasize nonprofits as carriers of social cohesion, participation, and civic values (Evers & Laville, 2004). The sector is thus not only a service provider but also a tool for cultivating public space, trust, and collective identity (Putnam, 2000; Edwards, 2014).

Three primary roles of nonprofits are recognized: service, advocacy, and participation (Salamon et al., 2000).

- Service role: delivering public goods and services, often where the market and state cannot, such as social care, education, healthcare, culture, and environmental protection. Nonprofits compensate for market failures and complement state activities (Weisbrod, 1977; Salamon, 2012).
- Advocacy role: representing marginalized groups and mediating between citizens and public institutions. Two dimensions exist: political advocacy (policy involvement) and public advocacy (influencing public opinion) (Anheier, 2014).
- Participation role: promoting civic engagement, volunteering, and community life. Participation within nonprofits generates social capital, i.e., networks of trust, reciprocity, and cooperation (Putnam, 2000).

Nonprofits also serve as intermediaries between the state and market, performing complementary, substitutive, cooperative, corrective, and innovative functions (Anheier, 2014; Evers & Laville, 2004; Kooiman, 2003). Over the past two decades, the sector has seen increasing professionalization (Billis, 2010), incorporating management principles such as strategic planning, project management, impact evaluation, and quality management. Hybrid forms, including social enterprises, combine economic and social logic (Defourny & Nyssens, 2017). Social impact measurement tools, e.g., SROI, help demonstrate effectiveness (Nicholls et al., 2015).

3.2 Economic pressures and structural vulnerability of the sector

The nonprofit sector in the Czech Republic has faced growing economic pressures since the early 2020s, significantly affecting financial stability and its ability to fulfill its mission. The economic environment has become increasingly unpredictable, both in terms of costs and funding availability. Inflation, rising energy, material, and staff costs increase

operational expenses, while the financing structure remains partially rigid and heavily dependent on public sources. According to STEM (2025), public transfers and grants constituted 37,2 % of nonmarket nonprofit institution revenues, income from nonmarket production 22,2 %, and the value of volunteer work 8,8 %. This income profile highlights the sector's high dependence on state and municipal budgets, increasing structural vulnerability to policy changes, grant reductions, or fiscal restrictions.

Changes in private funding are also significant. Private donors increasingly prefer projects with quick, measurable impact, making long-term programs less attractive for traditional fundraising models. This trend pressures organizations to adapt financing strategies and develop new income forms, such as crowdfunding campaigns, partnerships with the commercial sector, or income from entrepreneurial activities (Salamon, 2012; Anheier, 2014).

Structural vulnerability is also reflected in income concentration and insufficient diversification. Organizations dependent on a limited number of donors or state transfers are especially sensitive to changes, affecting both short-term cash flow and long-term institutional stability. Reduction of state grants, loss of key sponsors, or economic crises can threaten program continuity, reduce staff hours, limit service scope, or, in extreme cases, lead to organizational closure (Hansmann, 1980; Salamon, 2012).

Rising operational and administrative costs also drive the need for internal efficiency. Digitalization, project management, accounting standardization, and implementation of control mechanisms have become essential tools for maintaining efficiency and competing for limited resources. However, these processes require investments in personnel capacity, staff training, and monitoring tools, imposing additional burdens on smaller organizations (Billis, 2010; CRM pro neziskovsky, 2024).

The changing role of philanthropy and donor preferences is another trend. In 2024, donor interest shifted toward emergency aid for natural disasters, humanitarian crises, and social emergencies, while long-term projects saw decreased attention. Nonprofits needed to adapt fundraising strategies, emphasizing transparency and building long-term donor relationships (OSF, 2024). Structural vulnerability is further influenced by broader macroeconomic and social conditions, including population aging, rising demand for social and healthcare services, energy crises, and geopolitical uncertainty (Anheier, 2014; Salamon, 2012).

To ensure long-term sustainability and minimize risks from economic pressures, nonprofits must systematically diversify revenue sources, invest in digitalization and internal process optimization, strengthen human resources, and develop strategic management capacities. Monitoring risks, predicting impacts, and proactively adjusting organizational structures and program activities are critical for maintaining financial stability, institutional legitimacy, and effective mission fulfillment.

3.3 Institutional adaptation and long-term sustainability strategies

In response to economic and structural pressures, nonprofits develop strategies to maintain their mission and long-term sustainability. A key element of institutional adaptation is diversification of funding sources, combining state grants, foundation grants, corporate sponsorship, income from own activities, and crowdfunding campaigns. This diversification enhances financial stability and allows organizations to respond flexibly to economic changes, minimizing risks associated with the loss of main funding sources (Salamon, 2012; Anheier, 2014).

Optimization of internal processes is another critical adaptation aspect. Efficient project management, digitalized administration, implementation of control mechanisms, and strategic planning reduce costs and use resources effectively. Investments in human resources development, employee training, and volunteer motivation, forming the backbone of the sector, are essential for maintaining long-term capacity. Professionalization of management and use of outcome monitoring, impact evaluation, and social return measurement (SROI) enhance the ability to demonstrate value and social impact (Billis, 2010; Nicholls et al., 2015).

Strategic management becomes central for risk anticipation and response to changing conditions. Organizations develop strategic plans, assess potential risks, set success indicators, and monitor outcomes regularly. This process allows anticipation of crises, optimal resource allocation, and flexible adjustment of programs to target group needs. Strategic planning also involves creating and maintaining partnerships with public and private sectors, community organizations, and educational institutions, enhancing social capital, legitimacy, and resilience to economic and non-economic pressures (Evers & Laville, 2004; Kooiman, 2003).

Digitalization is a crucial adaptation tool, enabling more efficient donor management, fundraising optimization, increased transparency, and project impact monitoring. CRM systems, online fundraising platforms, and analytical tools

allow better communication, campaign targeting, and outcome evaluation. Digital tools require staff training and organizational capacity building, representing initial costs but yielding long-term efficiency and sustainability gains (Salesforce.org, 2023; TechSoup Europe, 2023).

Fundraising strategies are evolving with donor preferences, increasingly favoring projects with rapid, measurable impact, such as responses to natural disasters or humanitarian crises. Organizations must be flexible, transparent, and capable of building long-term donor relationships (OSF, 2024). Combining short- and long-term projects with diversified funding and strategic planning is the most effective way to minimize risk and ensure continuity.

Advocacy and active engagement in public policy are also key elements of institutional adaptation. Nonprofits enhance their capacity to influence policies, promote legislative changes, and raise awareness of socially significant issues. Capacity building, coalition formation, and modern communication channels increase advocacy effectiveness and support long-term sustainability (Anheier, 2014; Frič, 2010). Collaboration with the commercial sector is another effective sustainability strategy. Partnerships provide mutual benefits: nonprofits gain funding and expertise, while commercial entities enhance social responsibility and reputation. Cooperation often focuses on education, environment, and social inclusion, enabling more efficient resource use and broader impact (Good Company Circle, 2024).

Institutional adaptation in the nonprofit sector thus involves a comprehensive set of measures: revenue diversification, internal process optimization, human resources strengthening, strategic planning, digitalization, advocacy enhancement, and collaboration with public and commercial sectors. These mechanisms collectively enable organizations to maintain stability, flexibility, and mission fulfillment in a changing economic and social environment. Adaptation requires investment in organizational capacity and management development but ensures long-term sector resilience and sustainability, keeping nonprofits as key actors in civil society.

3.4 Dynamics of the Czech nonprofit sector under economic pressure – current trends and adaptation examples

In 2024, the Czech nonprofit sector faced significant economic pressures that affected its stability and ability to fulfill its mission. Gross value added increased by only 0.3%, representing the lowest growth in the past four years. An industrial recession, coupled with weak demand from Germany, impacted sectors dependent on exports and international cooperation, which also negatively affected nonprofit organizations involved in international projects and grant programs (STEM, 2025). In response to these challenges, Czech nonprofit organizations implemented various adaptation strategies. Organizations such as Caritas Czech Republic and People in Need strengthened their fundraising activities and diversified funding sources to reduce reliance on public funds and ensure the continuity of their programs (Anheier, 2014). These organizations also invested in digitalization and streamlining internal processes, enabling them to respond more quickly to changing conditions and the needs of their target groups (CRM for Nonprofits, 2024).

The Institute for Liberal Studies, responding to geopolitical crises and growing humanitarian needs, launched the “Kyseláč” operation. This initiative provided assistance to Ukraine through collections, logistics, and collaboration with local organizations, demonstrating flexibility and the ability to respond rapidly to crises (Frič, 2010). Similarly, smaller organizations focused on local community projects, such as civic associations supporting seniors or children in socially disadvantaged areas, had to reassess their budgets, optimize operational costs, and seek new forms of funding, including community fundraising and partnerships with local businesses (Salamon, 2012).

Beyond crisis response, Czech nonprofits also focus on ensuring long-term financial stability. Rising operational, staffing, and service costs require organizations to continuously seek new revenue sources, including partnerships with the commercial sector, foundation grant programs, and income from their own entrepreneurial activities, such as social enterprises or products with a charitable dimension (Defourny & Nyssens, 2017). This trend shows that the adaptability of the nonprofit sector is not only a reaction to immediate economic problems but also part of a systematic effort to strengthen its institutional capacity (Billis, 2010).

A crucial part of adaptation strategies is also investing in human resources and the education of employees and volunteers. Organizations emphasize the development of competencies in project management, fundraising, communication, and digital skills (Nicholls et al., 2015). For example, People in Need regularly organizes training for both staff and volunteers, focusing on crisis management, fundraising, and project evaluation. This approach increases organizational flexibility, allows for more efficient use of resources, and strengthens the ability to provide high-quality services to target groups even under growing economic and social pressures (Anheier, 2014).

Another trend is the strengthening of collaboration between nonprofit organizations and community actors at the local level. Partnerships with municipalities, schools, healthcare facilities, or cultural institutions allow not only for resource and knowledge sharing but also for better identification of community needs and targeted support for specific groups (Evers &

Laville, 2004). For example, collaboration between local cultural associations and nonprofits provides not only leisure activities for children and seniors but also creates a network of volunteers and promotes social cohesion. This collaboration model enhances the social relevance of nonprofits and supports the development of social capital, which is crucial for the long-term stability of the sector (Putnam, 2000).

Nonprofit organizations also leverage digitalization to improve efficiency and transparency. Implementing donor relationship management tools (CRM, 2024), analytical platforms for project impact assessment, and online fundraising campaigns enables more targeted communication with the public and better monitoring of resource use (Salesforce.org, 2023; TechSoup Europe, 2023). Digitalization also facilitates faster adaptation to changes in service demand, which is particularly important during unexpected crises or sudden increases in needs, such as humanitarian emergencies or environmental disasters (OSF, 2024).

These examples illustrate how Czech nonprofit organizations respond to economic pressures through innovation, collaboration, and strategic planning. Continuous adaptation of strategies, diversification of funding, and strengthening of institutional capacity are essential for long-term sustainability and the ability to respond effectively to future challenges. The Czech nonprofit sector thus becomes not only a provider of public benefit services but also an active actor promoting social cohesion, citizen participation, and innovation in the public sphere.

4. Conclusion

Analysis of the Czech nonprofit sector shows its irreplaceable role in society. Nonprofits not only provide services often unfulfilled by the market or state but also strengthen social cohesion, promote civic participation, and represent disadvantaged groups. Theoretical frameworks such as social capital, civic participation theory, and institutional economics confirm the sector's significance for democratic functioning and public space development. Current economic and non-economic pressures present considerable challenges. Rising operational costs, evolving donor expectations, changes in public funding, and technological innovations demand high flexibility, strategic management, and adaptive capacity. Structural vulnerability is especially evident in organizations dependent on limited sources, whose stability is threatened by funding gaps, shifts in public policy priorities, or economic crises. Institutional adaptation is key to long-term sustainability. Revenue diversification, internal process optimization, human resources development, digitalization, advocacy, and collaboration with the commercial sector enable organizations to maintain stability and respond effectively to changing conditions. Implementing these strategies requires investment and organizational capacity but ensures resilience and mission fulfillment.

Empirical examples of Czech nonprofits show that an effective combination of adaptive and strategic measures allows not only survival during economic fluctuations but also development of innovative projects and increased social influence (Frič & Vyskočilová, 2020; Pospíšil & Hyánek, 2018). The nonprofit sector thus remains a key civil society actor, responding to community needs while actively shaping conditions for participation, social cohesion, and public welfare (Škarabelová, 2019; Salamon & Anheier, 1998).

In conclusion, long-term sustainability of nonprofits results from the combination of adaptation, strategic management, and innovation (Helmig, Ingerfurth, & Pinz, 2014). Studying institutional adaptation mechanisms provides deeper understanding of sector dynamics, vulnerabilities, and opportunities to respond effectively to economic and non-economic pressures, contributing to the development of a stable, inclusive, and participatory civil society (Maier, Meyer, & Steinbereithner, 2016; Frumkin, 2002).

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Current Issues in ESG Reporting in the Context of Agriculture

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Abstract: ESG reporting is becoming more prevalent in practice. More and more companies are creating and monitoring environmental, social and governance indicators. This gives them a better chance of succeeding not only on the domestic market but also on international markets. A company's activities also have an impact on its surroundings and strong relationships are important for the successful development of business operations. A positive assessment of a company contributes to its long-term stability. Current ESG reports are undergoing a process of development and therefore differ from company to company. In our research, we focused on the trends, challenges and opportunities associated with the implementation of ESG in the agricultural sector. This study presents relevant taxonomy and legislation from the perspective of the European Union and Slovakia. We also focused on the implementation of ESG in the business environment and the reporting process. In the near future, agricultural enterprises can expect changes and adjustments to ESG reporting requirements. They should use the current transition period to adapt their enterprise information systems and create the necessary processes and tools for effective ESG reporting.

Keywords: sustainability, taxonomy, ESG reporting, enterprise, agriculture

JEL Classification: M21, O20, Q58

1 Introduction

In the current period, we are increasingly encountering ESG reporting in practice. The creation and monitoring of indicators in the field of environmental, social and management is carried out not only by companies that are required to do so by legislation. There are several reasons. One of them is the fact that still more customers are interested not only in the price and origin of the purchased products, but also in the ecological aspect of the products. Companies that follow the principles of organic production in their activities have a greater chance of succeeding not only on the domestic but also on the foreign market. Other important factors are the social and management aspects. The above aspects are also important in the internal corporate environment, and they are perceived sensitively in particular by employees. The company's activities also affect its surroundings, and the relationships it creates with customers, suppliers, buyers and other external entities are important for the successful development of its business. A positive assessment of a company contributes to its long-term stability. There are no strict rules for creating ESG reports and so it is different in individual companies. Our research is focused on agricultural sector.

2 Methods

The selected area of the presented research activity is ESG reporting and the field of agriculture. Agriculture is one of the important sectors of the national economy. Unlike other production sectors, it is characterized by the uniqueness of animal and plant production. However, the same laws and principles of business apply to agricultural enterprises as to other business entities. As part of our research activities at the Institute of Accounting and Informatics and the Institute of Economic Policy and Finance, we address the issue of ESG reporting from the perspective of current EU legislation, regulations and directives, as well as from the perspective of economic and achieving sustainability.

The main objective of the submitted contribution is to present ESG reporting from the perspective of the taxonomy of the European Union and Slovakia and the orientation towards agriculture. This goal is divided into sub-goals:

1. current ESG issues from the perspective of the European Union and Slovak legislation,

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2. specifics of agricultural production in the context of climate change impacts,
3. system requirements for compiling ESG reports in agricultural enterprises,
4. conceptual design of the ESG reporting system.

The materials used are regulations and directives of the European Union, legislation of the Slovak Republic, related scientific publications and results obtained by solving research tasks at the Institute of Accounting and Informatics and the Institute of Economic Policy and Finance in the period 2015 – 2025, research project VEGA 1/0489/15 "Increasing the effectiveness of managers' decision-making with the support of information systems and accounting", research project VEGA 1/0625/24 "Financing and insurance in agriculture: market failure and the role of policies", research project KEGA 058SPU-4/2024 "International finance and trade in agriculture". The basic research methods applied in the presented contribution are analysis, comparison, synthesis, deduction, systematic literature search, survey method - method of individual interviews with managers of agricultural enterprises, where the structured interview method was used with open questions focused on the corporate information system and reports, further system analysis of corporate information systems and information flows (basic research was carried out as part of solving the above-mentioned VEGA research tasks).

3 Research results

3.1 ESG issues in the context of taxonomy and European Union legislation

The Stockholm Conference in 1972 laid the foundation and general framework for understanding the global environmental problem. It was emphasized that environmental protection and improvement is a fundamental issue, the solution of which affects the quality of life and economic development throughout the world. The global Sustainable Development Goals (SDG Goals) are gradually gaining importance, are frequently cited and are becoming the basis for the development strategy of national and international institutions, sectors and professions. Less so for individual countries, although here they are often cited and emphasized by governments, too. The basic principles that should economic policy follow include changing the quality of economic growth, preserving and enriching basic natural resources, ensuring a sustainable population level, integrating ecological and economic aspects in decision-making, reforming international economic relations and strengthening international cooperation. The SDGs represent an important contribution to transforming the trajectory of economic and overall civilizational development on a global scale, but also for nation states. They are formulated in a comprehensive and sufficiently progressive manner. Goal 12 aims to ensure sustainable consumption and production, and Goal 13 aims to take urgent action to solve climate change and its impacts (Moldan, 2020). Climate change and environmental degradation are key global challenges of our time. Countries around the world recognize the urgent need to address these challenges. This is demonstrated by their support in the Paris Agreement and the UN 2030 Agenda for Sustainable Development (European Commission, 2025). The EU has made several ambitious commitments under the European Green Deal, notably to become the first climate-neutral continent by 2050 and to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. The EU also aims to strengthen its resilience to climate change, reverse biodiversity loss and environmental degradation. The objective of Article 3 (3) of the Treaty on European Union is to establish an internal market which contributes to the sustainable development of Europe based, *inter alia*, on balanced economic growth and a high level of protection and improvement of the quality of the environment. (EurLex,2025). Porter's hypothesis states that strict government environmental regulation does not have a negative impact on the economic performance of private companies, but rather motivates them to innovations, which brings a competitive advantage in the market. It assumes that properly set strict environmental standards can stimulate innovative activities in companies, which has a positive impact on their revenues. According to Porter, these revenues not only compensate for, but often exceed, the costs associated with complying with these high environmental standards (Porter and Linde, 1995). According to Tsang et al. (2023), voluntary disclosure of non-financial information on environmental, social and governance aspects (ESG) is a rapidly developing and increasingly important topic that has attracted much attention from both academic researchers and capital market participants in recent years. Currently, the performance of a company is assessed primarily by traditional financial analysis indicators (profitability indicators, liquidity indicators, activity indicators, debt indicators and capital market indicators) or by a set of indicators, such as creditworthiness and insolvency models (indicators) or a pyramid system of indicators. Traditional indicators also include indicators assessing the efficiency of production factors (i.e. productivity indicators), of which a single-factor indicator - the labour productivity indicator - is most often used in business practice. As advanced economies move towards circularity and overall sustainability, these traditional approaches seem to be insufficient. As the demand for monitoring sustainable value creation in companies (sustainable business) grows, there is also a debate on how to appropriately extend this traditional perspective. The practical application and monitoring of the principles of sustainable value creation are still evolving. The most significant trend is the integration of environmental, social and governance (ESG) aspects. This approach is referred to as sustainable enterprise

value. A significant proportion of companies (especially large corporations and multinational groups) focus not only on financial results, but also on integrating social responsibility into corporate governance and decision-making. Table 1 compares two key European sustainability directives: the Corporate Sustainability Reporting Directive (CSRD) and the Corporate Sustainability Due Diligence Directive (CSDDD).

Table 1 Comparison of two European sustainability directives

Directive	CSRD - Corporate Sustainability Reporting Directive	CSDDD - Corporate Sustainability Due Diligence Directive
Designation	2022/2464/EU	2024/1760/EU
Objective	Ensure transparent and comparable sustainability reporting	Initiate an obligation to identify and solve negative impacts on human rights and the environment
For whom	Large enterprises, listed companies, some SMEs	Large enterprises with more than 1000 employees and turnover over 450 million EUR
Areas of coverage	ESG factors (environmental, social, governance)	Human rights, working conditions, environmental damage throughout the value chain
Obligations	Disclosure obligations	Duty to act (due diligence, corrective action)
Effectiveness	Gradually from 2024 according to the size of the company	Transposition by July 2026, entry into force from 2027
Sanctions	Fines for failure to comply with the obligation to disclose	Fines, civil liability for damages
Link to other standards	Follow up on NFRD, is in accordance with EFRAG standards	Complements CSRD, follow up on international frameworks such as OECD and UN

Source: Own processing

The CSRD (Corporate Sustainability Reporting Directive) is a key EU legislative instrument that is dramatically changing the area of non-financial reporting and has a global impact. The CSRD is inherently a transformative legal act, aiming to move companies away from voluntary and often superficial "greenwashing" towards systematic, transparent and verifiable sustainability reporting. Although it poses significant challenges, its long-term goal is to redirect capital towards sustainable investments and contribute to achieving the goals of the European Green Deal. Current trends in relation to CSRD include expanding the scope of reporting to:

- all large companies (which meet at least two of the three criteria: more than 250 employees, turnover over 40 million EUR, assets over 20 million EUR).
- listed small and medium-sized enterprises (SMEs), with a deferred application and potentially simplified standards.
- companies from non-EU countries that have a significant branch or subsidiary in the EU and meet the turnover criteria.

This trend means that more companies, including suppliers to large companies, will be required to collect and report ESG data. A new reporting trend is the concept of double materiality, which means that companies must report not only on how environmental and social factors affect their financial performance (financial materiality), but also on how their own activities affect the environment and society (impact materiality). This holistic view is key to reporting and distinguishes CSRD from other global frameworks that primarily focus on financial materiality. According to Rábek et al. (2024) on 10 November 2022, the European Parliament approved a new Corporate Sustainability Reporting Directive, called the CSRD, which replaces the current Non-Financial Reporting Directive (NFRD). CSRD brings new requirements for the disclosure of non-financial data for a wider range of companies. Another trend is digital tagging and machine readability: Sustainability reports must be prepared in electronic XHTML format and digitally tagged (XBRL tagging) in accordance with the EU taxonomy. The aim is to make the data machine-readable, easily analyzable for investors, analysts and regulators. It is also important to mention that CSRD is not isolated and is closely linked to other EU legislative initiatives, such as the EU Taxonomy for Sustainable Investments and will also be linked to the upcoming CSDDD (Corporate Sustainability Due Diligence Directive), which will require due diligence in the supply chain. The new ESG Directive (ESG Slovakia, 2025) is fundamentally changing the way companies look at their responsibilities. By promoting ethical standards, transparency and accountability, it creates pressure to build a more sustainable and fair business environment. Companies that adopt this new approach will not only minimize risks and enhance their reputations but will also actively contribute to creating a more ethical global economy. The CSDDD Directive represents a fundamental move from voluntary social responsibility to binding and enforceable rules. While its implementation will be challenge for companies, its long-term goal is to create a fairer and more sustainable global economy. The CSDDD Directive imposes a comprehensive set of obligations on companies that transform a passive approach to ethics into an active management process (ESG Klub, 2025).

First, companies must thoroughly identify the risks associated with human rights violations and environmental damage, not only within their own operations but also across their entire supply chain. These findings must then be integrated into their internal policies and management systems. At the same time, the directive requires the introduction of a binding Code of Conduct that clearly defines ethical principles and rules. This code does not only apply to the company itself and its subsidiaries, but its compliance must also be required from business partners and suppliers, and companies must put in place mechanisms to verify this compliance. Transparency and responsibility are also key components. Companies must communicate openly about their actions and ensure a functioning redress system that allows for complaints to be resolved and victims to be compensated. In addition, all stakeholders, from employees to suppliers, must be actively involved in the entire process. With increasing pressure for transparency and sustainability, Slovak agricultural enterprises are increasingly facing reporting requirements. The Common Agricultural Policy (CAP) is currently becoming a key instrument for achieving the objectives of the European Green Deal. Slovak agriculture is expected to demonstrate higher ambitions in the field of environmental and climate protection through its strategic plan. This plan must directly contribute to the objectives of well-known strategies such as "Farm to Fork" and the "EU Biodiversity Strategy". The European Commission has formulated several key recommendations for Slovakia in this regard. The main priorities include reducing greenhouse gas emissions, better adapting to climate change, and increasing the country's ability to sequester carbon.

3.2 Specification of agricultural production in the context of climate change impacts

There is also a focus on protecting and restoring biodiversity, mainly by supporting natural features in the agricultural landscape. Other important goals include significantly reducing the use of pesticides, switching to organic farming and introducing more ambitious measures to improve animal welfare. The Commission also recalls the need for sustainable forest management and support for rural development, for example by improving access to fast internet (Pokrivčák et al., 2022). The EU and Slovak agricultural sector currently face several specific challenges that make it significantly more complex than other sectors. From collecting data on vast and diverse farms to the complexity of supply chains, farmers face unique challenges in measuring and reporting their environmental, social and governance impacts. ESG reporting in agriculture is challenging, particularly due to direct dependence on natural ecosystems, a dispersed and often seasonal workforce, and complex value chains. The most significant challenges include - data collection and quality: Unlike an industrial enterprise with clearly defined emission sources, measuring environmental impacts in agriculture is extremely complicated. Accurately quantifying greenhouse gas emissions from livestock farming (methane), land use, or fertilizer application (nitrous oxides) requires sophisticated models and is often only an estimate. Similarly, it is difficult to track water consumption, soil erosion, or the impact on biodiversity across vast and geographically diverse areas. Complexity and transparency of supply chains: The journey of the product from farm to fork involves a multitude of intermediaries – from primary producers to processors, distributors to retailers. Ensuring traceability and obtaining accurate ESG data from all suppliers, many of whom are small farmers without reporting capacity, is one of the biggest barriers. Seasonality and variability: Agricultural production is strongly influenced by weather and other unpredictable factors. These fluctuations cause volatility in data on resource consumption (e.g., irrigation water) and yields, making it difficult to make year-to-year comparisons and set long-term goals. Lack of standardized metrics for the sector: Although there are international frameworks such as the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB), which have already developed specific standards for agriculture (e.g. GRI 13), their implementation is still in its early stages. European Sustainability Reporting Standards (ESRS) for the agricultural sector are still under development. This inconsistency leads to difficulties in comparing performance across companies. Despite these challenges, the introduction of ESG reporting is necessary for the agricultural sector. It not only provides a tool for managing risks and identifying opportunities for improving efficiency but is also becoming a key factor for accessing financing and maintaining competitiveness in a market that places increasing emphasis on sustainability. For Slovak agribusinesses, this means the need to invest in data collection technologies, strengthen cooperation within supply chains, and gradually adopt international standards. As Polakovič et al. (2019) state, it is also important not only for agricultural businesses to invest in the education and development of employees in terms of competitiveness, but the need also to work with qualified professionals so that the company prospers and is valuable in the market. Among other things, today's global companies place high demands on people in terms of qualifications, and it is necessary for employees to be able to flexibly adapt to the changes brought about by the changing business environment in the market. One such change is the issue of ESG reporting.

3.3 ESG issues from the perspective of mandatory financial and non-financial reporting in the Slovak Republic

The obligation to report ESG data at the national level in the Slovak Republic is stated in the Accounting Act. The Act of the National Council of the Slovak Republic No. 431/2002 Coll. on Accounting, in its current legal version (2025), deals with the issue of reporting environmental, social and governance aspects in Section (§) 20 Annual Report. The annual report

contains the financial statements for the accounting period for which the annual report is prepared, the auditor's report on these financial statements (if the accounting entity must have its financial statements audited by an auditor) and, in particular, information on the development of the accounting entity, its current state, and significant risks and uncertainties to which the accounting entity is exposed. The information is provided in the form of a balanced and comprehensive analysis of the status and development forecast and contains important financial and non-financial indicators, including information on the impact of the accounting entity's activities on the environment and on employment, with reference to the relevant data presented in the financial statements. The Act defines the conditions under which banks and commercial companies are required to include in a separate, specially designated section of the annual report individual reporting of sustainability information, which includes information necessary to understand the impact of the accounting entity on sustainability aspects, including how sustainability aspects affect the development, performance and position of the accounting entity (Section 20c).

