10th International Scientific Conference, July, 4 -7, 2025, Portorož, Grand Hotel Bernardin

Economics, Management, Finance and Social Attributtes of Economic System (EMFSA 2025)

Proceedings

2025

Proceedings of the

10th International Scientific Conference, July, 4-7, 2025, Portorož, Grand Hotel Bernardin

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ISBN: 978-80-973642-7-4

EMFSA 2025 is organized by the Centre of Sociological Research and BCSS in cooperation with European Center for Economic and Social Research, Juraj Dobrila University of Pula, Faculty of economics and Tourism "Dr. Mijo Mirković", and Alexander Dubcek University of Trencin.

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Conference program

Friday, 4.7.2025
16:00 – 19:30 *Plenary Session*, Grand Hotel Bernardín, Adria conference room

Saturday, 5.7.2025
10:00 – 14:30 Section: *Economics and Finance,* Adria conference room

Sunday, 6.7.2025
10:00 – 14:00 Section*: Management and Marketing,* Adria conference room

Monday, 7.7.2025
10:00 – 14:00 Special section: *Doctoral students and young researcher,* Adria conference room
15:00 – 18:00 Special section: *Environment, Energy, and Society for the Twenty-First Century in frame of the program "HORIZON-MSCA-2022-SE-01" under the GA 101129820,* Online

4.7.2025: ***PLENARY SESSION: 16.00 – 19.30, Adria conference room in Grand Hotel Bernardin***

16:00 – 16:20	**Jaroslav Belás** **Yuriy Bilan**	*Opening of the conference*
16:20 – 16:40	**Sebastian Kot** *Czestochowa University of Technology* *Poland*	Intentions to consume dietary supplements among Gen Y: Extended Planned Behaviour Model
16:40 – 17:00	**František Pollák** *Institute of Technology and Business in České Budějovice* *Czech Republic* *University of Economics in Bratislava* *Slovak Republic*	COVID-19 Pandemic as a volatility factor in the stock market: Case study of technological sector
17:00 – 17:20	**Andrea Janáková Sujová** *Technical University in Zvolen* *Slovak Republic*	Experience of Companies with Agile Approach in the Context of Coping with Corona Crisis
17:20 – 18:00	Coffee break	
18:00 – 18:20	**Sándor Kovács** *University of Debrecen* *Hungary*	An evaluation of security systems' potential to provide income security for platform workers in the context of social risks
18:20 – 18:40	**Slavka Silberg** *Palacky University Olomouc* *Czech Republic*	Bridging the Perception Gap: Analysing Discrepancies in Organisational Climate and Intergenerational Collaboration Between Managers and Older Workers
18:40 – 19:00	**Hussam Musa** *Matej Bel University in Banská Bystrica* *Slovakia*	To What Extent Can Spreadsheets Shape Sustainability? A Machine Learning Approach to ESG Score Prediction
19:00 – 19:30	***Final discussion***	

5.7.2025: ***ECONOMICS and FINANCE****: 10:00 – 14:30, Adria conference room in Grand Hotel Bernardin*
(presentation may last up to 20 minutes)
Chief of the Section: prof. Ing. Jaroslav Belás, PhD.

No.	Time	*Last name, name*	Topic of the article
1.	10:00 – 10:20	*Elżbieta Szczygieł*	Circular Behaviours of households members - evidence from Poland
2.	10:20 – 10:40	*Silvia Lorincová, Mária Osvaldová, Marek Potkány*	Gender Differences in Consumer Engagement with Circular Economy Practices in Slovakia
3.	10:40 – 11:00	*Andrea Bencsik, Jaroslav Belas*	Inter-Organizational Knowledge Transfer Practices for SMEs
	11:00 – 11:20	Coffee break	
5.	11:20 – 11:40	*Vanessza Bölcsová, Kitti Hajmási, Tibor Zsigmond, Renáta Machová*	Going green or going broke? The price of sustainability
6.	11:40 – 12:00	*Maria Bartekova, Sabina Janikovicova*	Green Innovations and Their Barriers in Small and Medium-Sized Enterprises in Central Europe
7.	12:00 – 12:20	*Janka Grofčíková, Hussam Musa, Marek Potkány*	The Relationship Between ESG and Corporate Financial Performance: Bibliometric and Correlation Analysis
8.	12:20 – 12:50	*Tomas Kliestik, Pavol Durana, Katarina Frajtova Michalikova*	Mapping the Landscape: A Bibliometric Analysis of AI and Data Mining in Bankruptcy Prediction
9.	12:50 – 13:10	*Rita Remeikiene, Ligita Gasparėnienė, Marcus Box, Xiang Lin*	Assessment of the impact of financial fraud on state tax revenue
10.	13:30 – 13:50	*Yuriy Bilan, Romualdas Ginevičius*	Improving the organization's microclimate based on communication technologies
11.	13:50 – 14:10	*Judit Oláh, József Popp*	Transition to climate neutrality: Is the EU Green Deal enough?
	14:10 – 14:30	*Final discussion*	

6.7.2025: ***MANAGEMENT AND MARKETING:*** *10:00 – 14:00, Adria conference room in Grand Hotel Bernardin*

Chief of the Section: assoc. prof. Ing. Jaroslav Belás, PhD.

No.	Time	Author	*Topic of the article*
1.	10:00 – 10:20	*Romana Kušnírová et al.*	Proposal for the implementation of digitalisation in the creation of crisis scenarios for SMEs
2.	10:20 – 10:40	*Adriana Grenčíková, Kristína Kozová, Jozef Habánik*	The future of education and work: Generation Z and their views on careers, family and education
3.	10:40 – 11:00	*Jan Dvorsky*	Environmental, social and governance model in context of sustainability of the small and medium-sized enterprises of business environment of V4 countries
4.	11:00 – 11:40	Coffee break	
	11:40 – 12:00	*Martin Šikýř, Renata Skýpalová, Isaias Rivera, Zora Petráková*	A survey on socially responsible activities of business companies in Central Europe
5.	12:00 – 12:20	*Alexandra Hotkova, Jaroslav Belas, Dalia Streimikiene, Andrea Bencsik*	The impact of perceived advantages and disadvantages on the start-up of entrepreneurship by university students
6.	12:20 – 12:40	*Aranka Boros, Klaudia Balázs, Enikő Korcsmáros*	Does Size Really Matter? A Comparative Study on