The conditions include: a bank, except for the National Bank of Slovakia, a reinsurance company and an insurance company, except for a health insurance company, a commercial company, is obliged to do so if:

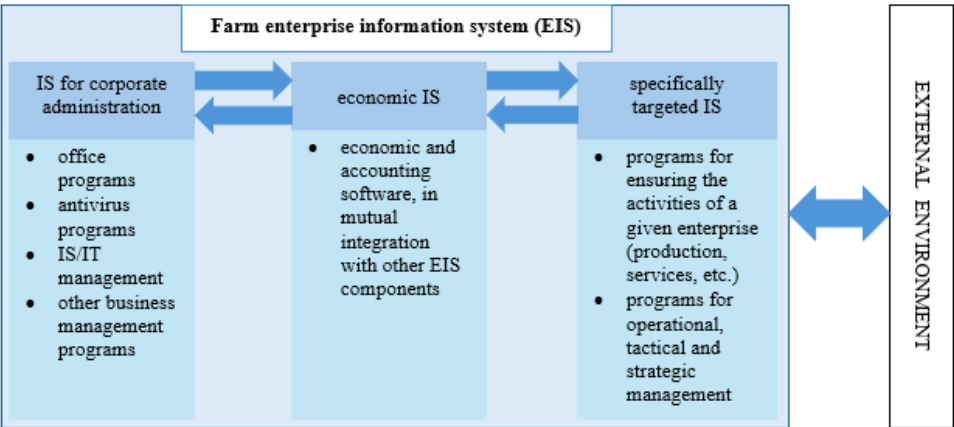
- a.) in each of the two immediately preceding accounting periods it meets at least two of the following conditions:
 - 1. the total amount of assets exceeded EUR 25,000,000,
 - 2. the net turnover exceeded EUR 50,000,000,
 - 3. the average number of employees during the accounting period exceeded 250 or
- b.) issued securities and these were admitted to trading in a regulated market of a Member State and in each of the two immediately preceding accounting periods it meets at least two of the following conditions:
 - 1. the conditions for classification in a size group: a) the total amount of assets exceeded EUR 450,000 but did not exceed EUR 5,000,000, b) the net turnover exceeded EUR 900,000 but did not exceed EUR 10,000,000, c) the average number of employees during the accounting period exceeded 10 and did not exceed 50,
 - 2. these conditions: 2a. the total amount of assets exceeded the amount of 5,000,000 euros, but did not exceed the amount of 25,000,000 euros, 2b. the net turnover exceeded the amount of 10,000,000 euros, but did not exceed the amount of 50,000,000 euros, 2c. the average number of employees during the accounting period exceeded 50 and did not exceed 250 or 3. these conditions:
 - 3a. the total amount of assets exceeded the amount of 25,000,000 euros, 3b. the net turnover exceeded the amount of 50,000,000 euros, 3c. the average number of employees during the accounting period exceeded 250.

The annual report of an accounting entity subject to the obligation to report data must be prepared in electronic format, and the accounting entity is obliged to mark its individual reporting of information on the sustainability of the regulation in accordance with a special regulation (EU Delegated Regulation 2019/815 as amended).

3.4 System requirements for compiling ESG reports in agricultural enterprises

The requirements for creating ESG reports in agricultural enterprises are based on generally binding standards, regulations and guidelines of the European Union and at the same time, consider the specifics of agricultural production. Before implementing ESG reporting, it is important to assess the information flows in agricultural enterprises regarding the possibilities of collecting and processing data into the required reports. This fact is largely influenced by the structure and quality of the corporate information system. Based on the interviews conducted with business managers and obtained in results of the research tasks solved, we have compiled a simplified model of the system architecture of an agricultural enterprise (Figure 1). Data flows are created between individual systems, and the systems are integrated and automated. The above is a prerequisite for incorporating ESG reporting requirements from collection, transmission, processing to archiving of documents.

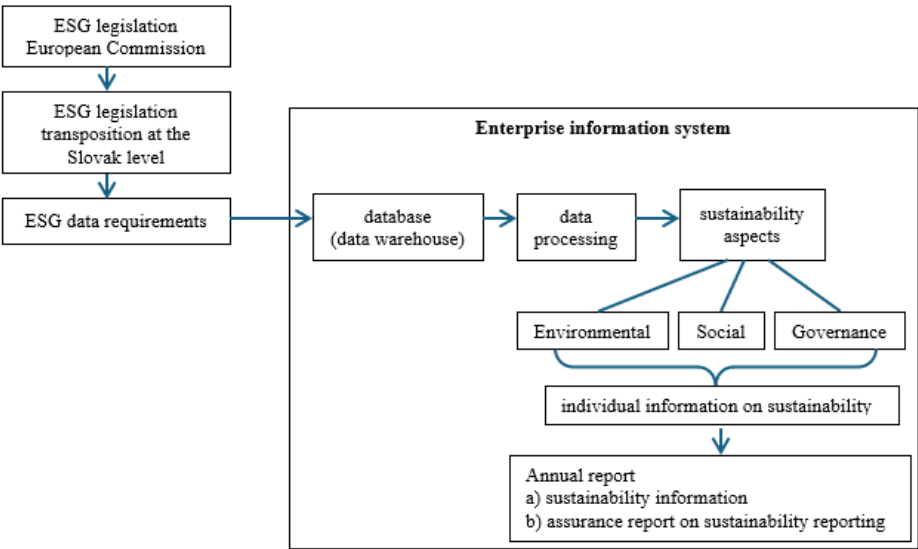
Figure 1 Simplified model of an agricultural enterprise



Source: Own processing

Credibility and verifiability of documents is a fundamental pillar for achieving positive results of ESG reporting in every area of monitoring. This is where independent verification comes into play. Setting up the process of creating ESG reporting in the interaction of the corporate information system is not a fixed process. It is not only the changing reporting requirements that are important, but also the need to (credibly) report changes that occur after evaluating previous findings and implementing measures. The seemingly identical cycle ultimately leads to improvements in the environmental, social and governance performance of the company. From a long-term perspective, the process is illustrated in Figure 2.

Figure 2 Conceptual design of an ESG reporting system in a company



Source: Own processing

4 Conclusions

Reporting information on the environmental, social and governance activities of a company is an important area of presenting business activities. The foundations of ESG reporting were formed already at 80-years of 20th century. Currently, the process of transposing ESG reporting rules from the European Commission level into the legislation of the EU member states is underway. In this paper, we present selected aspects of the taxonomy and legislation of ESG reporting. At the Slovak level, significant changes occurred in 2025, primarily in financial and non-financial reporting, which is regulated by the Act of the Slovak Parliament No. 431/2002 Coll. on Accounting. In our research, we focused on the field of agriculture and the introduction of ESG reporting into agricultural enterprises. According to the requirement for long-term monitoring of individual activities within the framework of ESG reporting, the task is to create or set up a corporate information system. The difficulty of this task for agricultural companies is influenced by the specific nature of farming and animal husbandry. According to ESG Guide for the Food and Agribusiness Sector, (2025) "ESG principles are

transforming the food and agribusiness sector and forcing companies to adopt more sustainable, socially responsible and transparent practices"

ESG reporting is governed by the rules set by the EU and the rules adopted at the national level. A range of indicators is required, which follows from the methodology of the above materials. For the agribusiness sector, ESG factors are an important part of today's business. ESG refers to a set of standards that measure a company's impact on the environment, its social responsibility and its management. In agribusiness, this means focusing on sustainable practices, fair working conditions and ethical decision-making (ESG Guide for the Food and Agribusiness Sector, 2025). Currently, programs are being developed, the implementation of which in the corporate information system will accelerate the process of introducing and monitoring the status and development of individual ESG indicators. For agricultural enterprises, for example, the FarmCloud platform (Introduction to ESG Reporting in Agriculture, 2025) enables effective management of ESG data, automation of the reporting process, access to advanced analytical tools, helps to meet not only formal requirements, but also actively improve environmental and social results. FarmCloud can be considered a significant tool to support modern agriculture in adapting to ESG requirements.

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Recent Developments in Corporate Taxation in the V4 Countries

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Abstract: The paper examines the development of corporate taxation in the Visegrad Group (V4) countries—Slovakia, the Czech Republic, Poland, and Hungary. The main objective is to analyse how the tax policies of these countries have evolved over time, to identify the key drivers behind these changes, and to assess their impact on businesses and the broader economy. The study also compares the corporate tax systems of the V4 countries with those of other EU member states and explores how global trends, such as tax harmonization and the digitalization of taxation, have influenced their fiscal frameworks. The study offers a comprehensive examination of the evolution of corporate taxation within the Visegrad Group (V4) countries—Slovakia, the Czech Republic, Poland, and Hungary—by combining both theoretical and analytical approaches. It explores fundamental concepts of corporate taxation and outlines the policy frameworks that have shaped tax systems in these economies. Furthermore, the analysis focuses on the broader economic and fiscal environment of the region, identifying the main factors that have influenced tax reforms, and the differing approaches each country has adopted in response to domestic and international challenges. The paper evaluates how changes in corporate tax structures and rates have affected business activity, investment levels, and overall economic performance. Building on the empirical findings, the study formulates policy recommendations aimed at improving the efficiency and fairness of corporate taxation. It emphasizes the need for balanced tax policies that stimulate entrepreneurship, attract foreign investment, and support sustainable economic growth while maintaining fiscal stability. Overall, the paper provides a valuable overview of corporate tax developments in the V4 countries and contributes to the broader discussion on tax competitiveness and harmonization within the European Union. Its conclusions and recommendations may serve as a useful resource for policymakers, economists, and legislators engaged in shaping future fiscal strategies.

Keywords: tax policy, corporate tax, Visegrad Group, development, competitiveness, FDI

JEL Classification: H25, H26, H32

1 Introduction

In today's globalized economy, businesses increasingly operate across borders, shaping the economic performance of individual countries. Corporate tax is a key policy tool that governments use both to regulate the business environment and to generate public revenue. Imposed on the income of legal entities, its rate and structure vary according to each country's economic strategy. Corporate taxation influences not only fiscal stability but also the attractiveness of a country for domestic and foreign investors. While some governments lower corporate taxes to stimulate investment and entrepreneurship, others maintain higher rates to strengthen public finances. Within the European Union, debates on tax harmonization aim to limit harmful tax competition and ensure fair market conditions.

The Visegrad Group countries share historical and economic ties, yet their approaches to corporate taxation differ considerably. Comparing these systems can reveal which policies are most effective in promoting growth, investment, and fiscal sustainability. This study examines how corporate tax regimes in the V4 countries have evolved in recent years, the factors that have shaped these changes, and their impact on the business environment. The analysis focuses on the relationship between tax rates, foreign direct investment and the sustainability of public finances. The findings may provide insights for developing more efficient tax policies in the future.

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2 Methods

The paper examines the historical development of corporate taxation in the Visegrad Group (V4) countries and identifies the main factors that have shaped changes in their tax policies. It also evaluates the economic effects of these changes—particularly on growth, employment, and foreign direct investment. The analysis focuses on differences in tax rates, incentives, and structures, while paying special attention to digitalization and international trends that may influence future tax systems in the region.

In the V4 countries, reducing the tax burden is often associated with an expansionary economic policy. This strategy aims to attract investment and stimulate innovation, which can have a positive impact on GDP growth. Conversely, a restrictive tax policy that increases the tax burden may slow down economic activity, raise unemployment, and disrupt market stability (Červená & Čakoci, 2019).

Tax competition among countries, particularly within the European Union, creates pressure to lower corporate tax rates. The main objective is to attract foreign capital and strengthen the business environment. Lower corporate tax rates in EU member states, especially in emerging economies such as those of the V4, contribute to increased foreign investment. Tax competition thus plays a significant role, as countries with lower rates tend to attract more foreign capital, thereby stimulating economic activity (Beljić, Glavaški, & Pejčić, 2023).

Tax evasion and the exploitation of differences between national tax systems represent a global challenge that also affects the V4 countries. The OECD and the EU are therefore working to implement measures aimed at increasing transparency and limiting so-called aggressive tax planning, which allows multinational corporations to shift profits to countries with lower tax burdens (Červená & Čakoci, 2019).

A comparison of corporate taxation between the V4 countries and the European Union reveals significant differences in both rates and structures. While the V4 countries—particularly Hungary, with the lowest rate of 9%—offer favourable conditions for investment, Western European countries such as France and Germany have rates exceeding 25%, which may discourage business activity. The average corporate tax rate in the EU stands at 21.6%, with some countries like Ireland (12.5%) remaining particularly attractive to international enterprises. Tax competition within the V4 has led to lower rates that have supported economic performance; however, this also poses a risk of eroding the tax base. Efforts to harmonize corporate tax bases within the EU could enhance transparency and fairness but may at the same time undermine fiscal stability in countries with low tax rates (Mamajek & Małecka-Ziembińska, 2021).

EU directives such as ATAD I and ATAD II emphasize increasing transparency and reducing tax avoidance. The V4 countries have implemented these policies as part of their efforts to combat tax base erosion; however, for businesses operating in these markets, they also introduce additional administrative costs and obligations (Birskyte & Giriuniene, 2018).

Digitalization is reshaping corporate taxation, and the V4 countries must adapt to the challenges of the digital economy. These include addressing profit shifting, improving VAT collection in cross-border trade, and ensuring fair taxation of digital platforms that generate profits without physical presence. Future reforms should modernize tax systems to reflect economic activity rather than physical location, introduce fair digital services taxation, and use technologies such as blockchain to enhance transparency and efficiency. Stronger coordination within the EU and globally will be essential to protect tax bases and prevent profit shifting. Overall, digital tax reform offers an opportunity to stabilize public finances, but it will require innovation, investment, and international cooperation to ensure a fair and sustainable framework (OECD Digital Economy Outlook, 2024).

The study applies both qualitative and quantitative research methods. It draws on academic literature, legislation, statistical data, and reports from institutions such as the OECD and Eurostat. The methodology combines literature and legal analysis with comparative and statistical approaches to assess tax systems, identify similarities and differences among V4 countries, and evaluate tax collection efficiency and the effects of legislative reforms.

Data were collected from Eurostat, OECD, and national statistical offices, as well as from legislative documents and expert studies on tax policy and economic performance. In this study, the primary period of analysis spans the years 2015 to 2023. An exception is made for the summary of tax rates, for which the dataset has been extended to include observations from 2010 as well as the most recent figures available for 2024. The results help identify key trends in corporate taxation and assess the effectiveness of tax policies in each country. Based on these findings, the paper formulates recommendations for optimizing corporate tax policy in the V4 region, considering global economic and technological developments.

3 Research results

The analysis of corporate tax rates has revealed several important findings regarding their impact on the business environment, economic growth, and foreign investment. Based on the data and statistics collected, we can identify distinct trends and evaluate their broader economic implications. The results suggest that differences in tax rates across countries play a significant role in shaping the competitiveness of national economies and the attractiveness of individual markets for investors. Moreover, the analysis highlights how adjustments in corporate taxation—whether through rate reductions, targeted incentives, or structural reforms—can influence business activity, stimulate investment, and ultimately affect overall economic performance.

3.1 Comparison of Tax Rates in the V4 Countries

The comparison of corporate tax rates in the Visegrad Group reveals distinct policy approaches and their economic outcomes. Hungary stands out with the lowest rate among OECD countries—9% since 2017—introduced to attract foreign investors and enhance competitiveness. This policy contributed to an estimated 18% rise in foreign direct investment over the next two years, particularly in the automotive and technology sectors (Forvis Mazars, 2024).

Slovakia, on the other hand, experienced a period of tax rate fluctuations. In 2013, the rate increased from 19% to 23% to boost public revenues but was later reduced to 21% in 2017 after negative feedback from the business community. Despite the adjustment, Slovakia still has the second-highest rate in the V4, which may slightly reduce its investment appeal.

The Czech Republic has maintained a consistent 19% rate for many years, creating a predictable and stable tax environment that supports long-term investment planning and steady economic growth.

Poland also applies a 19% standard rate but introduced a reduced 9% rate in 2019 for small and medium-sized enterprises (SMEs) with annual revenues up to EUR 2 million. This reform aimed to boost SME development and competitiveness, leading to a 12% increase in new business registrations the following year.

Overall, the V4 countries demonstrate varied strategies toward corporate taxation—Hungary prioritizes low rates to attract investment, Slovakia adjusts rates in response to fiscal pressures, the Czech Republic values stability, and Poland supports SMEs through targeted incentives. These differences influence each country’s business climate and long-term economic performance.

Table 1 Development of Corporate Taxation in the V4 Countries

Corporate Taxation				
Country	Y2010	Y2015	Y2020	Y2024
Slovakia	19%	22%	21%	21%
Czech Republic	19%	19%	19%	19%
Hungary	19%	10%	9%	9%
Poland	19%	19%	19%	19% (9% for SME)

Source: Own processing (Eurostat, 2024)

3.2 Impact on Foreign Direct Investment (FDI)

Lower corporate tax rates tend to enhance a country’s attractiveness to foreign investors. Hungary, which reduced its corporate tax rate to 9%, experienced a significant rise in foreign direct investment (FDI)—about 18% in the first two years—mainly in manufacturing sectors such as the automotive industry, with major inflows from companies like Audi and Mercedes-Benz.

Slovakia, on the other hand, recorded a slight decline in FDI between 2013 and 2017 following its tax increase to 23%, but later achieved a strong recovery between 2019 and 2021, when investments grew by approximately 16% due to more favourable investment policies.

The Czech Republic maintained a stable 19% rate (OECD, 2023), which contributed to a consistent inflow of capital, though growth has recently slowed to around 6%.

Hungary saw the most substantial increase overall, with total FDI rising by nearly 65% from 2015 to 2021, driven largely by investor-friendly tax conditions.

Poland also recorded steady growth in foreign investment, though at a slower pace in recent years—around 3%—possibly reflecting market saturation or changes in the investment environment.

Table 2 Foreign Direct Investment (FDI) in V4 Countries (2015–2023, in billion EUR)

Year	Slovakia	Czech Republic	Hungary	Poland
2015	2,5	7,2	4,3	11,5
2017	2,8 (+12%)	7,8 (+8%)	5,1 (+19%)	12,2 (+6%)
2019	3,1 (+11%)	8,3 (+6%)	5,7 (+12%)	13,0 (+7%)
2021	3,6 (+16%)	9,0 (+8%)	6,5 (+14%)	13,8 (+6%)
2023	3,9 (+8%)	9,5 (+6%)	7,1 (+9%)	14,2 (+3%)

Source: Own processing (OECD, 2024)

3.3 The Relationship Between Tax Policy and GDP Growth

Economic growth is a multifaceted process influenced by a range of factors, among which tax policy plays an important role. Corporate taxation directly shapes business decisions related to investment, hiring, and expansion. Lower tax rates can increase firms' disposable income, stimulate entrepreneurial activity, enhance competitiveness, and ultimately strengthen overall economic performance.

Following Hungary's reduction of the corporate tax rate to 9% in 2017, the country experienced moderate GDP growth and an increase in investments, particularly in the automotive and manufacturing sectors (OECD, 2023). However, this effect was not immediate, as a country's attractiveness to investors also depends on factors such as regulatory stability, infrastructure quality, and the availability of skilled labour.

Conversely, Slovakia's tax rate increase to 23% in 2013 was followed by a slight decline in GDP and stagnating foreign investment, highlighting how tax policy can influence economic dynamics.

In the Czech Republic and Poland, where the corporate tax rate has remained stable at 19%, economic growth has been driven primarily by export performance and domestic market expansion. The consistency of their tax systems has created a predictable and reliable business environment, which may, in many cases, be more valuable to investors than low tax rates alone.

Table 3 GDP Growth in V4 Countries (2015–2023, in %)

Year	Slovakia	Czech Republic	Hungary	Poland
2015	3,80%	4,20%	3,10%	4,50%
2017	3,90%	4,40%	3,60%	4,70%
2019	2, 8%	3,00%	4,10%	4,10%
2021	3,10%	3,50%	5,20%	5,00%
2023	1,90%	2,20%	3,50%	3,80%

Source: Own processing (Eurostat, 2024)

In Slovakia, GDP growth reached 3.8% in 2015 but slowed to 1.9% in 2023, suggesting a moderate decline in the pace of economic expansion. The Czech Republic experienced a similar trend, with growth of 4.2% in 2015 falling to 2.2% in 2023, reflecting a noticeable slowdown in economic activity. In Hungary, GDP growth showed an overall positive yet fluctuating trend, increasing by about 0.4 percentage points between 2015 and 2023, with a peak of 5.2% in 2021. Poland maintained relatively steady growth over the same period, recording 4.5% in 2015 and 3.8% in 2023, indicating a slight slowdown but continued economic resilience.

3.4 Anticipated Trends and Recommendations for Fiscal Policy

In the coming years, the Visegrad Group countries are expected to focus on optimizing their tax systems to ensure both economic competitiveness and fiscal stability. The increasing pressure from the European Union to harmonize tax policies, prevent harmful tax competition, and intensify the fight against tax evasion will likely drive further reforms in the region.

These changes will need to balance national economic priorities with international commitments, particularly regarding fair taxation and sustainable public finances.

Poland is expected to continue supporting its domestic business sector by expanding the benefits of the reduced corporate tax rate for small and medium-sized enterprises (SMEs) to a broader range of companies. Slovakia and the Czech Republic are likely to pursue measures aimed at reducing the administrative burden on businesses, simplifying tax procedures, and improving the efficiency of tax collection without necessarily lowering tax rates. Hungary will probably maintain its current low corporate tax rate, which has proven effective in attracting foreign investment, while introducing or expanding sector-specific taxes to offset potential losses in public revenue.

The analysis suggests several policy directions that could strengthen the fiscal and economic resilience of the V4 countries. One key recommendation is the modernization of tax administration through digitalization. The implementation of advanced data tools and automated systems for detecting tax evasion could improve transparency, enhance compliance, and increase revenue efficiency. Another important aspect is maintaining the stability and predictability of tax rates, as investors generally value a consistent tax environment more than frequent legislative changes. Furthermore, introducing targeted incentives for SMEs—such as tax relief for investments in innovation, technology, and digital transformation—could foster productivity, improve competitiveness, and support long-term economic growth across the region.

Overall, the future of fiscal policy in the V4 countries will depend on their ability to adapt to new economic challenges and global tax trends while maintaining a fair and growth-oriented approach to corporate taxation.

4 Conclusions

This paper examined the development and role of corporate taxation in the Visegrad Group (V4) countries—Slovakia, the Czech Republic, Poland, and Hungary. Its purpose was to analyse how tax policies have evolved in these economies, identify the factors that have shaped them, and assess their broader impact on the business environment and economic performance. The paper also compared the V4 countries' approaches to corporate taxation within the context of the European Union and global economic trends.

The analysis shows that corporate tax systems across the V4 region have undergone significant transformations over the past decades. Economic reforms, efforts to attract foreign investment, and the need to align with EU regulations have been among the key drivers of change. Despite their shared history and geographic proximity, the V4 countries have taken different strategic paths—some emphasizing low tax rates to attract investment, others focusing on expanding the tax base or offering targeted incentives to stimulate business activity.

A key finding of the study is that there is no single formula for an effective tax policy. Each national system has distinct advantages and limitations, and its success depends on the overall economic context and institutional framework. While low corporate tax rates can make a country more attractive to investors, their long-term effectiveness depends on other conditions, such as regulatory stability, infrastructure quality, and efficient governance.

The paper also highlights that international developments—such as tax harmonization efforts, the global fight against tax evasion, and the digitalization of tax systems—are increasingly influencing national tax policies. The V4 countries face the challenge of balancing tax competitiveness with fiscal sustainability and fairness, ensuring that their systems remain attractive while generating adequate public revenues.

Corporate income tax systems in V4 countries reflect a balance between national competitiveness, fiscal consolidation, and increasing alignment with international standards such as the OECD/G20. Despite differing statutory rates, the effective tax environment across the Czech Republic, Slovakia, Hungary, and Poland is becoming more uniform due to emerging minimum tax mechanisms.

The Czech Republic applies a 21% corporate income tax rate (increased from 19% in 2024), placing it near the EU average. The system maintains traditional features such as participation exemptions, while the adoption of the global minimum tax will primarily affect large multinational enterprises.

Slovakia introduced a tiered CIT structure in 2025—10%, 21%, and 24%—combined with a mandatory minimum corporate tax. This progressive model aims to support small firms and broaden the revenue base, though it may create incentives for firms to manage turnover strategically.

Hungary continues to offer the EU's lowest statutory CIT rate at 9%, reinforcing its position as a competitive investment location. However, Pillar Two implementation means large multinational groups will face an effective rate closer to 15%, reducing the statutory-rate advantage at the upper end of the market.

Poland retains a 19% standard rate with a 9% preferential rate for qualifying small taxpayers, alongside a newly implemented 10% minimum income tax. Poland has also adopted the global minimum tax and is pursuing sector-specific reforms such as higher CIT rates for banks, signalling a fiscal policy shift toward targeted revenue generation.

Taken together, while statutory CIT rates differ—ranging from Hungary’s 9% to Slovakia’s 24% upper tier—the regional trend points toward convergence in effective tax burdens. Minimum taxes expanded reporting obligations, and sector-specific levies increasingly shape the corporate tax landscape. As a result, investment decisions are influenced less by headline rates alone and more by broader considerations of compliance costs, tax certainty, and the interaction of domestic regimes with international minimum tax rules.

Overall, the findings suggest that the future of corporate taxation in the V4 region will depend on a combination of domestic policy decisions and global economic and regulatory developments. With ongoing debates about international tax reform and growing calls for fairer taxation of multinational corporations, further legislative adjustments are likely. To remain competitive and resilient, the V4 countries will need to maintain flexibility and adapt their tax systems in ways that support sustainable economic growth and long-term stability.

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Factors Influencing Precautionary Wealth of Slovak Households

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Abstract: Household financial stability is a fundamental pillar of overall economic well-being, especially during periods of uncertainty and crisis. Maintaining adequate precautionary wealth not only mitigates financial stress but also fosters more confident financial decision-making. Households with sufficient reserves are less dependent on credit, better protected against debt accumulation, and more capable of preserving long-term savings and investment strategies during short-term disruptions. This paper investigates the key determinants of precautionary wealth held by Slovak households. The study aims to identify and quantify the influence of wealth-related, demographic, and financial variables on the formation of precautionary wealth. We hypothesize that wealth-related factors, particularly the capacity to accumulate personal financial assets (PFA) play the dominant role. Using data from the Slovak sample of the Household Finance and Consumption Survey and employing ordinary least squares (OLS) regression, we estimate four models (full, preferred, factor, and simplified). The preferred model reveals that PFA has the strongest positive effect on precautionary wealth. Together, PFA and income account for over 56% of the total explained variance. Among financial indicators, ECB policy rates show a positive association, while real deposit rates have a negative effect, suggesting behavioral biases in household responses. Demographic variables, such as age, gender, and education, play a comparatively smaller role. The findings emphasize the dominant role of wealth-related and financial variables in precautionary wealth accumulation.

Keywords: personal finance, precautionary wealth, personal financial assets (PFA), income

JEL Classification: D14, D31, G51

1 Introduction

Household financial stability is a fundamental pillar of overall economic well-being, especially during periods of uncertainty and economic shocks. Events such as the global financial crisis of 2008, the COVID-19 pandemic, and recent inflationary pressures have highlighted the importance of households' ability to absorb unexpected income disruptions. A key element of such resilience is the accumulation of liquid financial resources that can be readily used to smooth consumption without relying on debt or the liquidation of long-term assets.

This motive is traditionally captured by the concept of precautionary saving, which reflects behavioral adjustments in current consumption in response to future uncertainty (Carroll & Samwick, 1998). As emphasized by Carroll and Kimball (2008), a distinction must be made between precautionary saving as a flow concept and precautionary savings as a stock concept. While the former describes the decision process that generates additional saving, the latter represents the accumulated wealth resulting from past precautionary behavior. To avoid terminological confusion, Carroll & Kimball (2008) propose the term precautionary wealth to denote this stock dimension.

This paper focuses explicitly on the stock perspective. The primary objective of this study is to identify and quantify the key determinants of precautionary wealth among Slovak households. We examine factors from three domains: wealth characteristics, demographic attributes, and the financial environment. We hypothesize that wealth-related variables, particularly the ability to accumulate personal financial assets (PFA), play the most significant role in the formation of precautionary wealth. While income provides the capacity to save, accumulated financial assets may better reflect long-term financial discipline, liquidity preferences, and past saving behavior.

Our motivation is twofold. First, understanding the drivers of precautionary wealth is essential for assessing household financial resilience. Second, insights into the relative importance of wealth, income, and financial conditions can inform policies aimed at strengthening households' financial preparedness. Enhanced precautionary wealth not only supports

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individual economic security but also contributes to broader macroeconomic stability by reducing households' vulnerability to income volatility.

Using microdata from the Slovak waves of the Household Finance and Consumption Survey (HFCS), we estimate several regression models to assess the determinants of precautionary wealth. Our findings indicate that personal financial assets are the most influential factor, while income has a similarly strong but negative effect, suggesting that rising income does not necessarily translate into increased precautionary wealth. Financial conditions, particularly monetary policy variables, also play a meaningful role, whereas demographic characteristics appear comparatively less important.

The remainder of the paper is structured as follows. Section 2 reviews theoretical perspectives and prior empirical research on precautionary wealth. Section 3 outlines the methodological framework. Section 4 presents the empirical results. Section 5 concludes.

2 Literature review

The study of money holding provides important insights into household financial behavior and the motives underlying the accumulation of liquid assets. In his analysis of the demand for money, Friedman (1969) distinguishes between money as an asset held and income as a flow earned over time. A key concept in his framework is the money-to-income ratio, which is conceptually related to the measure employed in this study. Keynes (1936), through the concept of liquidity preference, argues that households prefer holding money rather than bonds in environments characterized by low interest rates. He later emphasizes that the desired size of liquid holdings depends on income levels and the phase of the business cycle (Keynes, 1963).

Saving theories play a central role in explaining household behavior. Keynes's absolute income hypothesis views consumption as a function of current disposable income, largely ignoring expectations about future income. In contrast, Duesenberry's relative income hypothesis emphasizes the role of social comparison in consumption decisions (Lisý et al., 2016). Friedman's permanent income hypothesis and Modigliani's life-cycle hypothesis introduce a forward-looking perspective, suggesting that households smooth consumption based on expected lifetime income while allowing for temporary imbalances across different life stages (Begg, 2011).

Traditional saving theories often conceptualize savings as a residual of income after consumption. This perspective is extended by theories of intertemporal choice, most notably Fisher's framework, which explains how households optimally allocate resources between present and future consumption. Within this framework, the precautionary saving motive emerges as a key driver of asset accumulation under uncertainty. Carroll and Samwick (1998) show that income volatility and unexpected shocks increase saving behavior and lead to higher levels of accumulated precautionary wealth.

Macroeconomic and demographic factors further shape household saving outcomes. Lower interest rates are often associated with weaker incentives to save, while higher rates tend to support saving behavior (Dirschmid & Glatzer, 2004; Bohdalová & Pažický, 2019). Income uncertainty and adverse macroeconomic conditions also strengthen precautionary motives (Mastrogiacomo & Alessie, 2014; Denizer et al., 2002; Giavazzi & McMahon, 2012). Inflation also plays an important role, as rising inflation erodes the real value of liquid assets and may reduce households' incentives to accumulate precautionary wealth (Marenčák, 2023).

Micro-level heterogeneity is equally important. Empirical evidence suggests that households in transition economies often exhibit higher saving rates due to limited access to credit markets (Denizer et al., 2002). Education and expectations of future income may also influence saving behavior, while psychological characteristics such as self-control and financial discipline significantly affect households' ability to accumulate precautionary wealth (Gerhard et al., 2018).

Financial education provides an important link between theoretical models and real-world household behavior. Lyons and Neelakantan (2008) highlight that insufficient financial literacy can lead to suboptimal financial decisions, while Drexler et al. (2014) show that simple rules of thumb can substantially improve saving outcomes. A commonly cited benchmark recommends precautionary wealth equivalent to three to six months of expenses (Kapoor, 1988; Whittle et al., 2017). While insufficient precautionary wealth exposes households to financial vulnerability, excessively large precautionary wealth holdings may also carry costs, particularly in inflationary environments with negative real returns (Sabat & Gallagher, 2019).

Building on this literature, the present study contributes empirical evidence on the determinants of precautionary wealth among Slovak households, with a particular focus on the relative roles of wealth characteristics, behavioral dimensions, and financial conditions.

3 Methods

This study investigates the determinants of household precautionary wealth using data from the Household Finance and Consumption Survey (HFCS), coordinated by the European Central Bank (ECB) and implemented by national central banks. As the data are not publicly available, we gratefully acknowledge the National Bank of Slovakia (NBS) for providing access. The analysis uses household-level microdata from four survey waves: 2010, 2014, 2017, and 2021. The HFCS survey flags are presented in Table 1.

We analyze precautionary wealth, defined as the stock of liquid financial assets held for precautionary purposes. For practical interpretation, precautionary wealth is expressed as a financial buffer, measured by the number of months a household can sustain its current income level using available deposits. This measure captures the immediate liquidity available to households in the event of unexpected financial shocks.

Precautionary wealth is intended to cover both unexpected income disruptions and unforeseen expenditures. While expenditure-based measures are conceptually valid, this study expresses precautionary wealth relative to income for theoretical, practical, and behavioral reasons. The income-based normalization is consistent with Friedman's money-to-income framework, which treats desired liquidity holdings as a stock relative to income. From a behavioral perspective, households typically assess financial readiness using simple reference points, such as income levels, rather than detailed expenditure structures. Expressing precautionary wealth in months of income coverage therefore provides an intuitive and consistent measure of households' ability to absorb financial shocks, while remaining compatible with the stock-based concept of precautionary wealth and the available HFCS data.

Formally, the dependent variable is defined as the ratio of liquid assets to monthly disposable income, measured in months. Monthly income is derived by converting annual disposable income (DI2100) to a monthly figure, while liquid assets are proxied by deposit holdings (DA2101).

We include explanatory variables from three domains: wealth characteristics, demographic attributes, and the financial environment. This classification follows the precautionary saving literature, which explains the mechanisms underlying the accumulation of precautionary wealth. Wealth variables are expressed in thousands of euros to enhance interpretability and mitigate scale-related distortions in regression coefficients. Demographic variables include gender as a binary indicator (1 for male, 2 for female); age measured in years; education level ranging from 1 (primary education) to 5 (tertiary education, i.e. bachelor's, master's, or doctoral degree); and the number of employed household members, including employees, the self-employed, or individuals on maternity leave. Financial indicators are obtained from NBS and ECB sources at the macro level, as these variables are not captured within the HFCS microdata.

For data consistency and comparability, we exclude households where the reference person is self-employed, due to the potential mixing of household and business finances. We also omit households that did not report deposit holdings or reported zero income. Each observation corresponds to a single household, represented by its designated reference person.

All monetary values related to wealth are adjusted for inflation using deflators published by the HFCS to ensure comparability across survey waves. All values are standardized to 2021 price levels. Specifically, we apply an inflation factor of 1,105 for 2017, 1,111 for 2014, and 1,216 for 2010.

Table 1 Data specification and HFCS flags

Dependent variable						
buffer	own calculation, in months					
Explanatory variables						
Wealth:			Demography:			
income	DI2100	in EUR	gender	DHGENDERH1	binary value	
pfa	DA2100	in EUR	age	DHAGEH1	in years	
wealth	DA3001	in EUR	education	DHEDUH1	multi value	
net_wealth	DN3001	in EUR	employed_members	DH0004	numerical value	
total_debt	DL1000	in EUR				
mortgage_debt	DL1100	in EUR	Financial:			
other_debt	DL1200	in EUR	nom_ir_deposits	NBS	in %	
			real_ir_deposits	NBS, ECB	in %	
			ecb_main	NBS	in %	

The empirical analysis is based on an ordinary least squares (OLS) regression framework. Precautionary wealth (measured as months of income coverage) is regressed on a set of explanatory variables consisting of wealth-related variables, demographic characteristics, and financial environment indicators. This framework allows the estimation of the marginal influence of each determinant on precautionary wealth, while controlling for other factors.

Our empirical strategy follows a multi-step approach. First, we define the precautionary wealth as the ratio of deposits to monthly income. We then estimate regression models incorporating wealth, demographic, and financial variables. To address multicollinearity, we construct a preferred model retaining only statistically significant variables. Subsequently, we apply exploratory factor analysis to reduce dimensionality and uncover hidden structures. Finally, we perform an impact decomposition based on inter-percentile ranges (10th to 90th percentile) to quantify the practical influence of each predictor. This final analysis emphasizes a streamlined four-variable model, optimized for low multicollinearity and high explanatory power.

4 Research results

Household financial stability is a fundamental component of overall economic well-being, particularly in the face of unexpected income shocks. The ability to build and maintain adequate precautionary wealth is a key indicator of this stability, yet achieving such a buffer remains a challenge for many households. This research investigates the determinants of precautionary wealth accumulation among Slovak households.

The dependent variable in our analysis is the precautionary wealth measured as a financial buffer and defined as the ratio of household bank deposits to monthly income. This measure, expressed in months, reflects the number of months a household can maintain its current standard of living in the absence of income. To ensure consistency, we focus on households where the reference person is regularly employed. Observations involving unemployed, retired, or self-employed individuals are excluded, as the latter may mix personal and business finances, introducing potential bias.

Table 2 Summary statistics of dependent and explanatory variables

Variable	Obs	Mean	Std. Dev	Min	Max
buffer	4011	3,917	8,378	-	205,739
income	4011	1,745	1,183	0,055	22,466
pfa	4011	9,656	21,928	-	470,018
wealth	4011	108,793	152,495	-	6 076,995
net_wealth	4011	99,120	150,299	- 62,202	6 076,995
total_debt	4011	9,672	23,340	-	224,523
mortgage_debt	4011	8,548	22,945	-	224,523
other_debt	4011	1,124	4,172	-	79,064
gender	4011	1,422	0,493	1	2
age	4011	44,595	10,901	20	74
education	4011	3,692	1,226	1	8
employed_members	4011	1,703	0,731	-	6
nom_ir_deposits	4011	1,16	0,56	0,50	1,75
real_ir_deposits	4011	- 0,03	1,49	- 2,30	1,63
ecb_main	4011	0,37	0,46	-	1,00

Source: HFCS 2010, 2014, 2017, 2021, NBS 2025, ECB 2025

The set of explanatory variables is grouped into three categories: wealth, demographic, and financial factors. Wealth variables include disposable income, personal financial assets (PFA), total wealth, net wealth, total debt, mortgage debt, and other debt. All wealth variables are expressed in thousands of euros to improve the readability of regression coefficients. Demographic variables include age, gender, education level, and the number of employed household members. The average respondent is 44.6 years old, with approximately 1.7 employed individuals per household, while gender is evenly distributed across the sample. Financial variables include nominal and real interest rates on bank deposits, as well as the European Central Bank's (ECB) main refinancing rate, which averaged 0.37% over the analyzed period, reflecting a low-interest rate environment. Table 2 reports descriptive statistics based on a final sample of 4,011 observations.

The average level of precautionary wealth amounts to 3.92 months, suggesting that households, on average, maintain a reserve within the commonly recommended range of three to six months. The relatively high standard deviation highlights substantial heterogeneity in buffer levels across the population. However, as shown in Table 3, the median buffer is considerably lower at 1.42 months, indicating that at least half of households would be unable to sustain their current consumption beyond six weeks in the event of income loss. This value is well below than commonly suggested minimum

of three months. Notably, the mean buffer corresponds closely to the 75th percentile, reflecting the influence of a relatively small group of households with exceptionally large reserves. At the upper end of the distribution, approximately 10% of households appear to hold buffers that may be excessively high, potentially expose them to erosion of purchasing power, particularly in inflationary environments.

Table 3 Descriptive statistics of the dependent variable

Percentiles	Buffer
10%	0,094
25%	0,396
50%	1,417
75%	4,158
90%	9,311

Source: HFCs 2010, 2014, 2017, 2021, own processing

As a preliminary step prior to regression analysis, we examine the pairwise correlations (Table 4) between the dependent variable and the explanatory variables. No strong linear relationship is observed between precautionary wealth and any single explanatory variable. The highest positive correlation is observed with private financial assets (PFA) ($\rho = 0.569$), highlighting the importance of liquidity in household financial resilience. In contrast, income is virtually uncorrelated with the buffer ($\rho = -0.028$), suggesting that earnings alone are a weak predictor of precautionary adequacy. As expected, net wealth and total wealth exhibit an almost perfect correlation ($\rho = 0.988$), while total debt is highly correlated with mortgage debt ($\rho = 0.983$), indicating potential multicollinearity issues. Among financial variables, nominal and real interest rates are strongly correlated ($\rho = 0.922$), reflecting their shared dependence on inflation.

Table 4 The Pearson correlation matrix of dependent and explanatory variables

	buffer	income	pfa	wealth	net_wealth	total_debt	mortgage_debt	other_debt
buffer	1,000							
income	-0,028	1,000						
pfa	0,569	0,318	1,000					
wealth	0,156	0,428	0,361	1,000				
net_wealth	0,164	0,410	0,359	0,988	1,000			
total_debt	-0,037	0,155	0,043	0,169	0,017	1,000		
mortgage_d	-0,028	0,151	0,045	0,165	0,015	0,983	1,000	
other_d	-0,053	0,036	-0,012	0,040	0,012	0,183	0,004	1,000
gender	0,023	-0,113	0,010	-0,021	-0,008	-0,083	-0,082	-0,013
age	0,088	0,142	0,097	0,175	0,204	-0,168	-0,165	-0,034
education	0,115	0,233	0,217	0,184	0,166	0,131	0,132	0,004
employed_m	-0,063	0,418	0,053	0,105	0,098	0,057	0,047	0,062
nom_ir_depo	-0,043	-0,161	-0,102	-0,106	-0,088	-0,128	-0,130	0,002
real_ir_depo	-0,082	-0,138	-0,086	-0,110	-0,094	-0,116	-0,121	0,016
ecb_main	0,013	-0,161	-0,066	-0,077	-0,059	-0,119	-0,119	-0,010
	gender	age	education	employed_members	nom_ir_deposits	real_ir_deposits	ecb_main	
gender	1,000							
age	0,038	1,000						
education	0,091	0,018	1,000					
employed_m	-0,146	0,031	-0,031	1,000				
nom_ir_depo	0,020	-0,261	-0,138	0,066	1,000			
real_ir_depo	-0,031	-0,196	-0,083	0,065	0,922	1,000		
ecb_main	0,118	-0,318	-0,119	0,049	0,818	0,591	1,000	

Source: HFCs 2010, 2014, 2017, 2021, own processing

The analysis begins with the estimation of the full regression model, which includes all explanatory variables. As reported in Table 5, this model explains approximately 39.6% of the variance in precautionary wealth (Adjusted $R^2 = 0.3964$). Several variables, such as the number of employed household members, net wealth, and mortgage debt, exhibit limited explanatory power. Multicollinearity is particularly pronounced for total wealth and nominal deposit interest rates,

with a variance inflation factor (VIF) of 229.11, indicating substantial distortion of coefficient estimates and undermining model reliability.

To address these issues, we developed a preferred model by excluding variables with either low statistical significance or high multicollinearity. Specifically, we removed net wealth, mortgage debt, the number of employed members, total wealth, and nominal interest rates on deposits. This specification substantially improves the multicollinearity profile, with the maximum VIF reduced to 1.28. Despite the reduction in variables, the preferred model retains strong explanatory power, with an Adjusted R² of 0.3873. Overall, this specification provides a statistically robust framework for identifying the key determinants of household precautionary wealth.

Table 5 Full, preferred, factor, and simplified OLS regression models. T-statistics in parentheses *p<0,1, **p<0,05, ***p<0,01

FULL			PREFERRED			FACTOR			SIMPLIFIED		
Variable	Buffer		Variable	Buffer		Variable	Buffer		Variable	Buffer	
income	-1.854	***	income	-1.781	***	income			income	-1.656	***
	(0,112)			(0,096)						(0,093)	
pfa	0.242	***	pfa	0.241	***	pfa			pfa	0.244	***
	(0,005)			(0,005)						(0,005)	
wealth	-0.059	**	wealth			wealth	0.009	***	wealth		
	(0,024)						(0,001)				
net_wealth	0.060	**	net_wealth			net_wealth			net_wealth		
	(0,024)										
total_debt	omitted		total_debt			total_debt	-0.022	***	total_debt		
							(0,005)				
mortgage_d	0.052	**	mortgage_d			mortgage_d			mortgage_d		
	(0,025)										
other_debt	omitted		other_debt			other_debt	-0.097	***	other_debt		
							(0,031)				
gender	-0.589	***	gender	-0.615	***	gender			gender		
	(0,216)			(0,217)							
age	0.052	***	age	0.059	***	age			age		
	(0,010)			(0,010)							
education	0.421	***	education	0.299	***	education			education		
	(0,090)			(0,089)							
employed_m	0.106		employed_m			employed_m			employed_m		
	(0,159)										
nom_ir_depo	7.368	***	nom_ir_depo			nom_ir_depo	-0.502	**	nom_ir_depo		
	(0,993)						(0,232)				
real_ir_depo	-2.511	***	real_ir_depo	-0.631	***	real_ir_depo			real_ir_depo	-0.599	***
	(0,267)			(0,086)						(0,086)	
ecb_main	-1.763	***	ecb_main	2.068	***	ecb_main			ecb_main	1.456	***
	(0,581)			(0,290)						(0,277)	
_cons	-6.323		_cons	1.002		_cons	3.840		_cons	2.125	
	(1,239)			(0,644)			(0,328)			(0,135)	
Adj R-squared	0.3964		Adj R-squared	0.3873		Adj R-squared	0.0313		Adj R-squared	0.3805	
VIF	229.11		VIF	1.28		VIF	1.04		VIF	1.34	

Source: HFCS 2010, 2014, 2017, 2021, own processing

To further mitigate dimensionality and multicollinearity concerns, we conducted an exploratory factor analysis. Applying the Kaiser criterion (eigenvalues greater than 1), we retained four factors, which together capture the underlying structure among the explanatory variables. Table 6 presents the corresponding factor loadings, with values below an absolute threshold of 0.2 omitted for clarity. Variables highlighted in grey are selected as representative indicators for each factor and subsequently used in the regression analysis to ensure interpretability.

Table 6 Factor loadings

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Uniqueness
income	0,46	0,30			0,44			0,481
pfa	0,31	0,24					0,22	0,758
wealth	0,65	0,69	-0,23					-0,001
net_wealth	0,60	0,68	-0,37					-0,001
total_debt	0,43		0,89					-0,001
mortgage_d	0,43		0,88					-0,001
other_debt				0,98				-0,001
gender					-0,23			0,868
age	0,25		-0,31					0,780
education	0,25						0,35	0,787
employed_m					0,48			0,680
nom_ir_depo	-0,76	0,62						0,012
real_ir_depo	-0,69	0,56				-0,32		0,054
ecb_main	-0,64	0,52				0,38		0,123

Source: HFCS 2010, 2014, 2017, 2021, own processing

Although the explanatory power of the factor model is limited (Adjusted $R^2 = 0.0313$), it offers the advantage of minimal multicollinearity, as indicated by a VIF of just 1.04. The results, reported in Table 5, illustrate the improved statistical stability achieved through dimensionality reduction.

The next stage of the analysis refines the preferred model to include only four most relevant explanatory variables. The simplified model retains two variables from the wealth domain (income and private financial assets), and two from the financial domain (the real interest rate on deposits and the ECB's main refinancing rate). Together, these variables capture both household-level financial capacity and broader financial conditions. Demographic variables are excluded, as they did not exhibit sufficient explanatory power in earlier specifications. The resulting model maintains strong explanatory power relative to the full and preferred model while preserving low multicollinearity.

In the final step, we assess the contribution of each variable to precautionary wealth by conducting an impact decomposition. This approach combines estimated regression coefficients with inter-percentile ranges, defined as the difference between the 90th and 10th percentiles of each variable. This method captures the effect of realistic changes across the central 80% of observations, providing a more intuitive and behaviorally meaningful interpretation. Absolute impacts are calculated by multiplying coefficients by the inter-percentile ranges, while relative impacts are expressed as percentages of the total impact across all variables. The preferred model is used for this analysis due to its optimal balance between simplicity and comprehensiveness.

Table 7 Impact decomposition of explanatory variables (10th-90th percentile changes)

	Buffer	
	absolute	relative
income	-4.02	23.37%
pfa	5.63	32.71%
gender	-0.62	3.58%
age	1.80	10.44%
education	0.60	3.48%
real_ir_depo	-2.48	14.41%
ecb_main	2.07	12.01%

Source: HFCS 2010, 2014, 2017, 2021, own processing

5 Conclusions

Precautionary wealth represents a cornerstone of sound personal financial management. It functions as a financial cushion, enhances household stability, and enables households to cope with unforeseen expenses without jeopardizing their overall financial health. This study is guided by the hypothesis that wealth-related variables, particularly the capacity to accumulate personal financial assets (PFA), play a central role in the formation of precautionary wealth. To test this hypothesis, we identify explanatory variables from three domains: wealth characteristics, demography attributes, and the financial environment. Using ordinary least squares (OLS) regression, we estimate four models: full, preferred, factor, and simplified. We further conduct multicollinearity diagnostics to ensure the robustness of the results, and the preferred model is used as the primary basis for interpretation due to its favorable balance between explanatory power and statistical stability.

The empirical findings indicate that PFA exhibit the strongest positive association with the level of precautionary wealth, accounting for 32.7% of the explained variance (see Table 7). This strong relationship reflects more than mere liquidity availability. Households that are able to accumulate PFA are likely characterized by higher financial literacy, more disciplined budgeting behavior, and greater awareness of the importance of maintaining a financial buffer. These results are consistent with Gerhard (2018), who emphasizes the role of financial self-discipline in shaping saving behavior. Income emerges as the second most influential determinant but displays a negative coefficient (−4.02), contributing 23.4% to the total explained variance. This finding suggests that rising income does not necessarily translate into a proportionally higher precautionary wealth, potentially due to lifestyle inflation, relative income considerations (Duesenberry's hypothesis), expanded access to credit, or a tendency of households to target a nominal buffer that becomes relatively smaller as income increases. Together, the two wealth-related variables explain over 56% of the model's explanatory power.

Among financial indicators, the real interest rate on deposits has a statistically significant negative effect (−2.48), while the ECB's main policy rate is positively associated with precautionary wealth. Collectively, financial variables account for nearly 30% of the explained variance. From a theoretical perspective, higher real interest rates should encourage saving by increasing purchasing power. However, the results suggest the opposite: when inflation declines and nominal interest rates remain unchanged, households tend to reduce their precautionary buffers. This pattern is consistent with behavioral responses, where lower perceived inflation reduces the perceived urgency to save (Carroll & Samwick, 1998). In contrast, the positive relationship between ECB policy rates and precautionary wealth aligns with classical monetary theory, according to which higher nominal rates raise the opportunity costs of consumption and thereby promote saving (Friedman's monetarist view). These findings support prior evidence indicating that households respond more strongly to nominal interest rates and perceived inflation than to abstract real rate calculations (Dirschmid & Glatzer, 2004; Bohdalová & Pažický, 2019).

Demographic variables, including age, gender, and education, exhibit comparatively weaker explanatory power, jointly accounting for less than 18% of the total variance. Among these factors, age plays the most prominent role, contributing more than 10%, in line with Modigliani's life-cycle hypothesis (Begg, 2011), which predicts systematic variation in saving behavior over the life course. Overall, the results provide further insight into the mechanisms underlying precautionary wealth accumulation and underscore the dominant role of wealth-related and financial variables relative to demographic characteristics.

In summary, the findings highlight that the primary driver of precautionary wealth accumulation is the household's ability to build and maintain personal financial assets. Rising income alone does not guarantee higher buffer levels, and real interest rates appear to have limited practical influence on household behavior. Instead, households tend to respond more strongly to visible nominal signals and media narratives surrounding inflation. Future research may extend this analysis by incorporating additional explanatory variables and by utilizing forthcoming data from the 2025 wave of the Household Finance and Consumption Survey.

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Typical Approaches to Family Businesses Financing in the Czech Republic in period 2020–2022

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Abstract: The main aim of this paper is to determine whether the analysed groups of family business units differ significantly in their financial indicators. We examined a selected sample of family businesses based on data from their financial statements for the period 2020–2022, obtained from the Albertina database. Our analysis included almost 500 family companies in the Czech Republic that provided data to Albertina for all three years under review. Family companies were identified according to typical approaches to family business financing in the Czech Republic. The monitored indicators include debt ratio, return on equity (ROE), and personnel costs as a percentage of total costs.

The cluster analysis identified three clusters of family firms. Each cluster was described according to reported accounting data, size, and sector of the main activity of the grouped enterprises. It is evident that family businesses listed in the Czech family business register are micro, small, and medium-sized enterprises; large businesses are not included in the register. The highest representation is in the manufacturing industry, mainly metal processing, which applies to all three clusters. In the cluster analysis, we focused on centroids (typical average companies in the cluster), which represent typical approaches to corporate financing. The approach of family firms to debt financing is crucial, as most firms are risk-averse and primarily use their own capital for financing.

Keywords: financial reports, corporate finance, Czech Republic, family business.

JEL Classification: G32, G33

1 Introduction

Family businesses are an important part of the Czech economy, but their exact number is unknown. In the European Union, family businesses account for approximately 60% of all businesses. The definition of a family business in the Czech Republic is derived from the EU definition. Czech family businesses can voluntarily register in the database of the Ministry of Industry and Trade of the Czech Republic (ASME, 2020). We selected companies from this database for our research. We also required more detailed financial data, which limited our selection. The financial data of the selected family businesses comes from the period 2020–2022 in the Albertina database. The family businesses analysed in this study are small and medium-sized enterprises with a single legal form: limited liability company.

The aim of our research is to derive the typical characteristics of the financial behaviour of family businesses. We assume that some family businesses may have a significant aversion to risk and debt financing, while others may appear to be very risky enterprises. It is interesting to examine the reasons for risky behaviour in family businesses, which may be influenced by the generation making financial decisions, errors in asset reporting, rapid company growth, foreign investments, and other factors. We assume that owners of family businesses place greater emphasis on the long-term financial security of their families than other companies. Caution and a conservative approach mean that the financial health of family businesses is usually very good, and the vast majority of family business owners plan to pass their businesses on to the next generation. This is confirmed by research and analysis conducted by the Association of Small and Medium-Sized Enterprises and Entrepreneurs of the Czech Republic (ASME CR, n.d.).

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Szymańska (2015) noted significantly fewer bankruptcies and poor financial decisions in family businesses compared to other entities. Martínez and Requejo (2017) studied the relationship between ownership concentration and company value and concluded that family control has a positive effect on performance as long as family members remain influential. The results of the study by Pindado, Requejo, and De La Torre (2015) show that the involvement of family members in management reduces the sensitivity of debt to cash flow fluctuations. Active management and family involvement make decision-making processes more flexible, which significantly helps family businesses balance their capital structures. The authors concluded that family firms with active first-generation participation in management and control exhibit a weaker negative effect of cash flows on debt.

In connection with the financial structure of family businesses, Molly, Laveren, and Deloof (2010) evaluated the effect of intergenerational transition on financial structure and performance over a 15-year period (1991–2006) with a sample of more than 2,000 observations. Their main findings were that transferring a family business to the second generation negatively affects its debt level, while in later transfers this effect tends to reverse. The analysis also showed that the growth rate of first-generation family businesses decreases after the transition, whereas no effect on growth was identified for later generations.

Gallucci, Santulli, and De Rosa (2017), based on 448 articles, examined how family business literature and financial issues interact. The authors found that classical financial theory could not be fully applied to family firms. At the same time, their research revealed that socio-emotional wealth could contribute to a new perspective on the interplay between family and business.

Michiels and Molly (2017) also addressed financial decision-making in family businesses. These authors state that 131 reviewed articles on financing decisions in family businesses demonstrate unconventional approaches to financing decisions. These theories point to the importance of maintaining control, risk aversion, non-financial goals, and values in owners' financial decision-making. These factors lead to a preference for internal sources of financing over external ones. A recent article by Vekemans, Michiels, Steijvers, and Molly (2025) addressed the issue of bank financing for the growth of family businesses. The approach of family businesses to banking products is highly heterogeneous and deserves closer examination.

Acedo-Ramirez et al. (2017) also confirm that many different factors influence the resulting capital structure of family businesses. Variables may differ between individual family businesses due to differences in size, life cycle stage, gender of the manager, generation, and other factors. Alphy and Ranajee (2024) state that classical financial theories have limited applicability in the case of family businesses. Zellweger (2017) also addresses the capital structure of family businesses in one of his chapters. Hansen and Block (2020) mention regional differences caused by legislative regulations and local conditions. Many factors influence the capital structure of family businesses, including social, cultural, regional, and family aspects.

The literature often focuses on comparing differences between family and non-family business units in various sectors: agriculture (e.g., Williams and Scott, 2024), tourism (Camison, Forés, and Puig-Denia, 2016), and manufacturing (Erбетта, Menozzi, Corbetta, and Fraquelli, 2013).

2 Methods

The data sample consists of companies that expressed interest in being listed in the database of the Association of Small and Medium-Sized Enterprises of the Czech Republic and were subsequently approved by the AMSP. Therefore, we consider these companies to be verified family businesses. At the time the financial data was collected, the family business database contained 1,224 entries. We have obtained financial statements for the year 2022 from 475 of these companies using the Albertina Gold Edition database. This means our sample represents nearly 39% of the total database. The sample includes two types of companies: limited liability companies dominate the dataset, with 447 entities accounting for 94.1% of the sample, while joint-stock companies make up the remaining 5.9%.

The sub-aim of the paper is to determine whether the analysed groups of family business units differ significantly in financial indicators (defined by the debt ratio, ROE, and personnel costs).

The evaluation is based on these three indicators and was performed using cluster analysis methods.

H0 – There are no statistically significant differences between the constructed clusters.

HA – There are statistically significant differences between the constructed clusters.

To assess the differences, three financial ratios were selected. All indicators are derived from data obtained from the Albertina database. Initially, 15 indicators were considered; however, several were excluded due to missing or inaccurate data, as well as high interdependencies identified through correlation and functional analysis. The final selected indicators are Return on Equity (ROE), Debt Ratio, and Personnel Costs.

ROE is defined as the ratio of net earnings to equity and serves as a standardized metric in ratio analysis. It reflects the efficiency of a company's management in generating profit from its own capital. In our tables, ROE is presented as an index, although percentage values are occasionally used in commentary. The debt ratio, calculated as total liabilities divided by total assets (also referred to as the debt-to-asset ratio), indicates the proportion of a company's assets financed through debt. A ratio below 0.5 suggests that most assets are financed through equity, whereas a ratio above 0.5 indicates a greater reliance on debt financing.

Personnel Costs, the third indicator, are calculated as the ratio of personnel costs to the total costs incurred by the company.

Methods and Evaluation of Results

The evaluation process followed several steps. A detailed description of the cluster analysis is available in Pražáková et al. (2025). After removing cases with missing values, the final dataset included 1,183 business unit observations from 2020 to 2022. Standardization was applied to ensure each variable had a mean of 0 and a standard deviation of 1, using the formula:

$$Z = \frac{(z - \mu)}{\sigma} \quad (1)$$

where z is the original value, μ is the mean, and σ is the standard deviation. This step is crucial, especially for distance-based algorithms like k-means or k-nearest neighbours, which are sensitive to variable scales.

Cluster Analysis

Cluster analysis aimed at grouping business units based on similarities in selected indicators. The optimal number of clusters was identified using Agglomerative Hierarchical Clustering (AHC). Results from various AHC methods consistently suggested three clusters for subsequent k-means analysis. This value was recommended by five out of nine tested combinations, including Euclidean distance with single linkage, complete linkage, or Ward's method, and Manhattan distance with single linkage or complete linkage. The division of companies into the appropriate number of clusters was performed using the k-means method, which has been demonstrated to yield more accurate results than AHC methods. The k-means algorithm grouped the 1,183 observations into three clusters based on the selected indicators. After three iterations, the final distribution was obtained.

Centroid Analysis

Each cluster's centroid represents the most typical observation, i.e., the one closest to the average values of the cluster. In our case, this is the company that most accurately reflects the typical characteristics of the given cluster. The use of the centroid in determining cluster parameters provides a more precise depiction of the nature of the companies while incorporating elements of in-depth qualitative analysis.

Statistical Evaluation of the Clusters

Given the nature of the data, non-parametric methodologies were employed. The Kruskal-Wallis's test, a rank-based alternative to one-way ANOVA, was applied to assess whether the clusters differed significantly from each other. The null hypothesis that all samples originate from the same distribution or share the same median was tested (Siegel & Castellan, 1988). The mutual differences among the clusters were subjected to statistical testing. Due to the characteristics of the dataset, the Kruskal-Wallis statistical test was used. Based on the p-values of the pairwise comparisons of measures used for cluster construction, significant differences (at the 0.05 significance level) were found for almost all combinations. The only exception was the ROE indicator in the comparison between clusters 2 and 3. Based on these results, we can reject H_0 and confirm the differences between clusters.

3 Research Results

One of the sub-goals is to organize the data from the Albertina database. We used data from the period 2020–2022 obtained from the Albertina database. Only selected sectors from CZ NACE were included. The representation of the manufacturing industry within family businesses can be specific and unique in the Czech Republic. We selected industries that are significant for our sample or that we assumed would be significant.

3.1 Cluster Analysis

The results of hierarchical clustering indicated the optimal number of clusters. Therefore, we divided the dataset into three clusters for the k-means clustering method. The total of 1,183 observations was divided into three clusters in the following ratio: Cluster 1 covers 49%, Cluster 2 covers 33%, and Cluster 3 covers 18%. Cluster 1 is the largest, containing 580 observations, followed by Cluster 2 with 389 observations, and finally Cluster 3, which contains 214 observations (see Table 1). The average distance from the cluster mean is almost comparable in Clusters 1 and 2, with only a slight difference. In contrast, Cluster 3 has an average distance that is nearly one-third higher. The range of centroid distance and the maximum cluster distance is lowest in Cluster 2, followed by Cluster 3 and Cluster 1. The names of the individual clusters reflect the typical characteristics of each cluster.

Table 1 Characteristics of Defined Clusters

Characteristics	Cluster 1	Cluster 2	Cluster 3
Size	580	389	214
Minimal distance (centroid distance)	0.070	0.040	0.120
Average distance of the cluster	0.544	0.578	0.797
Maximum distance from centroids	5.790	1.650	4.900
Debt ratio	0.5371	0.4394	0.0814
ROE	0.0652	0.1988	0.3142
Personnel costs to the total costs	0.0814	0.3541	0.2076

Source: Own calculation in STATISTICA 12 SW

Cluster 1 – Enterprises with Low Return on Equity and Higher Liabilities

Micro-enterprises predominate in Cluster 1, accounting for 80% of the total number of enterprises. The next largest segment comprises small enterprises, which account for 17.9% of all selected enterprises. Medium-sized enterprises constitute just over 2% of the total. Companies in this cluster achieve the highest nominal cost of goods sold or service delivery, averaging CZK 4.8 million. Furthermore, these companies have a ratio of personnel costs to total costs of approximately 8%. Consequently, this is a technologically demanding industry with a lower proportion of human labour. This hypothesis is supported by the observation that the added value of this cluster is the lowest compared to the other two clusters (approximately one-third of the latter). The average debt ratio was slightly above 0.5, indicating that liabilities exceeded equity by 3.7% on average. Regarding debt, this group's performance is median, while its equity performance is significantly lower than that of the other groups. When compared to Cluster 2, it ranks third and does not approximate the values observed in Cluster 3.

Cluster 2 – Enterprises with High Equity and Retained Earnings

The largest group in Cluster 2 is micro-enterprises, accounting for 60%; small enterprises account for almost 36%, which is the highest proportion compared to other clusters. Medium-sized enterprises account for 4% of all business entities. The largest group in Cluster 2 is manufacturers, who make up 43% of the entire cluster (17% in the metalworking industry and 13% in unspecified manufacturing activities), followed by wholesalers and retailers, each representing 19%. It is evident that companies within Cluster 2 primarily fund their operations through self-generated resources. This is related to the highest ratio of retained earnings to total assets (more than 34%) compared to other clusters. Group 2 achieved average retained earnings in millions of CZK, which is double the value of Group 1 and almost triple that of Cluster 3.

Cluster 3 – Enterprises with the Most Debt

The composition of this cluster is as follows: 72% micro-enterprises, 26% small enterprises and less than 2% medium-sized enterprises. The predominant economic sectors in this region are manufacturing (38%), wholesale and retail trade (28%), and construction (17%). This cluster has the highest average level of debt financing, with an average value of 81%. This is also related to the relatively high ROE (31.4%), which reaches such elevated values due to the low level of equity. The return on assets (ROA) indicator can facilitate comprehension of the situation. The indicator on average achieves a rate of 5.3%, which is almost double that of cluster 1 (2.8% ROA). Consequently, retained earnings are at their lowest in this group, averaging approximately 11% of the company's total assets. It has been demonstrated that an increased level of debt can assist in enhancing a company's profitability the effective utilisation of its assets. The present study thus confirms the effect of financial leverage. Group 3 also has the highest total costs, exceeding CZK 45 million, and the total assets of the companies exceed CZK 51 million on average.

In conclusion, the representation of micro, small, and medium-sized enterprises in the clusters is similar. Micro-enterprises account for 60–80% of a cluster, small enterprises for 18–36%, and medium-sized enterprises for 1–4%. A similar situation occurs regarding the representation of industries in the clusters. This indicates that the size of the enterprise and the industry have no significant impact on its financial approaches.

4 Centroids

Centroids, sometimes referred to as typical observations of the cluster, have the lowest distance from the cluster mean. In our research, a centroid represents the company closest to the average values of the cluster, i.e., a typical representative. In our study, the evaluated companies are labelled only with a serial number due to anonymization. All three centroids are limited liability companies with paid-in capital of CZK 200,000.

Table 2 The Characteristics of Centroids

	Cluster 1	Cluster 2	Cluster 3
Variables	C156	C525	C246
Debt Ratio	0.4972	0.3748	0.9345
ROE	0.0232	0.2410	0.5552
Personnel Costs to the total costs	0.05713	0.3701	0.1234

Source: Own processing in STATISTICA 12 SW

Cluster 1 is represented by the company labelled C156 (see details in Table 2). The company is engaged in the construction of buildings for business and housing and is based in a village with fewer than 10,000 inhabitants in the Zlín Region. The company was founded in 2004 and has maintained a stable ownership structure since then. It has remained in the hands of the original founder without any record of changes in the register (justice.cz). The recalculated number of employees was around 35 full-time workers, and with respect to the average total assets of the company, we can classify it as a small enterprise. The annual sales turnover exceeded CZK 418 million; retained earnings do not exceed 49%, and the value added is around the cluster mean.

Compared to the average values of Cluster 1, the centroid achieves lower values in all three monitored measures (see Table 2 above). Like most companies in this cluster, it focuses on business with lower value added but requires a technological background and uses a considerable amount of fixed assets.

For Cluster 2, the typical observation (company C525) is a business founded in 2012 that produces knives. Knife production is one of the typical areas of family businesses that originated from traditional trades. Companies in Cluster 2 report the highest ratio of personnel costs to total costs. These facts are related to the range of products, which includes items requiring precise individual adjustments and manual work. The company was founded in 2012 by a founder, who later involved other family members in the business. His daughter and son became partners in 2020. Currently, the original founder owns 50% of the business, while his children own the other half (the daughter 40% and the son 10%). This family business has successfully resolved succession, at least for this generation. Handing over the business to the next generation has become a commonly researched topic in this field and remains an existential challenge for many family businesses.

The company is based in the South Bohemian Region in a village with fewer than 1,000 inhabitants. With nearly 90 employees, it is an important local employer. Annual sales turnover exceeded CZK 108 million (in the last observed period), and total assets increased by 5% in each of the three periods evaluated. The company's debt ratio is less than 38%. An analysis of the debt structure shows that the company uses only short-term liabilities. Most of these debts are liabilities to suppliers, followed by liabilities to employees and the state. Regarding liabilities to credit institutions, the company uses only a short-term operating loan. Therefore, we conclude that company C525 finances its activities mainly from its own resources, which corresponds to the value of retained earnings (51% of total assets).

It can be assumed that if the company used debt financing, it would increase its overall profitability and thus facilitate and accelerate development. However, we do not know the strategy or long-term goals of the owners, so the use of debt financing cannot be clearly recommended. The reason for not using external sources may not only be the lack of need but also a possible fear of indebtedness and exposing the family business to risk.

Companies in Cluster 3 have a completely different approach to financing. Compared to the cautious and protective financing method of the previous cluster, these companies are not afraid of debt financing. The average value of external capital in the cluster is around 81%, and the company with the lowest distance from the cluster means even reaches a value of over 93%.

The company C246 (the centroid of Cluster 3) was founded in Prague in 2001. Its main activity is the production of custom-made wooden products, and it employs five people. Annual sales turnover reaches almost CZK 20 million (during the last three years), and the average total assets for the last three monitored periods slightly exceed CZK 46 million.

The company C246 originally had two founders; only one remains and has brought his brother into the family business. At present, both partners hold equal shares.

With a very high debt ratio, low productivity, and accumulated losses from previous years, this company can be described as financially problematic. The problematic financial situation has persisted for a long time, as evidenced by insolvency proceedings initiated in 2011 at the proposal of one of the creditors. Although the proceedings were stopped by the court and the company later fulfilled its obligations, this is not a good signal for business partners and certainly affects the company's reputation.

Although the stated ROE value is by far the highest compared to the other clusters, it is caused by a very low equity ratio. In this case, it would be more appropriate to use ROA, which is 3.6%, incomparably lower than the 55% ROE.

5 Conclusions

As is demonstrated in the relevant literature, two partial contractionary views can be identified in the academic discourse concerning the relative use of debt by family firms compared to other types of companies. The first strand of theoretical research highlights the risk aversion of family firms due to their owners' low wealth diversification and argues that family firms avoid debt because of the accompanying increased bankruptcy risk (Mishra & McGonaghy, 1999; Anderson & Reeb, 2003). The second perspective, as articulated by Croci, Doukas, and Gonenc (2011), posits that family firms tend to favour debt as a financial strategy that does not dilute ownership structures, as opposed to raising new equity capital for the purpose of business development.

Both approaches to debt financing are reflected in our study. Firms in Cluster 2 exhibit low debt ratios, while those in Cluster 3 display very high levels of debt financing. In conclusion, the present study lends support to the initial theory, as evidenced by the observation that Cluster 1 also demonstrates a propensity for reduced debt. Consequently, it can be concluded that family businesses in our sample generally exhibit a tendency to maintain low levels of debt. Moreover, it has been shown that company size and industry do not necessarily influence the financial strategies of family firms. Hansen and Block (2020) confirmed that the risk aversion of family businesses is associated with lower debt ratios.

The research results reflect only those businesses that have voluntarily enrolled in the ASME family business register. Consequently, other family businesses are not included. With few exceptions, the companies in the sample are not subject to audit. Therefore, the veracity, accuracy, and completeness of the reported information are difficult to corroborate. It is also important to note that family businesses include a significant number of entrepreneurs who do not maintain accounting records at all. This is consistent with the paucity of detailed economic studies in this area. The utilisation of the obtained data was primarily motivated by the necessity to conduct the most comprehensive analysis possible within the limitations imposed by the scope of this contribution.

Future research will seek to augment the existing dataset, both in terms of the number of family business units and the duration of the research period. Additionally, the foreign comparison will be expanded. Further analysis of family businesses in the Czech Republic would be warranted, with a focus on the correlation between financial and functional analysis.

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The Use of Artificial Intelligence in Accounting Auditing

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Abstract: This article examines the growing role of artificial intelligence (AI) in accounting auditing, the opportunities it presents, methodologies, and challenges encountered from an academic perspective. With the proliferation of Industry 4.0 and big data, sampling-based approaches used in traditional auditing are becoming insufficient, creating a need to analyze the entire data universe. In this context, AI provides auditors with unprecedented capabilities to detect fraud, errors, and irregularities within large data sets, forming the basis of the “Audit 4.0” paradigm. The article addresses the three main areas of AI application in auditing—process automation, risk assessment, and decision support systems—within a theoretical framework. Anomaly detection-focused unsupervised learning methodologies, particularly clustering analysis and deep learning-based autoencoder architectures, are examined at a technical level. However, the practical application of AI also brings significant challenges, such as data imbalance, the interpretability of complex models (the “black box” problem), and potential biases in algorithms. As solutions to these challenges, Explainable Artificial Intelligence (XAI) techniques and the concept of “Trustworthy Artificial Intelligence” are discussed. In conclusion, it is emphasized that AI is not a technology that eliminates the auditor, but rather an “augmented intelligence” tool that enhances their capabilities. It is noted that the auditor's role is transforming from manual data verification to that of an expert who interprets AI models and oversees algorithmic systems. This transformation will shape the future of the auditing profession.

Keywords: artificial intelligence in auditing, AI in accounting, audit 4.0, AI auditing, intelligent auditing systems

JEL Classification: M40, M42, C55, O33, D83, J24

1 Introduction: Digital Transformation in the Auditing Profession

The digitalization process triggered by Industry 4.0 is fundamentally transforming the accounting and auditing profession (Erdoğan, 2019). The increasing level of digitalization in businesses has led to the production of data at unprecedented volumes, diversity, and speed. This phenomenon, known as “Big Data,” has called into question the effectiveness of sampling-based methods, which form the basis of traditional auditing (Warren et al., 2015). Facing data sets consisting of millions or even billions of transactions, drawing a general conclusion based on a small sample increases the risk of overlooking significant errors and fraud. This situation has given rise to the need for a new paradigm that directs auditors to analyze the entire data population (universe). This new approach is expressed by the concept of “Audit 4.0,” which integrates Industry 4.0 technologies into audit processes (Erdoğan, 2019).

Artificial intelligence (AI) is at the heart of this new auditing paradigm. AI-based analytical models offer auditors unprecedented capabilities to detect anomalies, fraudulent transactions, and complex patterns of irregularities hidden within large data sets (Serçemeli, 2018). Thanks to these technologies, auditing has the potential to evolve from a reactive, periodic process into a continuous and proactive assurance mechanism (Issa et al., 2016). Auditors can now focus on more complex and judgmental areas by interpreting the findings generated by AI systems, rather than manually verifying the accuracy of data.

The purpose of this article is to outline the theoretical framework for the use of AI in accounting auditing, examine its main areas of application and the methodologies used in these areas. In addition, the technical and ethical challenges encountered during the implementation of AI models will be addressed, and the potential impact of these technologies on the future of the auditing profession will be assessed. The following sections of the article will examine, in turn, the role and application areas of AI in auditing, fundamental technical methodologies, challenges in implementation, and ethical considerations, concluding with a perspective on the future of the profession.

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2 Theoretical Framework: The Role of Artificial Intelligence in Auditing and Its Application Areas

The integration of artificial intelligence into the auditing process is not merely about adopting a set of technological tools; it also provides a conceptual framework that redefines the fundamental logic, scope, and assurance level of auditing. AI enables auditors to analyze large data sets more deeply, revealing risks and anomalies that are difficult to detect using traditional methods. Based on the results of a literature review conducted on the SCOPUS database, the conceptual framework created by Firat (2025) summarizes AI's role in auditing under three main headings: process automation, risk assessment, and decision-making.

These three fundamental areas of application can be explained as follows:

- **Process Automation:** AI plays a key role in automating routine and repetitive auditing tasks. Using techniques such as Big Data analysis and Process Mining, tasks such as reviewing millions of journal entries or purchase orders, reconciling accounts, and performing standard controls can be performed at high speed and accuracy without human intervention (Jans et al., 2014). This automation allows auditors to devote their time to more complex, judgmental, and strategically important areas. More importantly, this transformation changes the nature of audit evidence; evidence evolves from manual verification and confirmation to system-level assurance and algorithmic controls. This fundamentally affects the auditor's control risk assessment.
- **Risk Assessment:** While risk assessment in traditional auditing relies heavily on the auditor's experience and sample results, AI makes this process data-driven and proactive. Machine Learning and Data Analysis algorithms scan the entire transaction population to detect transactions that deviate from "normal" behavior patterns (anomalies) (Chandola et al., 2009). The qualitative difference brought by this approach is the potential to reveal "unknown unknowns" that the auditor's experience cannot predict, rather than focusing only on known risk areas. AI enables the identification of high-risk areas with potential for fraud or error before they cause significant damage, even detecting previously unencountered fraud scenarios (Schreyer et al., 2019).
- **Decision Making:** AI is positioned as a tool that supports the auditor's professional judgment rather than replacing it. Technologies such as Fuzzy Neural Networks and Expert Systems assist auditors in decision-making processes by modeling complex scenarios and analyzing possible outcomes (Lin et al., 2003). For example, an expert system can analyze hundreds of different financial and non-financial indicators to provide a fraud risk score. This score serves as a baseline or "second opinion" for the auditor, forcing them to justify deviations from their own judgment. This process enhances the robustness, defensibility, and ultimately the quality of professional judgment.

The integrated use of these application areas has the potential to transform the nature of audit assurance. AI's ability to analyze the entire data universe has the potential to shift the level of assurance provided by the audit from "reasonable assurance" to "full assurance" (Varol, 2023).

3 Artificial Intelligence-Based Audit Methodologies

Understanding "how" artificial intelligence is used in auditing requires examining the technical methodologies that enable the theoretical framework to be translated into practical application. One of the most fundamental challenges in accounting and auditing is the scarcity of labeled and verified data sets related to fraudulent transactions. The vast majority of financial data sets consist of "normal" transactions, while fraudulent transactions constitute a very small portion of this set (Ali et al., 2022). This situation limits the effectiveness of supervised learning algorithms. Therefore, unsupervised learning and anomaly detection approaches, which do not require labeled data, are predominantly used in auditing applications (Chandola et al., 2009). These approaches focus on identifying outliers that do not conform to the general patterns learned from the dataset.

3.1 Clustering-Based Methods

Clustering is one of the most fundamental approaches in unsupervised learning and is widely used for anomaly detection in auditing. The basic logic of this technique is to create natural structures within the data by grouping (clustering) accounting transactions or records with similar characteristics (Thiprungsri & Vasarhelyi, 2011). For example, using algorithms such as K-Means, journal entries can be divided into clusters based on characteristics such as transaction amount, related accounts, and recording time. At the end of this process, clusters containing very few transactions (small populations) or located far from the centers of other clusters are considered suspicious and flagged for the auditor's review (Duan et al., 2009). This method provides an effective starting point for detecting anomalies hidden among similar transactions.

3.2. Deep Learning-Based Methods: Autoencoder Architecture

Deep learning, particularly the Autoencoder neural network architecture, has emerged as a powerful tool for anomaly detection in auditing. An Autoencoder is essentially a neural network that learns to compress data into a representative form (encoding) and then reconstruct the original data from this representation (decoding) (Schreyer et al., 2019). This model is trained solely on accounting records deemed “normal.” During the training process, the model learns the underlying patterns and relationships of normal transactions and successfully represents them in a low-dimensional latent space (Hawkins et al., 2002).

When presented with a new accounting transaction, the trained model attempts to compress and reconstruct it. If the transaction fits a “normal” pattern, the model can reconstruct it with a low error rate. However, if the transaction has an “abnormal” feature that deviates significantly from previously learned patterns (e.g., an unseen account combination or an unusual amount), the model struggles to reconstruct it and produces a high “reconstruction error” (Sweers, 2019). This high error is considered a strong signal that the transaction is anomalous. The greatest advantage of autoencoders is their potential to detect even previously unencountered and undefined fraud scenarios.

3.3. Other Statistical and Machine Learning Methods

AI methodologies used in auditing are not limited to clustering and autoencoders. In rare cases where labeled data is available, supervised classification algorithms such as Decision Trees, Support Vector Machines (SVM), and Random Forest can also be used to distinguish between fraudulent and normal transactions (Ali et al., 2022; Biau & Scornet, 2016).

A more innovative approach is the application of Social Network Analysis (SNA) metrics to audit data. In this method, the relationships between transactions are modeled as a network graph. For example, the parties involved in a transaction (customer, seller, employee) can be represented as nodes, and the money transfer between them as edges. Metrics calculated on this network, such as PageRank or degree centrality, can be used as features to identify actors that are unusually connected or centrally located within the network (Ball et al., 2023). These metrics are particularly effective in revealing hidden relationships and key players in organized fraudulent activities involving multiple actors.

While these methodologies, particularly deep learning models such as Autoencoders, offer unprecedented power in anomaly detection, the complexity of these models poses significant challenges in terms of interpretability and reliability. The “black box” problem, which must be addressed before they can be fully trusted in a high-stakes field such as auditing, is at the forefront of these challenges

4 Challenges in Implementation and Ethical Considerations

The integration of artificial intelligence (AI) technologies into audit processes offers revolutionary opportunities for detecting errors and fraud by increasing data processing capacity. However, a review of the existing literature and application examples reveals that the focus has been on the technical success of the technology, while the impact of AI on the structural, ethical, and legal foundations of the audit profession has not yet been sufficiently researched. This study examines critical areas that still require in-depth research in auditing literature and practice, such as the interpretability of algorithms, legal liability, professional independence, and ethical biases.

Successfully integrating artificial intelligence models into audit processes is not merely a technical achievement. This process also brings with it serious challenges related to data, models, and ethics that must be overcome. Properly managing these challenges is critical to the reliability and acceptability of AI-based auditing.

4.1. Imbalanced and Quality of Data

One of the most prominent characteristics of financial datasets is the extreme imbalance between classes (highly imbalanced dataset). The number of normal (non-fraudulent) transactions can be millions of times greater than fraudulent transactions (Ali et al., 2022). This poses a serious problem for training machine learning models. Since the model constantly sees normal transactions during training, it becomes overly focused on learning this class and tends to disregard the rare fraudulent transactions as “noise” or “outliers.” As a result, the risk of the model failing to detect fraudulent transactions, i.e., producing “false negatives,” increases significantly (Khoshgoftaar et al., 2010). From an auditing perspective, missing or failing to detect fraud can lead to unacceptable consequences, making data imbalance a fundamental challenge that must be addressed with specialized techniques (e.g., resampling or cost-sensitive learning) during model development.

4.2. Algorithmic Bias, and Data Privacy

AI models can learn biases from the data they are trained on, which can lead to unfair or incorrect outputs in audit results. Algorithmic bias can undermine trust in audit processes (Ağdeniz, 2024). In particular, whether data collected during an audit can be used for model training (purpose change) creates an ethical dilemma (ICAEW, 2024).

The confidentiality of customer data and the protection of trade secrets are at risk during the training of AI models. The lack of regulatory frameworks to ensure a balance between data privacy and algorithmic transparency necessitates increased academic and practical work in this area (ISACA, 2018; cited in Ağdeniz, 2024).

4.3. The “Black Box” Problem and Explainability (XAI)

Complex AI models such as deep learning, despite offering high accuracy rates, are often characterized as “black boxes.” This means that the model cannot provide a clear explanation of which factors it relied on and what logical sequence it followed to arrive at a particular decision or prediction. This situation is unacceptable for the auditing profession, as auditors must defend and justify their findings and conclusions to clients, regulatory bodies, and even courts (Firat, 2025). An AI model flagging a transaction as “suspicious” is insufficient as audit evidence unless the underlying “reason” can be explained.

The field of Explainable Artificial Intelligence (XAI) has developed as a solution to this problem. XAI techniques such as LIME (Local Interpretable Model-agnostic Explanations) and SHAP (SHapley Additive exPlanations) aim to make the decisions of black box models interpretable (Ribeiro et al., 2016; Lundberg & Lee, 2017). These techniques analyze why the model flagged a particular transaction as suspicious and present the auditor with how each feature of the transaction (e.g., transaction amount, time, related account) contributed to this decision and to what extent (Ball et al., 2023). This allows the auditor to translate the AI's “intuition” into a concrete and defensible rationale.

While research has demonstrated the technical success of methods such as unsupervised anomaly detection, there is a lack of guidance on how these results should be presented to auditors and how they should be integrated into the audit process (Nonnenmacher & Marx Gómez, 2021). The limited interpretability of the results undermines transparency and has the potential to create problems in regulatory reviews (Sattarov, Herurkar, & Hees, 2022). Therefore, how explainable artificial intelligence (XAI) techniques can be applied in the context of financial auditing is an area requiring urgent research (Manoharan et al., n.d.).

4.4. Trustworthy Artificial Intelligence and Algorithm Auditing

AI models carry the risk of learning and reproducing existing biases and prejudices in the data they are trained on. For example, if transactions belonging to a certain demographic group have been scrutinized more closely in past data, the AI model may learn this bias and disproportionately focus on transactions belonging to that group in the future. This situation may violate fundamental ethical principles such as fairness, transparency, and accountability (Munoko et al., 2020). These risks necessitate the adoption of “Trustworthy AI” principles in auditing. Trustworthy AI is a framework that aims to ensure that systems operate in a manner that is compliant with laws and ethical norms, robust, and reliable (Ağdeniz, 2023).

This new paradigm also expands the role of the auditor. Auditors are now responsible not only for auditing financial data and processes but also for auditing the AI algorithms that analyze this data. This new field, called “algorithm auditing,” aims to ensure that algorithms are fair, do not increase biases in data, and function as expected (Ağdeniz, 2023; Bandy, 2021).

4.5. Responsibility and Accountability in Automated Results

The question of who bears legal and professional responsibility when AI systems produce erroneous results remains a gray area in the literature. A recent incident at Deloitte, which resulted in AI producing erroneous references (“hallucinations”), has highlighted the risks of this technology. Discussions following this incident emphasized that AI cannot be held responsible for its work and that ultimate responsibility lies with humans (Vietnam.vn, 2025).

However, the risk that auditors may reach erroneous judgments if they place excessive trust in evidence produced by AI, and consequently be held liable in court, is an important legal dimension that needs to be explored (Özçetin, 2022). The issues of whether robots or autonomous software should be given a legal status such as “electronic person” and how the hierarchy of responsibility (software developer, user, auditor) should be established in the event of damage represent a major legal and ethical gap (Erdoğan, 2019).

4.6. Impact on Auditor Professional Independence and Competence

The inclusion of AI in audit processes may pose threats to auditor independence and professional skepticism. The extent to which external auditors can rely on businesses' own continuous monitoring systems or AI algorithms is debatable in terms of the independence principle (Firat, 2025). If the auditor becomes overly dependent on the client's system or shows a tendency to accept the results provided by AI without questioning them, this may lead to an erosion of professional skepticism (Özçetin, 2022).

Furthermore, although the International Ethics Standards Board for Accountants (IESBA) is working to develop ethical rules for the use of technology by professionals, whether auditors have the technological competence to evaluate AI outputs and how this competence gap affects audit quality requires further research (ICAEW, 2024).

A review of the literature reveals a broad consensus that AI increases efficiency in auditing; however, beyond the “how” of implementing the technology, there are significant gaps in the “how to manage it” and “how to oversee it.” In particular, explainability, legal liability sharing, safeguarding auditor independence, and data ethics are key areas that future research should focus on for the reliable adoption of the technology.

Overcoming these challenges is critical for AI to evolve beyond being merely a technological innovation in the auditing profession and become a reliable and valuable tool. These efforts will also shape the future role and competencies of the auditing profession.

5 Artificial Intelligence in Audit and Financial Analysis: Current Applications and Research Findings

Digitalization and Industry 4.0 processes have led to fundamental changes in the audit and finance sectors. Particularly in the post-2020 literature, studies focusing on the integration of artificial intelligence (AI) algorithms into error detection, customer loss prediction, and continuous auditing processes are noteworthy. In this section of the study, several recent applications and research studies added to the literature are analyzed in the context of the work, findings, and results.

A report prepared for the Australian government examined the outputs of the Generative AI model used by Deloitte. Following this incident, the AI usage policies of major audit firms such as EY, KPMG, PwC, and BCG were reviewed. The report prepared by Deloitte found that the AI generated three references that did not actually exist and a fabricated Federal Court citation (“hallucination”). It was emphasized that artificial intelligence cannot be held solely responsible, and that the ultimate responsibility lies with humans; the audit giants have adopted strict rules requiring AI outputs to undergo human review (Vietnam.vn, 2025).

Firat (2025) examined the transformative role of artificial intelligence in the auditing profession through a qualitative study based on secondary sources. The study focused on the impact of machine learning technologies on risk assessment, anomaly detection, and continuous auditing. It was found that AI technologies can identify patterns that may be overlooked in manual audits by processing large data sets, but they also carry risks such as data privacy, the “black box” problem (lack of explainability), and ethical biases. It was concluded that AI provides speed and accuracy in auditing, but regulatory frameworks and auditor competencies (skill sets) need to be developed for the effective use of these technologies (Firat, 2025).

Ball, Krüger, and Drevin (2023) proposed a “unified approach” to detect anomalies in financial transactions. In the study, a model was trained by combining autoencoder neural networks with Social Network Analysis (SNA) metrics. SHAP (Shapley Additive Explanations) analysis revealed that network metrics such as “PageRank” and “degree centrality” were the features that contributed most strongly to anomaly detection. Enriching transactional data with network metrics reduced the model's false positive rates and yielded successful results that reduced operational costs in fraud detection (Ball, Krüger, & Drevin, 2023).

Özcan, Kayapınar, and Adem (2023) predicted customer churn using Random Forest, Decision Tree, Logistic Regression, Gaussian, and K-Nearest Neighbor (KNN) algorithms on a 10,000-record bank customer dataset. The models were tested with hyperparameter optimization. Among the compared algorithms, the Random Forest algorithm showed the highest success with an accuracy rate of 84%. Logistic Regression, on the other hand, showed the lowest performance with 71%. It was concluded that tree-based algorithms (especially Random Forest) are more successful than other methods in analyzing banking data and can be used as an effective tool in preventing customer churn (Özcan, Kayapınar, & Adem, 2023).

Gür (2023) designed a Python-based application system for detecting fraudulent disbursements in businesses and used the Decision Tree algorithm. The study was conducted on an artificial dataset consisting of normal and fraudulent transactions belonging to a bank. The decision tree model demonstrated high success, achieving 97.1% accuracy, 98.4%

F1-score, and 98% sensitivity. It was determined that the designed system allows auditors to make meaningful selections based on machine learning outputs instead of random document selection and speeds up the fraud detection process (Gür, 2023).

Sattarov, Herurkar, and Hees (2022) proposed a framework using a “Denoising Autoencoder” to detect errors in complex financial data (e.g., Investment Funds Statistics). The model aims not only to find anomalies but also to explain which cell (column) the error originated from. The developed DAE (Denoising Autoencoder) model showed 5% to 30% higher performance in cell-based error detection compared to traditional autoencoders and principal component analysis (PCA). It was concluded that the model can answer the questions “why is it an anomaly?” and “what should be in its place?”, thus providing an explainable tool that overcomes the “black box” problem for auditors and domain experts (Sattarov, Herurkar, & Hees, 2022).

Hemati, Schreyer, and Borth (2022) proposed a “Continual Learning” framework to solve the problem of catastrophic forgetting, where AI forgets old information while being trained on new data in continuous auditing scenarios. The study was tested on Philadelphia and Chicago city payment datasets. The Experience Replay (ER) method outperformed the sequential fine-tuning method and reduced false positive alarms. The proposed framework has been proven to be more sustainable and transferable than existing methods for anomaly detection in non-stationary (time-varying) financial data (Hemati, Schreyer, & Borth, 2022).

Gür and Tarhan Mengi (2022) comparatively analyzed Decision Tree, Support Vector Machine (SVM), Logistic Regression (LR), and Artificial Neural Networks (ANN) methods on a 594,643-row bank dataset. The Decision Tree algorithm was the fastest and most successful model, with an accuracy rate of 99.42% and a processing time of 1.32 seconds. In contrast, the recall rates of the SVM and LR models remained low at 24% and 43%, respectively. It was found that time is critical in fraud detection and that the Decision Tree algorithm outperforms other methods in detecting fraudulent transactions in terms of both speed and accuracy (Gür & Tarhan Mengi, 2022).

Ali et al. (2022) analyzed machine learning techniques used in financial fraud detection by reviewing 93 articles published between 2010 and 2021. They determined that the most frequently used methods were Support Vector Machines (SVM) and Artificial Neural Networks (ANN), and that the most studied type of fraud was credit card fraud. However, it was found that unsupervised learning methods such as clustering were not sufficiently used in the literature. It was suggested that future studies should focus on text mining (Word2Vec, BERT, etc.) and unsupervised learning techniques (Ali et al., 2022).

Aksoy (2021) used data from 88 companies listed on the Istanbul Stock Exchange to predict financial statement fraud a year in advance using ANN, Decision Trees (CART), SVM, and Logistic Regression models. Artificial Neural Networks (ANN) and Decision Trees (CART) achieved a 96.15% overall accuracy rate by correctly classifying 100% of the fraudulent companies in the test set. The success rate of SVM and Logistic Regression remained at 80.77%. It was concluded that ANN and CART methods are highly effective in predicting fraudulent financial reporting and can be used by auditors as an early warning system (Aksoy, 2021).

6 Conclusion and Future Perspective

The findings examined in this article reveal that artificial intelligence is a force fundamentally transforming accounting auditing. AI is shifting auditing from a sampling-based approach relying on a limited data set to a technology-supported, risk-focused, and proactive paradigm that analyzes the entire data population. Through process automation, advanced risk assessment, and decision support systems, AI significantly increases the efficiency, accuracy, and scope of auditing.

One of the most important outcomes of this transformation is the redefinition of the auditor's role. The auditor of the future will no longer be someone who spends most of their time performing manual data checks and routine tests. Instead, they will become an expert who interprets the complex analysis results produced by AI models, thoroughly investigates the exceptional cases flagged by algorithms, and, most importantly, audits the fairness, transparency, and reliability of these algorithmic systems. This new role will require advanced competencies such as data science, statistical analysis, critical thinking, and ethical judgment, and will increase the auditor's professional value (Erdoğan, 2019).

Looking ahead, the impact of AI on auditing will deepen. With the proliferation of concepts such as continuous auditing and continual learning, auditing will evolve from a periodic activity into a real-time assurance mechanism integrated into the enterprise's systems (Hemati et al., 2022). AI models will be able to instantly adapt to changing business processes and emerging risks by continuously updating themselves with new data. Ultimately, artificial intelligence is not a technology that eliminates the auditor, but rather an “augmented intelligence” tool that enhances their perception, analytical ability,

and judgment. This collaboration will solidify the future of the auditing profession by providing stakeholders with deeper and more timely assurance than ever before.

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Session: Economics of Agriculture:
New Challenges and Opportunities

Barriers to Strategic Analysis and Smart Technology Adoption in Developed Dairy Farms: A Qualitative Pilot Study

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Abstract: Developed dairy farms face increasing turbulence from climate change, market volatility and rapid digitalization. While strategic analysis is widely promoted, its systematic use, and the strategic integration of smart technologies, remains limited. This qualitative pilot study, grounded in strategic management and innovation literature, explores these challenges by combining a targeted review with ten semi-structured interviews involving farmers (3), consultants (4), a veterinarian specialized in data-driven farming, a policymaker, and a professor of strategic analysis. Across this diverse group, seven interrelated barriers emerged: constrained information use, low digital readiness, behavioural resistance, weak entrepreneurial orientation, institutional uncertainty, underused advisory support and fragmented decision routines. The findings highlight a persistent gap between established strategic tools (SWOT, PESTEL, scenario planning) and their practical application: digital investments are often reactive rather than strategically embedded. The contribution lies in framing digital transformation as a strategic capability challenge, not only a technological one, and translating the barrier set into actionable levers for managers, advisors and policymakers. As a pilot, the study also sets out a research agenda for broader comparative analysis of strategy and digital adoption in agriculture, providing both immediate insights and directions for future work.

Keywords: strategic analysis, dairy farming, smart technologies, barriers, digital readiness

JEL Classification : Q10, Q16, O33

1 Introduction

Developed dairy farms are increasingly exposed to turbulence arising from climate change, market volatility, and rapid digitalisation (Graddy-Lovelace, 2021; EU, 2023). Strategic analysis is often recommended as a tool to strengthen resilience and guide long-term decision-making (Chaleb, 2024), yet its systematic application among dairy farmers remains limited. Meanwhile, smart technologies associated with Industry 4.0 and Agriculture 5.0 are increasingly available (Klingenberg, Valle Antunes Junior & Müller-Seitz, 2022; Jerhamre, Carlberg & Zoest, 2022) but adoption in practice is frequently reactive and operational rather than strategically integrated. This raises important questions about how farmers approach strategic planning in a rapidly changing environment.

The research gap lies in understanding why strategic analysis is underutilised, what prevents its broader adoption, and how overcoming these barriers, particularly by treating digitalisation as a strategic capability rather than a purely technical add-on, can improve long-term performance and resilience in dairy farming. Addressing this gap requires examining both systemic constraints and stakeholder perspectives to explain why strategic analysis remains underused in developed farms. This study addresses the question: *What are the main barriers experienced by managers of developed dairy farms in applying strategic analysis, particularly when adopting smart technologies, to respond effectively to a turbulently changing agricultural environment?*

Herewith, it contributes by triangulating literature, field evidence, and multiple stakeholder perspectives, and by highlighting divergences in how these actors perceive barriers, an angle that extends beyond prior studies which mainly confirm existing findings. The paper first reviews relevant literature on strategic analysis and barriers to technology adoption. It then outlines the qualitative research design, which combines a targeted literature review with ten semi-structured interviews. The results present seven interrelated barriers, which are positioned within established typologies and triangulated with field evidence. The discussion interprets these findings considering strategic management theory and digital transformation, and the paper ends with a conclusion.

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2 Methods

A narrative literature review (Scopus, Web of Science, Google Scholar) synthesized work on strategy in agriculture and digital adoption. Inclusion required relevance to strategic management/decision routines or digital transformation in agri-food and peer-reviewed status or recognized policy reports. Articles were included if they focused on strategic management, innovation, or digital adoption in agriculture; non-relevant or smallholder-only studies were excluded. The review yielded seven consolidated categories, financial, institutional, informational, behavioural, organizational, market, technological, consistent with recent syntheses (Flemming et al., 2019; Hayden, Mattimoe & Jack, 2021, Zhao et al., 2024; Nicolas-Davies et al, 2021).

Ten semi-structured interviews (June–September 2025) involved farmers (3), consultants (4), a data-driven veterinarian, a policymaker, and a professor in strategic analysis. Participants were purposefully selected to capture complementary perspectives on strategic behaviour, digital readiness, and innovation. The diversity was intentional for this pilot, aiming to explore a broad range of views rather than achieve representativeness. Interviews (45–75 min) followed a flexible guide, were held via MS Teams, transcribed verbatim, anonymised, and stored.

Transcripts were coded in NVivo (Lumivero, 2025) using two stages: descriptive codes for concrete frictions (e.g., capital constraints, data overload, advisory use), followed by theoretical coding linking segments to broader innovation, behavioural, and capability concepts (Vennix, 2019). Coding was done by the researcher, iteratively compared with literature categories. As a pilot, the goal was not saturation but to identify recurring themes and map them onto established typologies for future studies. The participant diversity was intentional, allowing for variation across farmers, advisors, policymakers, and experts, thereby ensuring that the exploratory coding captured a wide spectrum of perspectives within the limits of a pilot design.

3 Research results

The analysis identified seven interrelated barriers, summarised in Table 1, and mapped to established categories with supporting evidence from literature, field observations, and interviews. This crosswalk situates the findings within existing typologies while reflecting stakeholder perspectives. While most barriers reflect findings from prior studies, their interpretation diverged across stakeholders.

Constrained information use: Farmers and consultants both noted difficulties turning data into actionable insights. Multiple digital systems were used, but rarely integrated across platforms or with advisory input, creating silos between technologies and between farmers and advisors. Consultants emphasised underuse of advisory channels, while farmers framed the issue more as technical incompatibility. This finding aligns with earlier work on information bottlenecks (Flemming et al., 2019; Sutherland et al., 2023) but diverges in showing that farmers perceive the issue less as a knowledge-flow problem and more as a technical one, revealing a gap in how barriers are interpreted.

Low digital readiness: Strongly emphasised by both farmers and advisors, with adoption of IoT sensors and monitoring systems remaining uneven and largely reactive. Investments were often made only when problems arose rather than strategically. Farmers highlighted interoperability and lack of training, while consultants stressed reluctance to embed tools into decision-making. Previous studies underline infrastructural and interoperability challenges (Klerkx & Rose, 2020; Zhao et al., 2024), but the findings add nuance: even farms with relatively advanced infrastructure struggled, suggesting that readiness is as much about strategic embedding as technological capacity.

Behavioural resistance: Farmers described reliance on routines and “gut feeling” as pragmatic risk management, whereas consultants interpreted this as inertia. Generational contrasts appeared, with younger successors more open to structured analysis and older managers defending established approaches. While literature often treats behavioural inertia as a major barrier (Hayden et al., 2021; Dawkins, 2021), the findings diverge in showing that farmers themselves downplay this, reframing it as adaptation rather than resistance.

Weak entrepreneurial orientation: Advisors and policymakers pointed to limited diversification and cautious investment strategies. Farmers often adopted a financially conservative attitude, shaped by the capital intensity and risk of dairy farming. Consultants observed that investments were reactive rather than proactive, suggesting entrepreneurial drive was constrained by risk aversion, high fixed costs, and narrow market orientation. This finding supports prior research on strategic inertia (George et al., 2019; Kuipers et al., 2021) but adds that financial conservatism can be both protective and limiting, offering stability in the short term while hindering innovation over time.

Institutional uncertainty: Policy volatility and subsidy reforms discouraged long-term planning. Farmers and consultants agreed that shifting regulations undermined investment horizons, while policymakers admitted frequent reforms

contributed to this uncertainty. This aligns with prior evidence on destabilising policy environments (EU, 2023; Gonzales-Martinez et al., 2021), but our data highlight that consultants viewed uncertainty as manageable with scenario planning, but farmers rarely applied such tools. The finding diverges from literature that often assumes institutional barriers are external and unavoidable, showing that managerial routines also shape their effect.

Underused advisory support: Farmers often saw consultants as crisis problem-solvers rather than strategic partners, while advisors expressed frustration at being involved too late. This limited knowledge transfer and slowed adoption of innovations. The barrier also reinforced constrained information use, as advisory input could help translate data into strategy. Earlier work highlights underuse of extension services (Ingram et al., 2022; Helfenstein et al., 2020), but our findings diverge in showing that farmers were less aware of this gap, suggesting an unrecognised barrier that advisors identified more strongly than farm managers.

Fragmented decision routines: Decision-making was frequently ad hoc and short-term, shaped by financial pressures and operational demands. Farmers admitted choices were often made “day by day” without structured meetings or tools, with little use of frameworks such as SWOT, while consultants noted this weakened the use of strategic analysis. Literature links ad hoc planning to financial stress (Dong et al., 2019; George et al., 2019), but the findings add that fragmented routines interact with other barriers, limiting entrepreneurial orientation and advisory integration, thus increasing their impact.

Table 1 Mapping empirical barriers to barrier categories.

Empirical barriers	Barrier categories	Connection/Interpretation	Evidence Literature/field	Emphasis in interviews
Constrained information use	Informational	Farmers struggle to turn available data into actionable insights.	Lit: Bottlenecks in knowledge flows Field: advisory channels underutilized.	Moderate: consultants stress, farmers less explicit.
Low digital readiness	Technological	Lack of digital infrastructure and skills slows technological adoption	Lit: Smart-tech adoption challenges. Field: Reluctance to alter routines	Strong: repeatedly raised by farmers and advisors.
Behavioural resistance	Behavioural	Risk aversion and attachment to routines reduce willingness to adopt strategic tools	Lit: resistance widely noted. Field: Reluctance to alter routines.	Weak/moderate: Mainly highlighted by consultants.
Weak entrepreneurial orientation	Market/organizational	Limited strategic drive and financial conservatism reduce competitiveness	Lit: Strategic inertia constrains Innovation. Field: Slow diversification	Moderate: Advisors and policymaker emphasized.
Institutional uncertainty	Institutional	Policy volatility creates hesitation in long-term planning	Lit: CAP/policy unpredictability. Field: reluctance to invest.	Strong: consensus among all groups.
Underused advisory support	Informational/organizational	Weak uptake of extension services reducing learning and slow adoptions	Lit: Underused extension services. Field: Services not systematically embedded.	Moderate: Advisors confirmed, farmers less so.
Fragmented decision routines	Financial/organizational	Ad hoc decision making undermines long-term strategy	Lit: Linked to financial stress. Field: short-term focus common.	Strong: Mentioned both by farmers and consultants.

Source: own processing

4 Discussion

The novelty of this pilot study lies not in identifying new barriers but in triangulating literature, field evidence, and stakeholder perspectives to show how barriers are differently perceived. These divergences themselves emerge as barriers to strategic alignment. While the seven barriers align with prior typologies, their importance varied: institutional uncertainty

(Barrier 5) and low digital readiness (Barrier 2) were strongly emphasised, while behavioural resistance (Barrier 3) was downplayed by farmers but stressed by consultants.

The results confirm that barriers are interconnected across institutional, informational, technological, behavioural, market, financial, and organisational domains. This supports earlier findings that strategic inertia and fragmented routines (Barriers 4 and 7) are systemic rather than individual-level issues (George et al., 2019; Flemming et al., 2019; Roux et al., 2022). Framing these barriers as constraints on dynamic capabilities adds nuance to agricultural strategic management, which often treats technology adoption and strategic analysis separately (Klerkx & Rose, 2020; Fuertes et al., 2020; Sutherland et al., 2023).

Low digital readiness and constrained information use (Barriers 1–2) highlight that digitalisation is not only about tools but about capabilities. Investments in IoT, data platforms, and automation often remained reactive, repeating warnings that adoption without strategy brings limited gains (Zhao et al., 2024; Ingram et al., 2022; Klingenberg et al., 2022). Interoperability issues and data overload reinforced this pattern, suggesting that smart farming must be embedded in broader planning frameworks rather than treated as a technical add-on. This is consistent with recent studies stressing that digitalisation is a socio-technical transition requiring managerial as well as technical adaptation (Klerkx & Rose, 2020; Jakku et al., 2023).

A key divergence lies in perceptions of behavioural resistance (Barrier 3). Consultants emphasised inertia and reluctance to change, while farmers described pragmatism and reliance on routines as risk management in uncertain contexts. This suggests behavioural barriers may be under-recognised by farmers themselves, a finding that extends prior studies which present resistance as a dominant constraint (Hayden et al., 2021; Nicolas-Davis et al., 2021). Generational contrasts observed in our interviews further complicate this picture, with younger successors showing greater openness to structured analysis, a nuance less prominent in the literature.

Weak entrepreneurial orientation (Barrier 4) further constrained strategic capacity. Advisors and policymakers highlighted limited diversification and reactive investments, while farmers described financial conservatism as a necessary safeguard against market volatility and high capital intensity. This finding confirms earlier work on strategic inertia (George et al., 2019; Kuipers et al., 2021), but adds nuance: entrepreneurial drive is not absent, but channelled into risk avoidance, which may provide stability in turbulent markets yet restrict long-term competitiveness. By showing how entrepreneurial caution is perceived as both rational and limiting, the data extend the literature that often frames it as purely a weakness.

Institutional uncertainty (Barrier 5) was consistently stressed across stakeholder groups, with subsidy reforms and regulatory volatility discouraging long-term planning. This is in line with studies on the destabilising effects of policy environments (EU, 2023; Gonzales-Martinez et al., 2021; De Schutter et al., 2020). Yet our data also suggest that such uncertainty is not purely external: consultants saw tools such as scenario planning as a way to mitigate volatility, but farmers rarely adopted them. This diverges from the literature, which often frames institutional barriers as structural and unavoidable, by showing how managerial routines also shape their impact.

Underused advisory support (Barrier 6) and fragmented decision routines (Barrier 7) point to dual weaknesses: advisory services were seldom integrated into farm routines, and decision-making was reactive and short-term. This reinforces claims that advisory systems must move beyond technical fixes to foster strategic thinking (Ingram et al., 2022; Helfenstein et al., 2020; Borman et al., 2022). Advisors therefore play a pivotal role in bridging operational problem-solving with long-term capability-building, but their contributions remain underutilised.

As a pilot, participant diversity was intentional to capture varied perspectives. Future research should test this framework with larger and more homogeneous farmer samples. The added value of this study lies in showing that farmers frame day-to-day pragmatism as adaptation, consultants see resistance, policymakers stress institutional uncertainty, and there is a link between digital readiness to advisory use. These divergences are not minor details but practical frictions that hinder collective action. Viewed through a strategic management lens, this reframes digitalisation not as a technological upgrade but as a strategic capability challenge. Thus, the findings contribute to strategic management theory by demonstrating how systemic barriers constrain dynamic capabilities, and to digital transformation debates by reframing digitalisation as a capability rather than a purely technological issue. The contribution lies less in naming barriers and more in showing how misaligned perspectives hinder their resolution. Addressing these misalignments is crucial to building the shared strategic capacity needed for developed dairy farms to systematically engage in strategic analysis and smart technology adoption. These findings extend beyond dairy farming, as the misalignment of stakeholder perceptions can be understood as a coordination failure within dynamic capabilities, reflecting broader debates in strategic management about how organizations integrate, build, and reconfigure resources under uncertainty (Teece et al., 1997; George et al., 2019).

By situating agricultural digitalisation within this theoretical lens, the study links sector-specific barriers to more general challenges of strategic alignment in turbulent environments.

5. Conclusion

This pilot study examined barriers to the use of strategic analysis and the integration of smart technologies in developed dairy farms, identifying seven interrelated barriers mapped onto established typologies that confirm the importance of financial, institutional, informational, behavioural, organisational, market, and technological factors. Its contribution lies in two ways: first, by triangulating literature, field observations, and stakeholder perspectives to connect conceptual models with practice; and second, by showing that divergences in stakeholder perceptions, rather than any single barrier, can themselves hinder the uptake of strategic analysis and smart technologies. By surfacing these misalignments and reframing digitalisation as a strategic capability challenge rather than a purely technological issue, the study offers a relational explanation for why strategic analysis remains underused in developed dairy farms. While not claiming representativeness or saturation, it provides a grounded framework and entry points for larger comparative research, demonstrating that misaligned perceptions themselves form a barrier to collective strategic action and that overcoming them is essential to build the shared capacity required for systematic strategic analysis and smart-technology adoption. The study shows that divergent perceptions are as constraining as institutional or technological barriers, underscoring the need for shared strategic capacity in digitalising dairy farming. Therefore, although rooted in dairy farming, the study speaks to strategic management more broadly: it shows that overcoming misaligned perceptions is not only a sectoral challenge but a fundamental condition for building dynamic capabilities in organizations facing technological and institutional turbulence.

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Predicting the Profitability of Agricultural Enterprises Using Area-related Ratios

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Abstract: This study investigates the predictive ability of financial and area-related ratios in forecasting future asset profitability. The predictive modelling was conducted using the Random Forest algorithm. The analysis encompassed both conventional financial ratios and their modified counterparts. Specifically, the following indicators were examined: profit-to-assets ratio, profit per hectare, sales-to-assets ratio, sales per hectare, debt-to-assets ratio, debt per hectare, fixed asset ratio, assets per hectare, and labour productivity. Empirical results indicate that profitability ratios, particularly the profit-to-assets ratio, exhibit strong predictive performance. Furthermore, area-related variants—such as profit per hectare and debt per hectare—demonstrated enhanced accuracy in certain scenarios. Nonetheless, the practical applicability of these area-related indicators is constrained by challenges related to data availability and consistency.

Keywords: financial analysis, Area-related ratios, profitability prediction, agricultural enterprises.

JEL Classification: G32, G33, Q14

1 Introduction

Attempts to predict future developments in corporate financial health date back to the 1960s. Beaver (1966) analysed the financial statements of 79 companies that failed and 79 that survived between 1954 and 1964. He examined more than 30 financial indicators and assessed their ability to individually distinguish between healthy and troubled firms.

The first multivariate method introduced was Altman's Z-score (1968), which used discriminant analysis to construct a predictive model based on five financial indicators. Later, Ohlson (1980) applied logistic regression to forecast bankruptcy.

With the advancement of computer technology, the range of predictive methods has expanded significantly. These now include Logit/Probit models, decision trees and random forests, neural networks, and other machine learning techniques. The scope of predicted phenomena has also broadened: Altman (1968) focused on bankruptcy, Beaver (1966) on bankruptcy and insolvency, Gurčík (2002) on achieving a desired level of profitability, and Neumaierová and Neumaier (2025) on financial health, company value growth, and the attainment of a positive EVA (Economic Value Added).

Due to the specific characteristics of agricultural enterprises, models reflecting the peculiarities of this sector were soon developed. Agricultural models can be considered Gurčík's G-index (Gurčík, 2002); the Index of the Operational Programme Rural Development and Multifunctional Agriculture (Rosochatecká & Řezbová, 2004); and the CH-index (Chrastinová, 1998).

The adaptation and testing of existing models for agricultural applications have been addressed by several authors, including Purves et al. (2015), Rajin et al. (2016), and Stojanović and Drinić (2017). Further validation of model reliability was conducted by Kopta (2009), Soukal et al. (2024), Srebro et al. (2021), and Karas et al. (2017). These studies consistently reported low predictive accuracy of the tested indicators, which was attributed to both the inappropriate selection of category boundaries and the use of unsuitable indicators. Another frequently cited issue is the high interannual volatility of financial data (Karas et al., 2017).

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Another way to enhance predictive reliability is by integrating non-financial indicators into forecasting models. The potential of such indicators has been explored by Jones et al. (2017), Liang et al. (2016), and Doumpos et al. (2017), with Purves et al. (2015) also investigating their relevance in the context of agricultural enterprises.

The goals of this study are based on these foundational insights and seek to further investigate the predictive power of financial and area-related indicators in the agricultural sector. The primary objective of this study was to identify financial and area-related indicators that most effectively predict the future performance of agricultural enterprises.

2 Methodology

Data: The Albertina database was used to identify suitable agricultural enterprises. Enterprises that provided complete data for the period 2019–2023 were selected. This dataset was further enriched by linking it to the State Agricultural Intervention Fund (SZIF) database of subsidy recipients, which provided information on the size of the farmed area. Only enterprises farming more than 500 hectares were included in the analysis. In total, data on 437 enterprises were obtained. Of these, 101 enterprises were classified as unprofitable in 2023, while 336 enterprises were classified as profitable.

Selection of independent variables: The independent variables were categorised into two groups. The first group comprised financial analysis indicators, including return on assets, return on sales, return on fixed assets, asset turnover, turnover of fixed assets, turnover of current assets, cost of output consumption, personnel cost ratio, depreciation cost ratio, debt ratio, current liquidity, and the acid test ratio. Each indicator was calculated in two variants: the first based on the current annual value, representing the indicator in the year immediately preceding the prediction; the second based on the average value of the indicator over the four years prior to the prediction. The second group consisted of area-related indicators, specifically profit per hectare, revenue per hectare, assets per hectare, debt per hectare, and labour productivity, measured as revenue per employee.

Statistical methods: Differences in the mean values of the ratios between profitable and unprofitable companies were statistically tested. Additionally, the Spearman correlation coefficient was calculated to assess the relationship between each independent variable and the future level of profitability. The core part of the predictive analysis was conducted using the Random Forest method.

3 Results

Table 1 presents the overall reliability of the model in distinguishing between profitable and unprofitable enterprises. The model demonstrates higher accuracy in identifying profitable farms. In contrast, its performance is less reliable for loss-making enterprises, with 18% of unprofitable farms incorrectly classified as prosperous.

The overall performance of the model is reflected in two key metrics: the coefficient of determination (R^2), which reached 87.29%, and the mean absolute error (MAE), which was 0.0136. The R^2 value indicates how well the independent variables explain the variability of the dependent variable—in this case, future profitability. A value of 87.29% suggests that the model accounts for a substantial portion of the variance in the data, demonstrating strong predictive power. The MAE represents the average magnitude of errors between predicted and actual values, without considering their direction. A low MAE value, such as 0.0136, indicates that the model's predictions are very close to the actual outcomes, further confirming its reliability.

Table 2 presents the reliability matrix based on ROA quartiles. The model demonstrates the highest accuracy in the middle range of ROA, where the prediction error is nearly zero. At the extremes—both low and high ROA—the model tends to underestimate or overestimate profitability. Nevertheless, the model proves to be highly reliable, especially for enterprises with average performance.

Table 1 Classification error rate

	Correctly classified		Missing classified	
Positive profitability (336 total)	318	94.64%	18	5.36%
Negative profitability (101 total)	75	74.25%	26	25.75%
Overall success rate (437 total)	393	89.93%	44	10.07%

Source: Albertina database, own calculations

Table 2 Reliability matrix by ROA quartiles

Quartile (ROA category)	Average actual ROA	Average predicted ROA	Average residual	Standard deviation of the residual
I.	-0.0475	-0.0280	-0.0194	0.0232
II	0.0144	0.0142	0.0001	0.0105
III	0.0358	0.0317	0.0040	0.0092
IV	0.0832	0.0660	0.0172	0.0165

Source: Albertina database, own calculations

3.1 Selecting appropriate indicators

Among the classical financial analysis indicators, profitability proved to be the most decisive. All applied methods confirmed the strong predictive power of return on assets (ROA). High Spearman correlation coefficients suggest that agricultural enterprises tend to maintain their relative positions in the dataset over time. This finding aligns with previous research, such as Klepáč and Hampel (2017), who also emphasised the critical role of profitability in successful prediction models.

Other profitability indicators, such as return on sales (ROS) and return on equity (ROE), exhibited lower predictive ability, primarily due to their higher volatility. In contrast, the indicator profit per hectare demonstrated superior predictive performance compared to traditional ROA measures. Its relative importance in the Random Forest model reached 0.240, whereas ROA achieved only 0.147. A similar pattern was observed in the correlation coefficients: Spearman's correlation for profit per hectare was 45%, while the classic profitability ratios were 10 to 15 percentage points lower.

Interestingly, the Labour Costs/Sales indicator showed unexpectedly high predictive power, despite being rarely used in prediction models. The correlation between this indicator and profitability was negative (-24%), indicating that a lower share of labour costs is strongly associated with higher profitability.

Table 3a: Independent variables, their characteristics and predictive power

Independent variable	Profitable farms	Unprofitable farms	Standard deviation: Profitable farms	Standard deviation: Unprofitable farms	p-value of the difference
ROA	5.35%	4.68%	3.22%	4.87%	0.1037
Profit/hectare	5.22	3.28	4.09	4.20	0.0000
ROE	5.80%	4.66%	5.96%	9.03%	0.1394
ROS	7.29%	5.34%	5.96%	6.05%	0.0043
Labour costs/Sales	0.21	0.23	0.07	0.08	0.0014
Asset turnover	0.57	0.64	0.19	0.26	0.0030
Sales per hectare	75.35	55.95	58.11	31.44	0.0014
Turnover of fixed assets	3.33	1.21	42.46	0.78	0.6165
Turnover of current assets	1.96	1.68	4.80	0.63	0.5633
Debt ratio	32.49%	33.71%	0.19	0.22	0.5905
Debt per hectare	49.04	31.29	87.46	29.74	0.059
Long-term debt/assets	18.06%	19.20%	0.14	0.16	0.037
Short-term debt/assets	13.78%	14.37%	0.12	0.12	0.033
Current liquidity	6.32	5.55	12.07	7.78	0.046

Source: Albertina database, own calculations

Table 3b: Independent variables, their characteristics and predictive power

Independent variable	Spearman's coefficient	Spearman's coefficient: p-value	Point-biserial correlation	Point biserial p-value	Mean Decrease in Impurity
ROA	36.40%	0.0000	7.79%	0.104	0.147
Profit/hectare	45.93%	0.0000	19.50%	0.000	0.240
ROE	31.32%	0.0000	7.08%	0.139	0.047
ROS	34.38%	0.0000	13.64%	0.004	0.034
Labour costs/Sales	-24.08%	0.0000	-15.27%	0.001	0.089
Asset turnover	-11.37%	0.1074	-14.15%	0.003	0.046
Sales per hectare	30.01%	0.0000	15.24%	0.001	0.096
Turnover of fixed assets	-11.83%	0.1304	2.40%	0.617	0.047
Turnover of current assets	2.06%	0.6677	2.77%	0.563	0.040
Debt ratio	-3.79%	0.4288	-2.58%	0.591	0.037
Debt per hectare	16.85%	0.0004	9.56%	0.046	0.059
Long-term debt/assets	-1.34%	0.7801	-3.38%	0.481	0.037
Short-term debt/assets	-9.06%	0.0583	-2.13%	0.658	0.033
Current liquidity	3.95%	0.4097	2.90%	0.546	0.046

Source: Albertina database, own calculations

The predictive capabilities of activity indicators proved to be weak, and in most cases, the correlation with future profitability was negative. This finding is somewhat surprising, given that this ratio indicators are commonly included in prediction models. One possible explanation is offered by Lososová and Zdeněk (2013), who demonstrated a relationship between the altitude at which an enterprise operates and its activity indicators. Altitude appears to influence activity indicators more significantly than it affects overall business success. Another explanation is provided by Boďa and Úradníček (2019), who evaluated various prediction models in agriculture and attributed the low predictive power of activity indicators to their high volatility.

Indicators based on yields per hectare showed slightly better predictive performance than traditional activity ratios, with a relative importance score of 0.096. Moreover, a notable positive correlation was observed between yields per hectare and achieved profitability (30.01%).

For this indicator, the difference between prediction results calculated per hectare (sales per hectare) and those calculated per assets (sales per assets) was the most pronounced. The authors of this study do not yet have a definitive explanation for this discrepancy. One possibility is the influence of production focus and intensity. A more likely explanation, however, may lie in the limitations of Czech national accounting practices. Among other issues, the accounting treatment of land value is particularly problematic. While the adjusted indicator reflects the actual cultivated area, the traditional asset-based indicator fails to account for leased land (which constitutes the majority of agricultural land in the Czech Republic) or values it at historical prices, which are disconnected from current economic realities.

The impact of accounting methods on financial health prediction has been discussed by Dvořáková (2015), while Sedláček (2010) highlights the differences between IFRS and Czech accounting standards. According to Sedláček, IFRS prioritises the accuracy and reliability of financial data, whereas Czech accounting emphasises formal compliance with rules and the principle of prudence.

The ability to predict future developments using debt indicators was generally low, which contradicts several studies that confirm the influence of debt on financial performance. For example, Klepáč and Hampel (2017) found a strong negative correlation between debt and profitability. Other studies report moderately strong or weak negative correlations (Gabrić, 2015; Maxim, 2021). One possible explanation for the low predictive power of debt indicators in this study is the influence of legal form. Aulová and Hlavsa (2013) demonstrated that legal form significantly affects debt levels.

On the other hand, the debt-to-hectare ratio emerged as a meaningful predictor. Again, the authors do not yet have a reliable explanation for this finding. It is possible that production focus and intensity play a role. Intensive farms specialising in livestock production typically manage fewer hectares but achieve higher profitability.

Liquidity indicators also showed low predictive ability. This finding is consistent with the assumptions of Střeleček et al. (2011), who identified a strong relationship between liquidity and the production focus of agricultural enterprises—specifically, that livestock-oriented farms tend to have higher shares of current assets and thus higher liquidity. In such cases, liquidity reflects production structure more than business success. The low predictive power of liquidity indicators is further supported by Saleem and Rehman (2011). However, Ehiedu (2014) found a positive correlation between ROA and liquidity, suggesting that the relationship may vary depending on context and methodology.

The assumption that area-related indicators can enhance predictive accuracy was confirmed. Indicators such as profit per hectare, sales per hectare, and debt per hectare showed stronger correlations with future economic performance than traditional financial ratios. Moreover, in the Random Forest model, these area-related variables demonstrated higher relative importance, further supporting their predictive relevance.

Using Area-Related Ratios reduces the impact of external influences and better reflects management performance, enabling more accurate benchmarking, particularly where accounting systems may distort financial results. The approach is valuable for policymakers when comparing business models or targeting support to vulnerable farms.

4 Conclusion

Among classical financial analysis indicators, return on assets (ROA) emerged as the most reliable predictor of future performance. Interestingly, and in contrast to previous studies, the ratio of personnel costs to company sales also proved to be significant. On the other hand, liquidity and asset turnover indicators contributed little to distinguishing between profitable and unprofitable enterprises. This may be because liquidity tends to reflect the production focus—distinguishing crop-oriented farms from livestock-oriented ones—rather than overall business success. Although asset turnover is traditionally included in prediction models, its limited usefulness in classification may be explained by its strong correlation with altitude (see Lososová & Zdeněk, 2013) or its high volatility in agricultural enterprises (see Boďa & Úradníček, 2019).

The assumption that classical ratio indicators could be effectively replaced by area-related indicators, where profit or sales volume is measured relative to the size of farmed land, was confirmed. These modified indicators demonstrated superior predictive performance compared to their unadjusted counterparts. However, it must be acknowledged that calculating modified indicators and obtaining the necessary data is more complex.

A key limitation of this study is that the classification of profitable and non-profitable enterprises is based solely on data from the fiscal year 2023. While this period was chosen for the primary validation of the proposed methodological framework, the limited temporal scope may not fully account for long-term economic fluctuations. This is further complicated by the inconsistent informativeness of accounting statements; for instance, varying proportions of leased assets and different accounting practices can distort activity indicators even among farms of comparable size and structure. Consequently, the validity and robustness of the current findings remain subject to further research, which will focus on longitudinal verification across broader time periods to confirm the stability of these indicators over time.

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The Impact of Agricultural Subsidies on the Economic Situation of the State

Kateřina Mazancová¹

Abstract: The agricultural sector plays a pivotal role in global economic development by ensuring food security, contributing to GDP growth, and supporting other industries through resource transfer and trade. However, it is characterized by high volatility due to climatic uncertainty, market fluctuations, and global crises such as the COVID-19 pandemic and the war in Ukraine. These events have triggered significant increases in food prices, intensifying inflationary pressures and reducing welfare, particularly in developing countries. As a result, state intervention in agriculture has regained prominence, with policymakers applying diverse protectionist and redistributive measures, such as subsidies, tax incentives, and direct payments, to stabilize markets and support producers. In the European Union, the Common Agricultural Policy (CAP) remains a cornerstone of this intervention, yet it faces criticism for inefficiency, uneven redistribution, and inadequate targeting of vulnerable groups. Empirical studies demonstrate mixed results: while some confirm the positive effects of agricultural support on productivity and poverty reduction, others reveal inefficiencies, reverse redistribution, and fiscal burdens. This review highlights the complex relationship between agricultural protection, price stability, and social welfare, emphasizing the need for targeted, evidence-based policies that balance economic efficiency, fairness, and sustainability in both developed and developing economies.

Keywords: agricultural policy, subsidies, redistribution, food price inflation, welfare, Common Agricultural Policy

JEL Classification: Q10, Q18

1 Introduction

The agricultural sector, which includes crop cultivation, animal husbandry, fisheries and forestry, is a critical driver of economic growth that cannot be ignored by the economies of industrialised and developing countries (Awokuse & Xie 2015). Furthermore, it makes a significant contribution to the economy, especially in the early stages of economic growth and development, by feeding the population and transferring resources to other sectors (Kuznets 1972). The fact that agricultural products (food) are both a trade commodity and a vital resource for human well-being sustains and deepens the role of the sector in the economy. In particular, the accumulation of capital in the agricultural sector helps in the initial phase of the economic growth process. Agricultural products find consumers in international markets, bring in foreign exchange, and at the same time improve the country's gross domestic product (GDP). In this regard, the agricultural sector helps in the development of other industries (Taylor & Lybbert 2020). Agricultural growth is an important tool for regional development and poverty reduction, as mentioned by Bekun & Akadiri (2019). However, as globalization spreads, increases in income and wealth, population, and life expectancy around the world have led to an increase in food consumption rates. This was particularly evident in the 2000s, when food consumption outpaced production (Abbott et al. 2008), leading to inflationary pressures. Valentina (2020) notes that in recent years, policymakers in national economies have focused on combating inflation as a major concern. However, food price inflation has been rising faster than the consumer price index (CPI) in all regions of the world due to supply disruptions caused by the COVID-19 pandemic (Gruère & Brooks 2021). Various factors, including increased input costs (Algan et al. 2021), global climate change (Singh-Peterson & Lawrence 2015), and losses in agricultural production, have contributed to the global increase in agricultural prices (Edwards et al. 2011).

The significant increase in the prices of agricultural products in recent years has seriously affected low-income consumers. In developing countries in particular, these price increases have a negative impact on the well-being of low-income consumers, as noted by Jomo and Chowdhury (2020). Agriculture plays a key role in reducing poverty and hunger in many developing countries (OECD, 2005). Increases in food prices can trigger social discontent by reducing income per capita in these countries, which spend a significant portion of their income on food.

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The agricultural sector has a fundamental influence on macroeconomic factors such as economic growth, as Gollin (2010) points out, and is a fundamental determinant of the consumer price index and welfare, especially economic growth. Over the last decade, especially after the 2008 crisis, the idea of returning to the ideas of John Maynard Keynes as a means of resolving economic crises has begun to be seriously discussed. This idea, known as "Keynes Resurrected", has led to a renewed interest in fiscal policy as an important and effective tool of economic policy and to the reopening of debates on state interventionism (Alesina 2012). As a result, almost every developed and developing country has adopted interventionist measures in agriculture as part of an active economic policy for economic and social reasons (Searchinger et al. 2020). Policymakers support the agricultural sector through various measures, such as direct support to agriculture, tax incentives, technology and knowledge transfer, market protection measures, non-tariff barriers, quotas and price support (Clapp, 2017). These instruments aim to support agricultural development and expand foreign trade in agricultural products (Vozarova and Kotulic 2016).

One of the main reasons for government intervention in the agricultural sector is to reduce the volatility of agricultural product prices and protect farmers from these effects (Özdemir 1989). Economic development is one of the main goals in both developed and developing countries, and it can only be achieved through stable economic growth. There is consensus that capital accumulation, which can be achieved through the agricultural sector, is a key factor for the initial phase of economic development and a leading factor in economic growth, which in turn contributes to economic development (Taylor & Lybbert 2020).

Recently, there has also been a debate about the role of the agricultural sector in increasing welfare, reducing poverty and hunger, and as a means by which increases in agricultural prices negatively affect household welfare, as mentioned by Bekun and Akdiri (2019). These effects are particularly strongly felt in developing countries. Based on these discussions, some researchers have focused on studying the impact of protection measures applied to the agricultural sector and their impact on economies. Studies on the effects of agricultural support on macroeconomic performance are limited in the literature. For example, Balisacan and Roumasset (1987) conducted research focused on the relationship between protection rates for major cereals and economic development in 68 countries during the period 1979-1981. Their conclusion suggests that there is a strong link between economic development and agricultural protection. In contrast, Köse and Meral (2021) focused on Turkey and found no relationship between agricultural support and economic growth. However, Albers and Peeters (2011) found that agricultural support had a reducing effect on food inflation in their study of nine Mediterranean countries between 2002 and 2010. Caracciolo et al. (2014) examined the links between world and domestic prices of staple crops such as maize, rice and wheat in four developing countries. They found no direct correlation between wheat and rice subsidies and world prices of these crops, but maize seed subsidies had an impact on world prices.

Agricultural support contributes to increasing food supply and reducing food prices, which Oyakhilomena and Zibah (2014) argue helps to reduce poverty. Gollin (2010) emphasizes that increasing agricultural productivity is a key source of economic growth in many developing countries. Several studies have been conducted in this regard. Erdal et al. (2021) and Canbay (2021) found in their studies that government agricultural support policies positively affect agricultural productivity. On the other hand, Uslu and Apaydın (2021) argue that agricultural sector supports have a negative impact on agricultural productivity. Rad-Tüzün and Aslan (2018) also pointed out that agricultural supports have positive effects on some products and negative effects on others. Kalabak and Aslan (2021) found that this effect is limited. Yıldız (2017) concluded in his study that there is a bidirectional causality between variables, while Roe et al. (2002) did not find a statistically significant relationship between variables. The literature shows that there are only a limited number of studies focusing on this issue and their results vary. These differences in results are due to different levels of agricultural support in the countries/groups of countries studied, climatic conditions and insufficient technological infrastructure in the sector. Mistakes in marketing strategies, cyclical developments in input prices, lack of physical and human capital and inconsistent implementation of support plans also contribute to the different results.

The war in Ukraine, which began in early 2022, has fundamentally affected global agricultural commodity markets and has sparked a discussion about the need to protect domestic agricultural producers (Hassen & Hamid, 2022). In the Czech Republic, this protection is manifested mainly in the form of increased support and crisis measures aimed at ensuring stable supplies of key commodities to the domestic market (Aliu et al., 2023).

According to some analyses, protection of agricultural producers in the form of higher subsidies or administrative price restrictions can help stabilize food prices on the domestic market, thereby slowing the rise in inflation that was evident throughout Europe after the outbreak of the conflict in Ukraine. On the other hand, there is a risk that excessive support will reduce competitive pressures and may increase the fiscal costs of the state (Aliu et al., 2023). In this case, there is

pressure on public budgets and the possibility of increasing secondary inflationary pressures, especially if the support is debt-financed.

Increased protection of domestic producers can lead to a decrease in agricultural imports and at the same time to a weakening of exports, for example, if there is an administrative regulation of export prices (Swinen et al., 2024). As a result, the trade balance in the agricultural trade segment may deteriorate, but at the same time the domestic supply of key commodities is stabilized (Hudecová & Rajčániová, 2023). For the Czech Republic, which is dependent on external sources for some commodities, it is crucial to carefully balance protection measures so that they do not undermine trade ties with strategic partners and do not threaten export opportunities.

Economic models suggest that support mechanisms can increase production in a given sector in the short term and contribute to rural job creation (Hassen & Hamid, 2022). However, in the long term, excessive reliance on subsidies can lead to lower competitiveness and limit innovation potential. If protection is provided across the board and without a clear targeting strategy (e.g. for technological modernization or transition to more sustainable forms of farming), it can lead to the so-called “entrenchment” of inefficient enterprises (Swinen et al., 2024).

Protection of agricultural producers is often promoted with the aim of preventing the social impacts of sharp price fluctuations and ensuring food security. In the context of the war in Ukraine, which has affected not only production but also transport capacities and global trade flows, this goal is perceived as a priority. However, as Hudecová and Rajčániová (2023) point out, the long-term burden on public budgets with higher expenditures can limit the government’s ability to invest in other key areas (e.g. education, healthcare, infrastructure). From a social impact perspective, there is also debate about whether support is targeted fairly and whether the most vulnerable groups of the population (e.g. low-income households) benefit from lower food prices, or whether most of the profits go to producers themselves (Aliu et al., 2023).

2 Methods

This paper applies a qualitative analytical approach based on a structured review and synthesis of academic literature and official policy documents. It combines conceptual economic reasoning with comparative policy analysis to assess agricultural support instruments under conditions of “economy under pressure.” The CAP 2023–2027 framework is examined with a particular focus on Pillar I measures and their implementation in the Czech Republic as a contextual case. Alternative instruments used in international trade (export subsidies, tariffs, and quotas) are discussed in terms of their fiscal and welfare implications, using historical and recent shock-related evidence (COVID-19 and the war in Ukraine). The study is interpretative rather than econometric and aims to synthesize existing findings rather than estimate causal effects quantitatively.

3 Agricultural Support Instruments in Times of Economic Pressure

In addition to direct domestic subsidies, international trade traditionally employs policy instruments that states use to protect and support agriculture, in particular export subsidies and import barriers such as tariffs and quotas. Export support measures, or export subsidies, are defined as financial instruments that enable domestic producers to sell goods on international markets at prices lower than domestic prices, often leading to the phenomenon of international dumping (Friedland, 2002; Svoboda, 2010). The key difference between these instruments lies in their fiscal impact. Export subsidies represent a net cost to the state budget and result in a significant increase in public expenditure (Holmann, 1996). Economic analysis shows that in the exporting country these subsidies generate a net welfare loss, referred to as the “deadweight loss effect.” In contrast, import tariffs and quotas, although they raise the price of imported goods on the domestic market, generate revenue for the state budget (Matoušek & Sabelová, 2007).

The authors’ view on the use of these measures in times of “Economy Under Pressure” is ambivalent, reflecting both historical lessons and global commitments. In general, economists agree that protective measures may temporarily bring benefits, such as shielding domestic sectors, wages, and employment, and addressing acute social problems (Rožehnalová et al., 2010). However, experiences from the trade wars of the 1930s demonstrated that the escalation of trade barriers ultimately led to losses for all participating countries (Samuelson & Nordhaus, 2009). The new Strategic Plan of the Common Agricultural Policy for the period 2023–2027 places a strong emphasis on results, performance, and sustainability, thereby aligning with the objectives of the European Green Deal. Within Pillar I, key instruments have been implemented, namely the Complementary Redistributive Income Support for Sustainability and the Schemes for Climate, Environment, and Animal Welfare (eco-schemes).

The Complementary Redistributive Income Support is designed to ensure a fairer distribution of financial resources in favor of small and medium-sized agricultural holdings. Under the Czech CAP, this payment is applied to the first 150 hectares of agricultural land managed by each farm. The Czech Republic has voluntarily allocated 23% of the total direct

payments budget to this intervention, thereby significantly exceeding the minimum EU requirement. The selected model, based on a uniform rate applied to the entire 150 hectares, creates a strong financial incentive, as the total support granted for the first 150 hectares is almost three times higher than the basic income support rate applied to the remaining area. This approach aims to compensate for the competitive disadvantages of smaller farms, which lack economies of scale. Eco-schemes represent a new, voluntary instrument within Pillar I of the CAP, intended to promote agricultural practices that contribute to the protection and enhancement of the environment and the landscape. Member States are required to allocate at least 25% of their direct payments' envelope to eco-schemes, while the Czech Republic allocates more than 30% (Fiala, 2022).

4 Effects of redistribution of political support

Agricultural policy has traditionally focused on redistributing income and supporting public goods. (De Gorter & Swinnen, 2002) Governments intervene in markets to limit price volatility or to restrict imports and promote exports of agricultural commodities. They also provide subsidies and credit for inputs and support rural infrastructure, scientific research, and regulations to ensure food safety and protection from invasive species and animal diseases. However, over the past four decades, rural and trade policy analysts have increasingly focused on the negative welfare impacts and inefficiencies associated with market interventions and price distortions through regulations. Most of the world has gradually moved away from such interventions in agricultural and food markets, thanks to unilateral trade liberalization and the rise of more open economies under the auspices of the GATT and the WTO (Anderson, 2009).

Despite several reform efforts, the Common Agricultural Policy (CAP) of the European Union (EU), especially as regards direct payments, is still considered relatively complex and it is not clear how exactly it contributes to achieving its main objectives. Direct payments can currently support the continuation of agriculture in the EU. However, according to Matthews (2023), farms highly dependent on public support may not be in line with the objective of improving their productivity, although the move to decoupled payments may reduce the efficiency losses associated with the previous partially coupled payments.

Another criticism of the CAP concerns the way subsidies are allocated at the macro level (between Member States) and at the micro level (between farmers). Support based largely on hectares does not take into account local conditions and is therefore not an effective way to incentivise farms to provide public services (Bureau et al., 2012). This redistribution criterion would be appropriate for homogeneous agricultural systems that focus primarily on arable production, but might be inappropriate for highly heterogeneous systems with different production orientations and morphological features. The method of allocating direct payments based on hectares may discriminate and favor farms based on the land they own rather than their actual contribution to income and employment. Alternative methods, such as value added or labor, better capture the heterogeneity that characterizes certain systems (Adinolfi, Little, & Massot, 2011).

Bonfiglio et al. (2020) report that decoupled direct payments have a significant impact on technical efficiency in most specialised farms that have received higher levels of support. However, the impacts are contrasting. In arable crop farms, direct payments are negatively associated with technical efficiency, while in livestock farms, public subsidies have a positive effect.

The redistribution of policy subsidies induces negative changes in technical efficiency in some or all farms. For this reason, the aim is to avoid potential conflicts with other CAP instruments that are specifically designed to increase productivity. Bonfiglio et al. (2020) suggest adopting models of internal convergence that are less redistributive and more targeted. The results presented here may be useful for policymakers to better understand the possible efficiency implications derived from alternative policy options regarding the redistribution of direct payments.

The distribution of subsidies under the CAP is closely linked to the size of farms, whether in terms of physical size or economic indicators. If we compare the distribution of subsidies between two countries, for example country A where the policy is implemented and country B where it is not, any differences may be due to differences in the size structure of farms rather than to the policy itself. If we compare the situation before and after the implementation of the policy within a single country, the results will be partly influenced by "changes in the structure of agricultural holdings". However, this comparison is likely to provide more robust results as changes will generally be gradual and affect the period from year to year (DG AGRI, 2020).

The basic motivation for the current distribution of Single Payment Scheme (SPS) payments is to compensate for historical reductions in agricultural price support (first introduced in 1992 because of the MacSharry reform). One possible justification for the SPS could be capital market imperfections that prevent farmers from borrowing to finance investments

(Shah, 2006). Another justification is environmental externalities that cannot be reflected in market prices (Cong and Wei, 2010). In terms of income redistribution, the current system also has some serious shortcomings.

First, farmers with the highest land productivity, and therefore competitive in the market, receive the highest payments per hectare. Farmers with less fertile land receive lower payments per hectare and therefore their farms face marginalisation and abandonment, which could have irreversible and damaging effects on European agricultural production and its cultural landscape (Brady et al., 2009). Second, because payments are area-based, the largest farms receive the largest total payments. As a result, the current CAP and its single payment scheme may entail reverse redistribution, i.e. redistribution from the poor to the rich (GarciaPenalosa & Wälde, 2000). The single payment scheme should be better targeted at poorer farmers (small farms) and the environment. In principle, high-income households should receive a low subsidy (if any) and low-income households a high subsidy (Ahmed et al., 2001). As public goods, environmental products should be subsidised by the CAP to cover their costs. However, the reality may be more complex. On the one hand, more direct payments to peripheral regions and poorer farmers will affect investment and will not contribute to economies of scale (Dunne and O'Connell, 2002). On the other hand, the current subsidy system harms small farms and poor farmers through inverted distribution, which will be detrimental to social cohesion and environmental protection (Magnani, 2000).

5 Conclusions

The literature clearly demonstrates that agriculture remains a fundamental pillar of economic stability and social welfare, yet it is also one of the most vulnerable sectors to external shocks and market distortions. Global development from the food crises of the 2000s to the COVID-19 pandemic and the war in Ukraine have underscored the strategic importance of ensuring food security and stabilizing agricultural markets through well-designed policy interventions. While state support for agriculture, particularly through mechanisms such as subsidies and price regulation, can mitigate market volatility and protect producers and consumers, its long-term effectiveness depends on precise targeting and fiscal sustainability.

Redistributive policies within frameworks like the EU's CAP illustrate both the potential and pitfalls of government intervention. Although decoupled and redistributive payments have succeeded in sustaining agricultural production and preventing rural decline, they often perpetuate inefficiencies, concentrate benefits among large landowners, and strain public budgets. The empirical evidence remains inconclusive, suggesting that the impact of agricultural support varies according to local conditions, institutional capacity, and the structure of national economies.

Future policy design must therefore balance efficiency, equity, and resilience. Agricultural protection should prioritize productivity-enhancing measures, technological innovation, and environmental sustainability, while avoiding the entrenchment of inefficient enterprises and fiscal dependency. A shift toward targeted, transparent, and conditional support, aligned with broader economic and environmental objectives, is essential to ensure that agricultural policies contribute meaningfully to long-term economic development, food security, and social cohesion.

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EU CAP environmental actions for land management with a focus on the economic sustainability of agri- businesses

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Abstract: Partial agri-environmental measures and ecological management schemes should provide adequate compensation for the implementation of specific practices or ecological commitments regarding land management by business entities under EU Common Agricultural Policy. The agricultural output of such production-related enterprises is commonly achieved with reduced input consumption and lower pressure on the environment. In addition, such production of agricultural primary production enterprises may come from marginal areas that could be left without economic utilisation without financial support, including the associated potential for the provision of ecosystem services, as an additional dimension of social benefits in the framework of landscape management, and the associated potential for the development of biodiversity of the area concerned. This article aims at exploratory study of available secondary data of EU Farm Accountancy Data Network on diversity in agricultural land usage among farms in order to identify relationship between development of their economic performance and structure of land use.

Keywords: land management, EU Common Agricultural Policy, economic performance.

JEL Classification: Q18, Q15

1 Introduction

Significant efforts and resources are being invested into integrated landscape management interventions, a fact closely tied to the challenges of mitigating the impacts of climate change and the related need for regional adaptation in accordance with specific territorial characteristics. Empirical research aimed at quantifying ecosystem services in terms of their benefits to nature and society must necessarily be linked to the evaluation of their effects and their most intensive possible integration with economic activities and the associated use of natural resources (del Río-Mena, 2023). MacDonald et al. (2000) analyse the process of agricultural land abandonment in the mountain regions of Europe (Alps, Pyrenees, Apennines, Carpathians) in the second half of the 20th century. The authors document that between 1960 and 1990, approximately 25% of agricultural land in mountain regions was abandoned. The main factors include: low productivity and high labour costs on sloping land, depopulation of rural areas, ageing of the farming population, poor accessibility and infrastructure. The study describes in detail the environmental consequences of abandonment - initially positive (reduction of erosion, regeneration of vegetation) but in the long term negative (loss of biodiversity of the cultural landscape, increased risk of fires, loss of landscape-forming function). The authors analyse policy responses including compensatory payments in less favourable areas. They show that a combination of economic incentives, support for local products and development of multifunctional agriculture is necessary to effectively prevent land abandonment.

The growing global population and the rising standard of living are driving demand that influences the scale of intensive agricultural production, often associated with the conversion of permanent grasslands or even forests into arable land. These factors negatively affect both carbon retention in organic soil matter and the extent of ecosystem services. Finding a compromise solution to these changes that balances the interests of affected stakeholders and broader societal concerns remains a significant challenge (Johnson et al., 2023). Addressing climate change must objectively involve carbon sequestration from CO₂ emissions through ecosystems. This will play a crucial role in achieving the EU's climate neutrality target by 2050. Activities that can contribute to carbon retention or enhance soil carbon sequestration capacity include afforestation, forest restoration, agroforestry, adoption of agricultural and forestry practices that protect and increase soil carbon, wetland conservation, peatland restoration, and the promotion of long-term and circular bio-based products (European Commission, 2021).

Data from the European Union Farm Accountancy Data Network (EU FADN) indicate that agricultural holdings in areas with natural constraints are associated with less intensive farming practices than farms outside ANC areas. These

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farms exhibit lower labour intensity, use fewer inputs (especially mineral fertilizers and pesticides), have lower livestock densities (measured in livestock units per hectare), and make more favourable use of agricultural land compared to farms outside those areas. These general trends are consistent across different types of farming. The least intensive agricultural practices are demonstrably carried out by farms in mountainous areas. From an economic perspective, farms in areas facing the natural constraints typically have smaller economic size and income, lower intermediate consumption, and receive relatively more subsidies per hectare of agricultural land compared to farms outside those areas (European Commission, 2023). This article aims at exploratory study of available secondary data of EU Farm Accountancy Data Network on diversity in agricultural land usage among farms in order to identify relationship between development of their economic performance and structure of land use.

Methods

A multivariate input for the explorative analysis using hierarchical clustering approach is using the EU Farm Accountancy Data Network (FADN) indicators as following: (SE300) Crop protection (€/farm), (SE295) Fertilisers (€/farm), (SE025) Total Utilised Agricultural Area (ha/farm), (SE028) Permanent grassland (ha/farm), (SE027) Permanent crops (ha/farm), (SE026) Arable land (ha/farm), (SE415) Farm Net Value Added (€/farm), (SE420) Farm Net Income (€/farm).

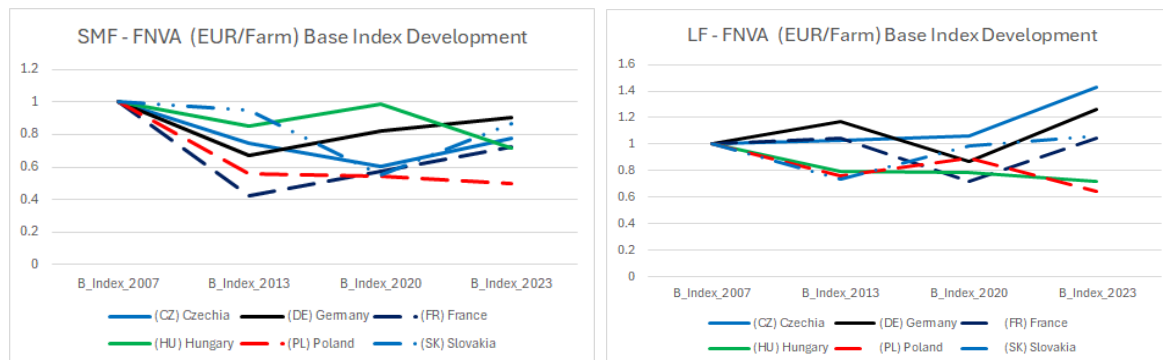
The researched size categories of businesses are according Commission Regulation (EC) No 1242/2008 regarding the amount of their standard output of production as follows: Category 1: 2 000 - 7 999 EUR; Category 2: 8 000 - 24 999 EUR; Category 3: 25 000 - 49 999 EUR; Category 4: 50 000 - 99 999 EUR; Category 5: 100 000 - 499 000 EUR; Category 6: 500 000 EUR and higher. As the sample of small and medium sized farms are regarded entities with their standard output of production lower than 100,000 EUR. Farms with the standard output of production higher then 100,000 EUR are regarded as the large farms.

Software TIBCO Statistica 14 was used for the hierarchical clustering procedures.

2 Research results

Empirical results of this contribution are based on the exploratory analysis of available secondary data arising from a representative long term survey regarding farm accounting data provided by businesses entities.

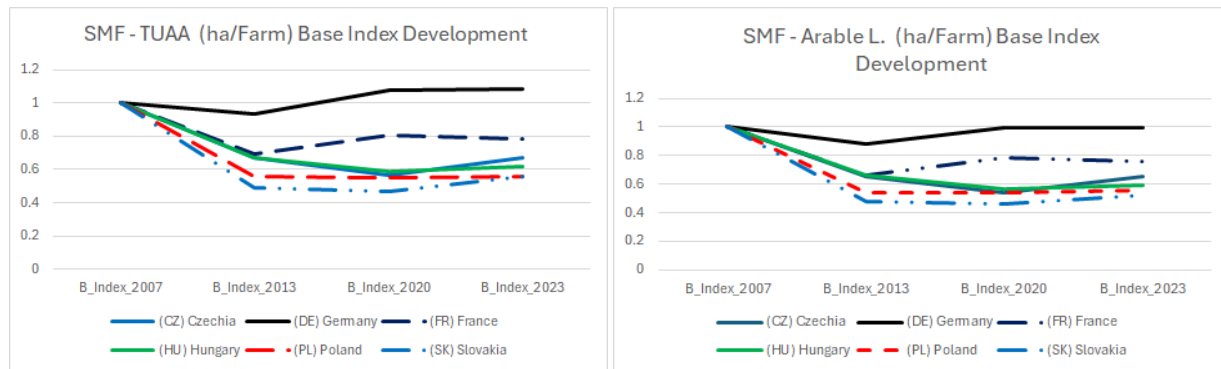
Figure 1 Development of Farm Net Value Added indicator using base index 2007 = 1 of selected EU countries



Source: own work using data of European Commission (©2025)

Fig. 1 illustrates the base index development of Farm Net Value Added (FNVA) for small farms (SF) and large farms (LF) across six European countries - Czechia, Germany, France, Hungary, Poland, and Slovakia - over the years 2007, 2013, 2020, and 2023. Large Farms show greater volatility and higher growth potential in FNVA compared to small farms. Small farms exhibit more stable but lower base index values, indicating slower or more constrained growth in the potential to gain the positive factor income.

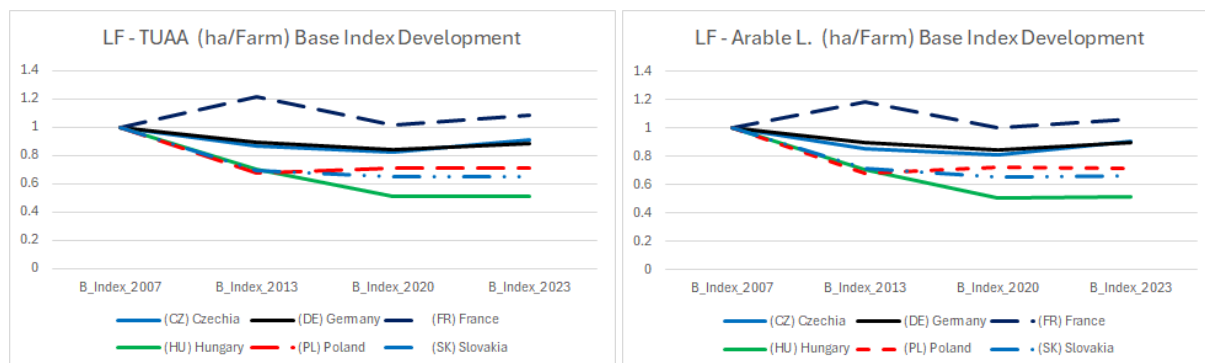
Figure 2 Development of Total Utilised Agricultural Area in comparison with indicator Arable Land using base index 2007 = 1 of selected EU countries for small and medium sized farms in selected EU countries



Source: own work using data of European Commission (©2025)

The Total Utilised Agricultural Area (TUAA) in comparison with the Arable Land index for the case of the small farms follows a similar but slightly less pronounced trend compared to TUAA (see Fig. 2). The gap between TUAA and Arable Land indices in some countries (e.g., Czechia, Slovakia) suggests a diversification of land use beyond arable farming, possibly into permanent grasslands or other agricultural uses. Countries with stable indices (Germany, France) may reflect mature agricultural structures with limited land expansion or consolidation. The divergence in trends between TUAA and Arable Land in countries like Poland may indicate policy-driven land use changes or structural shifts in farm management.

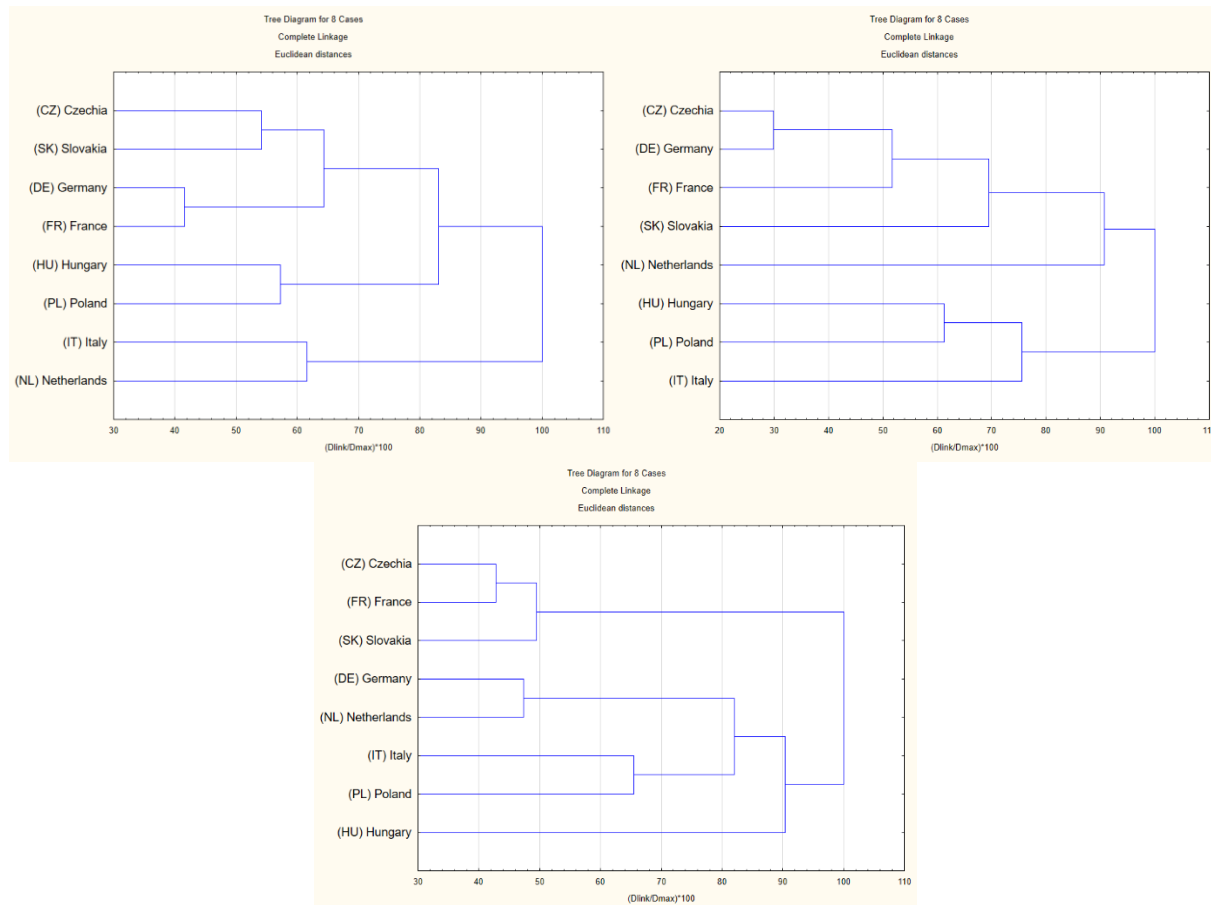
Figure 3 Development of Total Utilised Agricultural Area in comparison with indicator Arable Land using base index 2007 = 1 of selected EU countries for the largest farms in selected EU countries.



Source: own work using data of European Commission (©2025)

The identified trends on Fig. 3 regarding Total Utilised Agricultural Area (TUAA) in both indicators are highly correlated, indicating that changes in total utilised agricultural area are largely driven by changes in arable land. This finding is similar to the previous findings regarding small and medium sized farms.

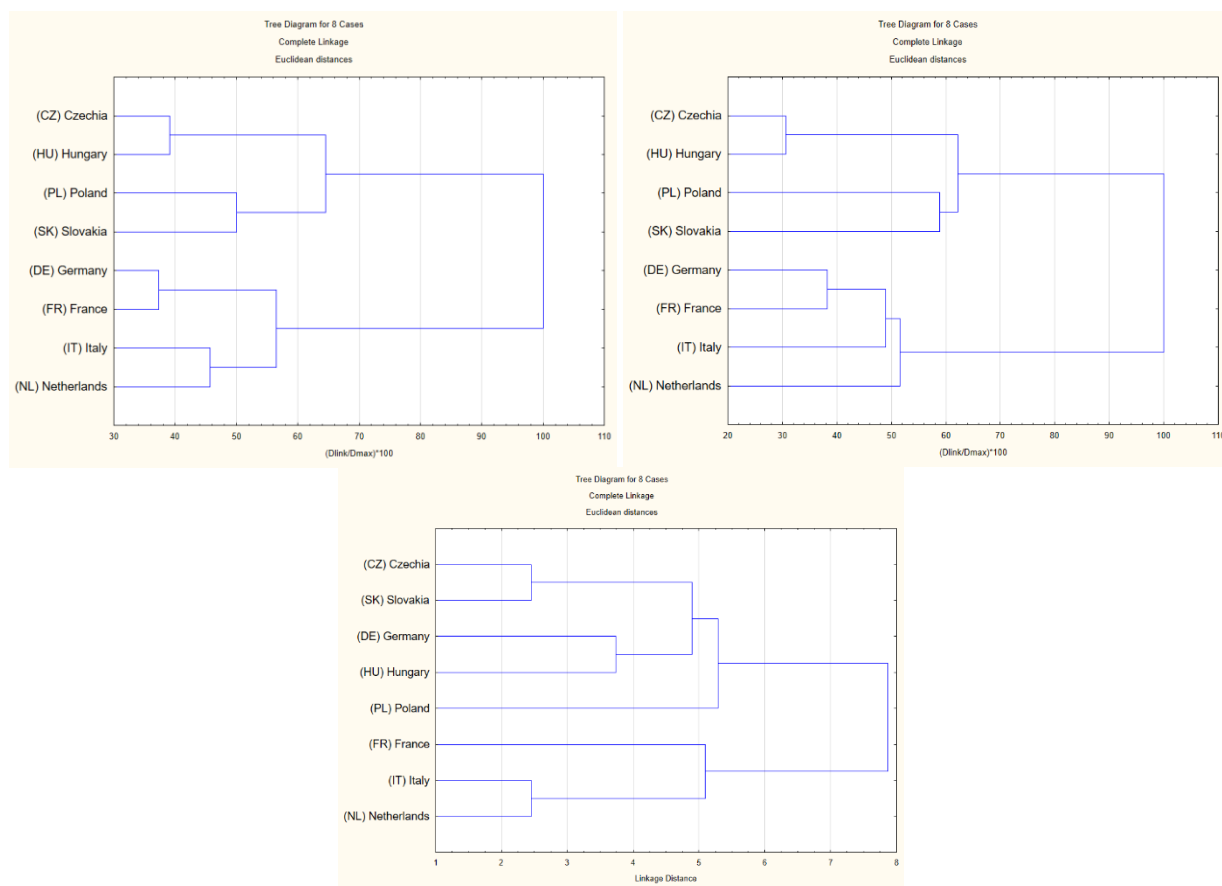
Figure 3 Results of hierarchical clustering regarding the multivariate criteria for the observed small and medium farms



Source: own work using data of European Commission (©2025)

Dendrograms presented in Fig. 3 represent a dynamic view on the selected multivariate criteria, involving % of Environmental subsidies from total operating subsidies, % of LFA subsidies from total subsidies, Crop protection Expenditures (€/farm), expenditure for Fertilisers (€/farm), Total Utilised Agricultural Area (ha/farm), Permanent grassland (ha/farm), Permanent crops (ha/farm), Arable land (ha/farm), Farm Net Value Added, Farm Net Income (€/farm). Czechia (CZ) and Slovakia (SK) form the closest pair, reflecting also their historical, economic and structural characteristics. Germany (DE) and France (FR) cluster suggesting a core EU representatives in the sample. Hungary (HU) and Poland (PL) form a distinct cluster representing Central-Eastern European countries. Italy (IT) and Netherlands (NL) are more distant, indicating divergent development paths, possibly due to differences in agricultural structure characteristics. Development towards the observed time period of years 2021 -2023 (bottom down dendrogram) refers that small and medium-sized farms gets closer regarding the multivariate characteristics in Czechia (CZ) and France (FR). It could reflect a CAP policy-driven convergence accompanied with a similar trends in innovations. Slovakia (SK) also joins this cluster, reinforcing the Central European core country. Germany (DE) and Netherlands (NL) form a separate cluster, possibly reflecting highly industrialized agricultural systems. Italy (IT), Poland (PL), and Hungary (HU) form a broader cluster, suggesting shared challenges in their development.

Figure 4 Results of hierarchical clustering regarding the multivariate criteria for the observed large farms



Source: own work using data of European Commission (©2025)

Dendrograms presented in Fig. 4 also represent a dynamic view on the selected multivariate criteria as provided regarding the previous Fig. 3, but for the case of the largest farms. Eastern European countries Czechia, Hungary and Poland are tightly grouped, suggesting regional convergence. Western countries form separate clusters, indicating divergence in their development for the initial observed period of years 2007 – 2013 (upper left dendrogram). Through the next development representing years 2014 – 2020 (upper right dendrogram), it is identified a possible internal cohesion over time. Germany shifts closer to France and Italy, indicating alignment in their Common Agricultural Policy harmonization. The last observed period of years 2021 – 2023 represent a less regionally determined situation. It could represent a divergence at EU-level, reshaping traditional grouping.

3 Conclusions

FADN represents the only harmonised system for collecting microeconomic data from commercial agricultural holdings across the EU (EJ FADN ©2025). In the previous studies e.g. Špička and Smutka (2014) it was analysed the technical efficiency of agricultural enterprises and also were identified factors that influenced it. The results showed significant variability in efficiency between countries - enterprises in the "old" member states (especially the Netherlands or Belgium) achieved higher efficiency than in the new member states, including the Czech Republic. The study identified as key factors of efficiency: enterprise size (larger enterprises are more efficient), production specialization, capital intensity and the farmer's level of education. Scown et al. (2020) carry out an extensive spatial analysis combining FADN data with geographical information on land use across the EU. The study quantifies that only 15% of agricultural land in the EU is managed in a way that significantly supports environmental objectives. Yet CAP subsidies are distributed largely by area, without regard to environmental performance. Pe'er et al. (2019) criticize the current structure of the CAP and proposes reforms to increase environmental efficiency. The authors identify three main structural problems: (1) Area-based direct payments encourage concentration and intensification at the expense of landscape diversity, (2) ecological focus areas have minimal environmental benefits because they allow for too wide a choice of measures, including low-value ones, agri-environmental schemes cover only a limited part of agricultural land and often compensate for practices that have limited impact. Their article presents an alternative model based on real environmental performance, where subsidies would be

linked to measurable environmental objectives (biodiversity, soil quality, water retention, carbon sequestration). The authors argue that the current land use structure in the EU - dominated by large, homogeneous blocks of arable land - is unsustainable and requires a transformation towards a mosaic landscape with a more diverse land use structure. Lakner et al. (2022) assess whether the new instruments will lead to a diversification of land use patterns. The study shows considerable heterogeneity between Member States in the design of eco-schemes - some Member States propose ambitious measures (e.g. conversion of arable land to permanent grassland, extensive orchards), while others limit themselves to minimalist measures. An economic analysis based on modelling of FADN data shows that eco-schemes can lead to a 5-15% decrease in income for intensive farms, but this decrease is fully compensated by subsidies. For extensive farms, eco-schemes can even increase income, as the requirements are close to their current practice. The article identifies potential trade-offs between productivity and environmental objectives and discusses how different land use patterns affect the economic viability of farms.

Zagata et al. (2020) provide a historical and sociological analysis of the development of Czech agriculture after 1989, with an emphasis on the adoption of the concept of sustainability. The authors use a combination of quantitative data (statistics on the structure of enterprises, land use, subsidies) and qualitative methods (interviews with 50 farmers). The study shows that the transformation of Czech agriculture had three phases: (1) 1990-2000: privatization and restitution, decrease in farming intensity due to the economic crisis, (2) 2000-2010: growth of large enterprises, increase in intensity, beginning of organic farming, (3) 2010-present: diversification, increase in small enterprises, growing interest in sustainable practices. An important finding is that Czech agriculture remains highly concentrated (average farm size 152 ha, the highest in the EU) with a dominance of large corporate farms. Agro-environmental measures were adopted mainly by small and medium-sized enterprises, while large enterprises are oriented towards intensive production. The study also documents a generational change - younger farmers are more open to sustainable practices and diversification.

This paper presents an exploratory analysis of farm accounting data from selected EU countries, focusing on small and large farms. Large farms show higher volatility and growth potential in Farm Net Value Added compared to small farms, which demonstrate more stable but slower growth. Identified Land Use Trends regarding small and medium farms, the gap between Total Utilised Agricultural Area (TUAA) and Arable Land suggests diversification into non-arable uses (e.g., grasslands). Stable trends in countries like Germany and France reflect mature agricultural systems, while divergence in Eastern European countries may indicate structural changes. For the sample of large farms the Total Utilised Agricultural Area and Arable Land indicators are highly correlated, indicating that changes in land use are primarily driven by arable land adjustments. Exploration arising from the hierarchical clustering approach for the sample of small and medium farm reveals regional similarities for the Czechia and Slovakia forming a close pair, Germany and France representing core EU countries, while Hungary and Poland cluster together as Central-Eastern European countries. Over time period of years 2021–2023 Czechia, France, and Slovakia converge, possibly due to CAP policies implementation and innovation trends. For the sample of the observed representatives of the largest farms, Eastern European countries (Czechia, Hungary, Poland) cluster together, while Western countries diverge. Over time, Germany aligns more with France and Italy, showing possible CAP harmonization. By 2021–2023, regional patterns become less distinct, suggesting a shift in EU-level agricultural dynamics.

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Predictive Capabilities of Working Capital as an Indicator of Impending Insolvency of a Company in the Czech Republic[#]

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Abstract: The aim of the study is to analyze the predictive capabilities of changes in working capital as an indicator of impending insolvency of companies in the Czech Republic. The research uses empirical data from the financial statements of companies that entered insolvency proceedings between 2019 and 2024 and compares them with a control sample of financially stable entities. The analysis was performed using logistic regression and additionally verified using ROC analysis. The results confirm that selected working capital indicators, in particular current liquidity and the ratio of working capital to total assets, have a significant ability to predict financial instability. The findings highlight the practical importance of effective working capital management for the early identification of insolvency risk and provide a basis for the development of early warning models in the corporate sector.

Keywords: working capital, insolvency, predictive models, liquidity, Czech companies

JEL Classification: G32, G33, C35

1 Introduction

The financial stability of companies is a key determinant of sustainable economic growth and competitiveness. Corporate insolvency is not just an individual problem for a single entity, but has systemic impacts on the broader economic environment, including employment, supply chains, and capital markets. Identifying warning signs of impending financial instability is therefore an important topic in corporate finance and public policy.

Traditional insolvency prediction models, starting with Altman's Z-score, rely primarily on static ratios that capture the financial situation of a company at a given point in time. While these approaches have provided a basic framework for estimating bankruptcy risk, their ability to capture dynamic changes in a company's financial health is limited. In response, research over the past two decades has focused on dynamic indicators that better capture operating liquidity and the management of short-term assets and liabilities, particularly working capital.

Working capital is the difference between current assets and current liabilities and is an indicator of a company's operating liquidity. Changes in working capital reflect a company's ability to effectively manage its inventories, receivables, and payables, and thus its flexibility in generating cash flows. A rapid deterioration in these areas may signal a transition from a phase of financial equilibrium to a phase of stress, which often precedes insolvency proceedings.

Empirical studies (Gavurová et al., 2022; Kim et al., 2024) confirm that selected working capital indicators can have significant predictive power. However, in the Czech context, this relationship remains relatively unexplored. The Czech economy is characterized by a high proportion of small and medium-sized enterprises, which are often sensitive to changes in liquidity, while the availability of short-term financing is more limited than in advanced Western economies. These factors make the analysis of working capital in the context of insolvency particularly relevant.

The aim of this study is to empirically verify whether selected working capital indicators can serve as early indicators of impending insolvency of companies in the Czech Republic. The study combines an econometric approach based on logistic regression with descriptive analysis to ensure the robustness of the findings. The results contribute to the literature on corporate financial health and also have practical implications for corporate management, banks, and investors.

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2 Methods

2.1 Data set

The empirical analysis is based on financial data from companies registered in the Czech Republic that entered insolvency proceedings under Act No. 182/2006 Coll. on Bankruptcy and Methods of its Resolution between 2019 and 2024. The data comes from the specialized forensic agency Surveillance, s.r.o., from the Justice.cz, ARES, and Albertina databases.

The data was limited to medium-sized companies with an annual turnover of between CZK 15 and 300 million.

For the purposes of descriptive analysis, a total of 155 companies were used that entered insolvency during the period under review and for which financial statements existed for the three accounting periods prior to the commencement of insolvency proceedings.

For the purposes of the insolvency model, a total of 366 companies were used, half of which were companies that entered insolvency during the period under review and for which financial statements were available for one accounting period prior to the commencement of insolvency proceedings. The other half consisted of a control sample of financially healthy comparable companies. Extreme values (1% of the highest and 1% of the lowest values) were removed from the set. This created a balanced data set that allowed for a fair comparison of both groups.

2.2 Variables and their construction

The empirical model used variables that reflect the individual components of working capital and the basic characteristics of financial stability. These are listed in Table 1 below.

Table 1 Definition of variables in the insolvency model

Abbreviation	Indicator	Calculation
DIO	Days Inventory Outstanding – inventory management efficiency	(Inventory / Sales) × 365
DSO	Days Sales Outstanding - speed of converting sales into cash	(Receivables / Sales) × 365
DPO	Days Payables Outstanding - ability to defer payments	(Liabilities / Sales) × 365
CCC	Cash Conversion Cycle - measure of operational efficiency	DIO + DSO – DPO
CR	Current Ratio - short-term solvency	Current Assets / Short-Term Liabilities
WC/TA	Working Capital to Total Assets - structural stability	Working capital / Total assets
WC/E	Working Capital to Equity - ratio of operating funds to equity	Working Capital / Equity

Source: Own processing

2.3 Econometric Specification

Logistic regression was chosen for the empirical analysis, which models the probability of a company's insolvency $P(Y_i = 1)$ based on selected financial indicators. The general form of the model is:

$$\text{logit}(P_i) = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + \varepsilon_i \quad (1)$$

where X_{ki} represent individual working capital indicators and control variables. The dependent variable $P(Y_i = 1)$ takes on a binary value of 1 (if the company has entered into insolvency) or 0 (healthy company).

A model diagnosis was performed, specifically Pearson's test, which identified possible problems with the model specification (Almquist, 2023). Based on these findings, robust testing was performed to verify whether the identified problems could affect the statistical significance of individual predictors.

For the purposes of robust testing, White's robust standard errors in the HC0 variant (Long and Ervin, 2000) were used, which take into account the possible presence of heteroscedasticity in the residuals.

Taking heteroscedasticity into account affects the accuracy of the statistical evaluation of some variables. For this reason, the use of robust standard errors can be considered an important step towards increasing the reliability of the results of the corporate insolvency prediction model.

To ensure even greater reliability of the derived conclusions, the bootstrap inference method was applied. This approach does not require assumptions about the shape of the error distribution and allows for empirical estimation of the variability of the model coefficients based on repeated sampling from the original training data (Zivot, 2021). The method verifies whether the coefficient estimates are stable across different sampling conditions, thereby providing additional support for their interpretation and practical application.

2.4 Model validation

To ensure predictive reliability, the data was divided into a training (80%) and testing (20%) sample. The predictive ability of the model was evaluated on the testing sample using:

- Confusion matrix to determine classification accuracy,
- Receiver Operating Characteristic Curve („ROC“ curve),
- Area Under the Curve („AUC“) and
- Precision, Recall, and F1-Score for sensitivity and specificity balance.

3 Research results

3.1 Descriptive statistics

Table 2 summarizes the basic statistical characteristics of the variables in the sample of 155 insolvent companies. The results show that insolvent companies exhibit a significant deterioration in cash conversion cycle (CCC) and days payable outstanding (DPO) one year prior to insolvency, and conversely, an improvement in days inventory outstanding (DIO). All these factors reflect a lack of cash in the company and confirm that the effectiveness of working capital management can be significantly related to the financial stability of the company. Although these trends are clearly observable one year before insolvency, it can also be observed that the deterioration in working capital begins to occur one year earlier (i.e., two years before insolvency). The deterioration in liquidity is also indicated by the development of the current liquidity ratio (CR).

The WC/TA and WC/E indicators then paint a picture of a disrupted financial structure. Declining WC/TA medians indicate a gradual decline into structurally unsustainable ratios between working capital and assets. The growth of the WC/E indicator can be explained by the negative values of working capital and equity capital, which arose as a result of deepening losses. In such a situation, the indicator grows numerically, but its development must be interpreted in the broader context of other financial indicators, because on its own it can no longer reliably indicate the actual financial stability of the company.

Table 2 Descriptive characteristics of the sample of insolvent companies

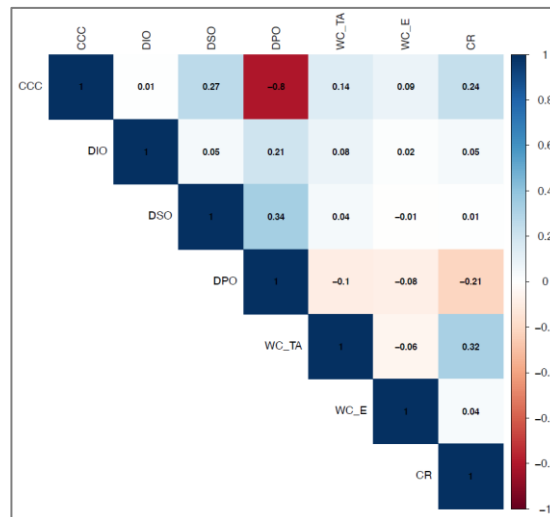
Median values	3 years before insolvency	2 years before insolvency	1 year before insolvency
DIO	11.8	11.6	7.7
DSO	65.8	66.3	66.1
DPO	132.2	147.1	215.8
CCC	-21.1	-31.3	-82.9
CR	1.14	1.07	0.77
WC/TA	8%	4%	-13%
WC/E	66%	83%	87%

Source: Own processing

3.2 Correlation analysis

As can be seen in Figure 1, the correlation matrix reveals the expected relationships between individual variables. Most variables are not strongly correlated with each other and are therefore suitable for inclusion in the model. Based on these results, it was decided to leave the individual variables in the regression model separately and to exclude only CCC as a composite indicator.

Figure 1 Correlation matrix of financial indicators



Source: Own processing

To verify that there was no strong interdependence between the explanatory variables, the Variance Inflation Factor (VIF) was also calculated. The results showed that none of the variables had a VIF value higher than 5. Multicollinearity was not identified, confirming the suitability of the data for logistic regression.

3.3 Logistic regression

The logistic model estimates the probability of insolvency as a function of selected working capital indicators on the training data set. The resulting coefficients, including White's robust standard errors, are shown in Table 3.

Table 3 Parameters of the insolvency prediction model

Variable	Coefficient estimate	Standard error	Z-value	P-value
(Intercept)	1.0037	0.6941	1.4460	0.1480
DIO	0.0005	0.0045	0.1190	0.9050
DSO	0.0088	0.0028	3.1830	0.0015**
DPO	0.0027	0.0014	1.9700	0.0488
WC/TA	-2.7182	1.0027	-2.7170	0.0066**
WC/E	-0.1164	0.0700	-1.6630	0.0962
CR	-1.4190	0.4964	-2.8580	0.0043**

Significance: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; . $p < 0.1$

Source: Own processing

The subsequent application of the bootstrap inference method summarized in Table 4 confirmed the results of the previous robust analysis. However, it shows different degrees of stability of individual variables in the model.

Based on 95% confidence intervals, it can be stated that the variables DSO, WC/TA, and WC/E have intervals that exclude zero and can therefore be considered statistically significant and robust predictors. In addition, they retain a significant influence even at increased confidence levels (up to 99%), which further strengthens their credibility (Bobbitt, 2021).

In contrast, the variables DIO and DPO do not show significance at any of the tested levels, as their intervals contain zero, suggesting that their influence on the risk of bankruptcy is not statistically consistent and is likely to depend on the specific form of the data (Zivot, 2021).

The CR variable appears to be marginally significant in the bootstrap CI, while in the output with robust standard errors it was statistically significant, its bootstrap interval includes zero, which indicates greater uncertainty about its stability across samples. Its influence should be interpreted with caution, and any confirmation would warrant additional analysis.

Overall, bootstrap inference confirms the high quality of the basic model and contributes to a detailed understanding of which predictors can be considered reliable benchmarks in predicting corporate insolvency.

Table 4 Overview of bootstrap testing for 90%, 95%, and 99% confidence intervals

Variable	90% confidence interval	95% confidence interval	99% confidence interval	Significance
Intercept	[0.0622; 3.3416]	[-0.0980; 3.9783]	[-0.3787; 5.1974]	Only at the 90% level
DIO	[-0.0063; 0.0088]	[-0.0070; 0.0106]	[-0.0101; 0.0146]	Insignificant at all levels
DSO	[0.0052; 0.0167]	[0.0044; 0.0184]	[0.0033; 0.0228]	Stable and significant
DPO	[-0.0002; 0.0053]	[-0.0005; 0.0061]	[-0.0013; 0.0084]	Not significant
WC/TA	[-4.8092; -1.0004]	[-5.3413; -0.7103]	[-6.3131; -0.1867]	Highly significant
CR	[-0.2961; 0.1315]	[-0.3360; 0.1957]	[-0.4186; 0.3347]	Borderline significant
WC/E	[-3.4576; -0.9227]	[-4.0062; -0.8364]	[-5.4000; -0.6964]	Stable significance

Source: Own processing

3.4 Evaluation of the model on the test data set

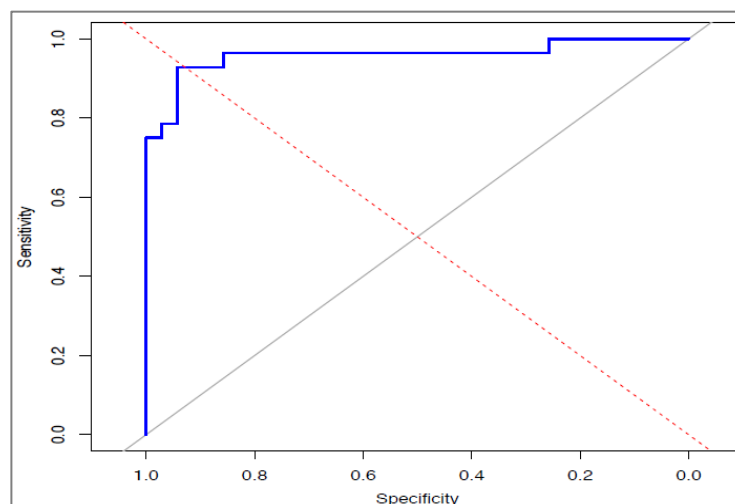
After training the model on the training set and verifying its robustness, it was validated on independent test data. The aim was to verify how well the model can classify companies as healthy or insolvent and to assess its predictive capabilities outside the original sample. The main metrics for evaluating the model's performance were the confusion matrix and ROC curve together with the AUC value (Betinec, 2006).

The confusion matrix allows the accuracy of the model's classification to be assessed. The model created on the training data sample was applied to the test sample with 90.48% accuracy. The model correctly classified 30 healthy and 27 insolvent companies, while it classified 5 healthy companies as insolvent and 1 insolvent company as healthy. This result indicates that the model is very good at identifying insolvent companies, but in some cases it mistakenly classifies healthy companies as insolvent, which can lead to false alarms.

To supplement the evaluation, a ROC curve was constructed, which shows the relationship between sensitivity and (1 - specificity) depending on the classification threshold used (Betinec, 2006). The results are presented in the Figure 2.

The AUC reached a value of 0.959, which indicates the model's excellent discriminatory ability. The curve shows a sharp increase in sensitivity while maintaining high specificity, which indicates that the model is very effective in separating the two classes.

An AUC approaching 1 is considered a sign of high predictive quality. The result of 0.959 confirms that the model created can be considered a reliable tool for predicting insolvency risk.

Figure 2 ROC curve

Source: Own processing

4 Conclusions

Working capital is not only an accounting category but also an important indicator of financial stability. Its management is a strategic tool for preventing insolvency and should be an integral part of modern approaches to financial management. The results show that:

- the effectiveness of working capital management is a key determinant of financial stability and
- current liquidity indicators and the ratio of working capital to assets have the highest predictive power.

These findings confirm the hypothesis that changes in working capital can serve as a reliable indicator of impending insolvency of companies in the Czech Republic.

Although the results show high robustness, the study faces several limitations. First, the data set used mainly includes companies that publicly disclose their financial statements, which may lead to selection bias.

Secondly, the model does not take into account macroeconomic variables such as interest rates, inflation, or GDP growth, which may affect companies' ability to maintain operational liquidity.

Thirdly, logistic regression only captures linear relationships between variables and the probability of insolvency, whereas non-linear effects (e.g., DSO or CR thresholds) may be significant.

Incorporating these factors into future models could increase the accuracy and usability of prediction systems in practice. It could also be interesting to analyze differences across various industries.

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The Size Factor in the Inclusion of Regional Foods in School Canteen: An Empirical Analysis

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Abstract: School catering is an important element of the public food service system and represents a stable market with high and consistent demand for food. In recent years, increasing academic and political attention has focused on the inclusion of regional food into school canteens. Such an initiatives are also linked to sustainability goals, regional economic support, and reduction of environmental impact of food system. This study investigates the relationship between school canteen size (measured by the number of meals served per day) and the share of regional food used in daily operations. A data from a survey among primary schools in Brno (Czech Republic) revealed no significant correlation between canteen size and the use of regional food in school canteens. These results contribute to understanding factors that are important for designing more sustainable food systems.

Keywords: school canteen, local farms, sustainability, SFSCs, agriculture

JEL Classification: Q13, Q18, Q12

1 Introduction

The primary goal of school catering is to provide children and students with a consistent supply of nutritionally balanced meals during the school day. This initiative aims to support healthy growth, proper development, and concentration in children while also promoting the adoption of healthy lifestyle habits (Nixon et al., 2025). Proper nutrition during childhood is crucial for healthy growth and development, both physically and cognitively. It also plays a significant role in preventing obesity and other lifestyle-related diseases later in life (Cohen Kadosh et al., 2021). Additionally, school catering has a social dimension, as it fosters shared dining experiences and ensures that affordable meals are available to all children (Hart, 2016). In the Czech Republic, school catering is an integral part of the healthcare system for children and youth. Its organization is grounded in legal regulations, particularly the Education Act No. 561/2004 Coll. and Decree No. 107/2005 Coll. on School Catering. These legal frameworks define the operational rules for school canteens, categorize diners by age, and establish nutritional requirements (Kejvalová, 2010; Klimešová & Stelzer, 2013). High-quality meals should not only provide the necessary energy and nutrients but also positively influence students' school performance, intellectual ability, immune systems, and mental well-being. Conversely, excessive consumption of sugars and unhealthy fats can contribute to the rising prevalence of childhood overweight and obesity (Dehghan et al., 2005). The demand for school meals is notably extensive and stable. School canteens in the Czech Republic prepare approximately 383 million meals each year, serving around 2 million children aged 2 to 19 daily (New rules for school canteen, 2025). School lunches are substantially subsidized, with the subsidy rate reaching around 60% (Pavel, 2023). The state allocates approximately CZK 2.4 billion annually for the operation of school canteens, while about CZK 10 billion is spent each year on food purchases for these lunches.

The sustainability of food production within agricultural farms is becoming an urgent issue. Declining farm profits, along with the pressure to reduce production costs and commodity prices, create increasing barriers to market access, leading many farms to leave the agricultural sector (Berti & Mulligan, 2016). One potential solution to address the challenges posed by conventional agri-food systems is to reconstruct regional and local agri-food systems. This approach could serve as a competitive or survival strategy for agricultural farms (Berti & Mulligan, 2016).

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Direct sales to consumers are typically conducted through channels such as farmers' markets, community-supported agriculture, farm stands, and other consumer-oriented sales channels (Low et al., 2015). However, a new marketing option has also emerged — the so-called “intermediated market channel,” which appeared alongside the growing consumer demand for locally and regionally produced foods. This channel includes sales made directly to restaurants, institutions, or regional food aggregators, such as schools and hospitals (Low et al., 2015; Christensen et al., 2017). The expansion of intermediated market channels can benefit agricultural farms by improving their access to the expanding local food market (Dimitri & Gardner, 2018). This approach increasingly serves to respond to the challenges posed by conventional agri-food systems (Berti & Mulligan, 2016; Gori & Castellini, 2023).

The State Agricultural Intervention Fund (SZIF) and the Ministry of Agriculture (MZe) are working to incorporate local foods into public catering. These priorities align with the European Union's agricultural strategy, which emphasizes the “Farm to Fork” approach aimed at producing sustainable and healthy food. Additionally, they contribute to achieving goals related to climate action, biodiversity, and public health.(Elshaer et al., 2023).

The article argues that larger canteens are generally better equipped, from an administrative perspective, to engage local suppliers in their supply and demand processes. They have a more comprehensive management and logistics structure, which allows them to integrate local suppliers more effectively into their catering systems.

This article aims to confirm or refute the following statement concerning the higher share of local foods in larger canteens. The research is based on data from a survey conducted by the Brno City Municipality.

One of the main contributions of this article is to verify the possibilities for involving local suppliers in the catering system of kindergarten and primary schools and to identify the barriers that hinder such involvement.

2 Methods

The theoretical background of this article is given by the Local Food Systems Theory, which assumes that connections between producers, distributors, and consumers within a specific region (locality) generate not only economic but also social, environmental, and institutional benefits (Martinez et al., 2010). In the context of school catering, this theory explains why and how individual institutions, such as school canteens, involve-regional food suppliers in their catering systems and what factors influence this process. According to the above-mentioned theory, the involvement of regional foods is a function of institutional capacity and supplier networks (van Paassen et al., 2022). For these reasons, we assume that larger canteens, with more robust management and logistics structures, are better prepared (equipped) to integrate local (regional) suppliers into their catering systems and therefore tend to exhibit a higher share of local (regional) foods.

In this context, the following hypothesis was formulated: The average share of regional foods is influenced by the size of the canteen. Larger canteens are expected to show greater involvement of regional foods.

By testing this hypothesis, the article defines a regional food as a product that originates from a specific geographic area known as a region. In the context of sustainability, particularly near regional borders, it is also appropriate to include local foods that come from the immediate vicinity of the consumption area, even if they technically belong to a different region (Augere-Granier, 2016; Holcomb et al., 2018).

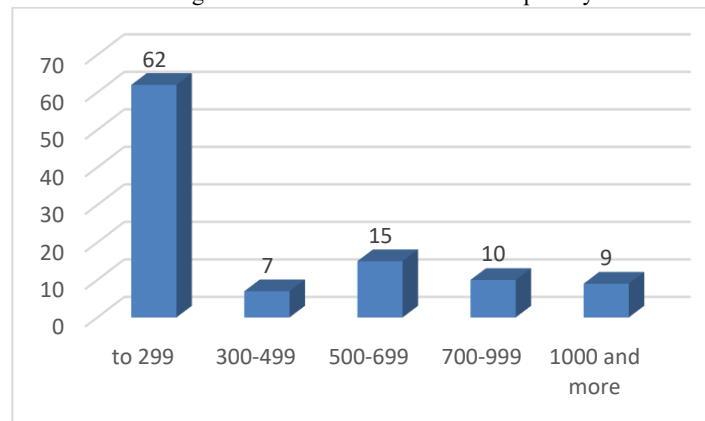
The presented data are the outcome of the survey “*Utilization of Regional Food Production in School Canteens*”, conducted by the Department of Strategic Development of the Brno City Municipality within the MECOG-CE project (Metropolitan Cooperation and Governance in Central Europe) under the Interreg Central Europe program, under the patronage of JUDr. Irena Matonohová, Councillor for Education. The survey was carried out in February 2025 among kindergarten and primary school canteens established by the Statutory City of Brno. In total, 127 school canteens were contacted, and 103 completed questionnaires were received.

The size of the school canteens was determined by the average number of lunches served each day. Figure 1 shows the distribution of canteen sizes.

To test the hypothesis regarding the relationship between the use of regional foods and the size of the school canteen, a linear regression analysis was conducted. The goal was to determine if there is a statistically significant association between the number of lunches served daily (which reflects the canteen size) and the proportion of regional foods utilized. In this analysis, the dependent variable was the average percentage of regional foods used, while the independent variable was the average number of lunches served per day, representing the size of the canteen.

The regression analysis was performed using a dataset comprising 103 observations.

Figure 1 The size of the school canteens according to the number of served lunches per day



Source: Results of the questionnaire survey conducted by the Brno City Municipality, own processing

The relationship in the regression was modelled using the following equation:

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

where:

- Y is the dependent variable (the share of the regional food),
- X is the independent variable (number of the served meals),
- β_0 is the absolute term (intercept),
- β_1 is the regression coefficient (slope),
- ε is the random error (residue).

We assume that the predictor (explanatory variable) does not have a linear effect on the dependent variable.

The null hypothesis $H_0: \beta_1=0$

A residual analysis was conducted to verify the assumptions of linear regression, specifically data normality. The results of the analysis showed that the data exhibited strong skewness and therefore did not meet the assumption of normality. Due to the need for transformation, data with a zero share of regional foods were removed. The subsequent data, adjusted through logarithmic transformation, still did not meet the required normality assumption; therefore, the Box-Cox data transformation was applied. The Box-Cox transformation is a method used to stabilize variance and bring data closer to normality. It is mainly applied in regression models where the assumption of normally distributed residuals is not met (Atkinson et al., 2021). After applying the transformation, the models can be interpreted more easily, and the results are statistically more robust.

The regression analysis was applied to 66 adjusted data for the given variables.

3 Research results

The article aimed to map the level of involvement of regional/local suppliers in the nursery and primary school canteens established by the statutory city of Brno. Based on the obtained results (Figure 2), it can be concluded that only about 25% of school canteens do not monitor the regional origin of their food. On the other hand, more than 37% of school canteens show interest in the regional origin of food several times a week.

The involvement of local farmers, growers, and small-scale processors in the school catering system can offer several benefits, as suggested by Ilbery & Maye (2005). These advantages include increased transparency regarding the origin of ingredients and improved communication between the school canteen and suppliers. As well as the locality leads to fresher and higher quality of food due to shorter storage times. This approach also reduces the unnecessary packaging and food waste while supporting the regional economy and promoting sustainable rural employment (Renting et al., 2003).

In addition to the positive impacts mentioned above, the involvement of school canteens in short food supply chains also entails several disadvantages (Martinez et al., 2010). Schools often face administrative, logistical, and legislative barriers that complicate the involvement of the regional suppliers (Martinez et al., 2010; Bayir et al., 2022).

Figure 2 The possibility of monitoring the origin of regional foods by the school canteens



Source: Results of the questionnaire survey conducted by the Brno City Municipality, own processing

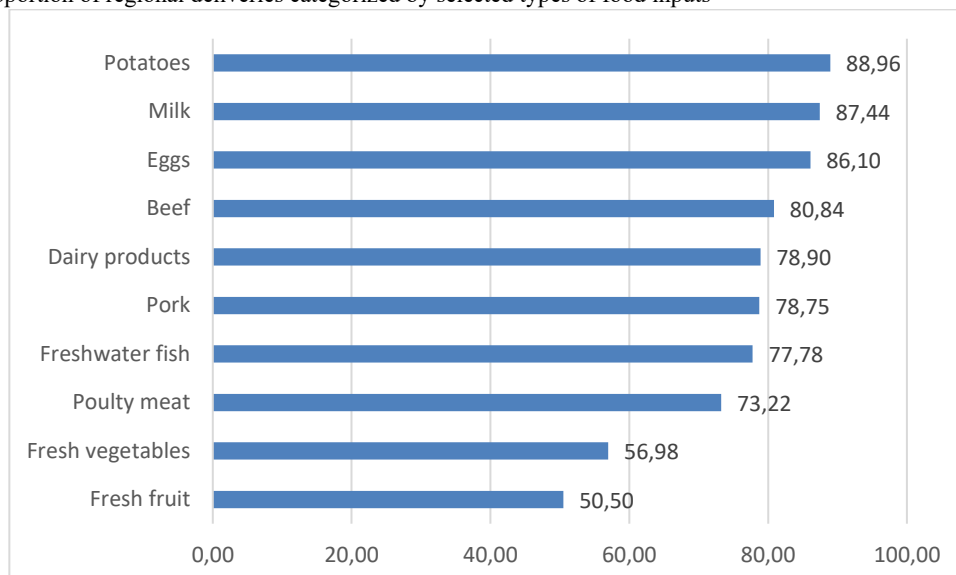
Considering the administrative barriers mentioned earlier, the research hypothesis was based on the premise that larger canteens, which typically have more advanced management and logistics systems, are likely to be better positioned to involve regional suppliers. As a result, these canteens tend to have a higher proportion of regional foods in their food sources.

To verify the hypothesis, a regression analysis was conducted based on 66 observations.

The calculated correlation coefficient $r = -0.10075$ ($p < 0.42086$) indicates a very weak negative relationship between the size of the canteen, expressed by the number of meals served, and the share of regional suppliers. The coefficient of determination shows that the calculated model explains only 1.02% of the variability of the dependent variable. The t-test for the regression coefficient confirms the statistical insignificance of the model.

Based on the presented results, it can be stated that the dependence between the size of the canteen and the level of involvement of local suppliers was not confirmed.

Figure 3 The proportion of regional deliveries categorized by selected types of food inputs



Source: Results of the questionnaire survey conducted by the Brno City Municipality, own processing

In terms of the share of individual foods sourced by nursery and school canteens from local suppliers (Figure 3), over 80% include potatoes, milk, eggs, and beef. Approximately 70% of the products come from dairy products (such as yogurts, curd cheese, cheeses, and cream) and various types of meat (including pork, poultry, and freshwater fish). Foods that have about a 50% share from local suppliers consist of vegetables and fruits.

The questionnaire survey results indicate that about 77% of school canteens intend to increase their use of regional suppliers in the future.

The main barriers for increasing the use of regional products are often mentioned by the respondents as higher prices (76%), seasonal supply issues (64%), and a shortage of suppliers able to provide sufficient product volumes (58%). Additionally, 77% of respondents noted that having a list of available products from local suppliers could be an effective tool for boosting the share of regional foods.

4 Conclusions

This article investigates the relationship between the size of a school canteen and its use of regional food when preparing meals for students.

Findings from the metropolitan area of Brno in the Czech Republic revealed that most school canteens are generally attentive to the origin of the food. Nonetheless, about 25% of school canteens do not screen at all whether the food comes from the local region. The school canteens mostly source potatoes, milk, and eggs from the local suppliers. On the other hand, fruit and vegetables are sources less often from local suppliers. The substantial majority of respondents revealed plans to increase the proportion of regional foods used in meal preparation.

The local food systems theory presumes that integration of regional foods in school canteens is a function of institutional capacity and supplier networks (van Paassen et al., 2022). For these reasons, we expected that larger canteens are better prepared (equipped) to integrate local (regional) suppliers into their catering systems because of a more robust management and logistics structure, and therefore larger school canteens would exhibit a higher share of local (regional) food served to the students.

Interestingly, the data did not confirm a relationship between the size of the school canteen and the level of involvement of local suppliers. A regression analysis was performed, and the statistical hypothesis $H_0: \beta_1 = 0$ (indicating no linear relationship) was not rejected. This suggests that canteen size does not significantly influence the use of regional food, implying that other factors are probably at play or the existence of barriers to increase the share of the food coming from the local region. The survey revealed such barriers preventing to increase the share of regional products in school canteens in Brno such as higher prices of local food when compared to non-local, seasonality of supply and lack of suppliers able to deliver adequate volume of the product. This is in line with existing literature (Bayir et al., 2022; Campbell, 2023; Zuercher et al., 2024).

A limitation of explanatory power of this study is its negligence of other factors and focus only on school canteens in Brno. The future research should incorporate other factors into the econometric analysis e.g. institutional rules, procurement procedures, or stakeholder motivations as well as the storage capacities, price factors, supply base in the region, administrative and legislative barriers.

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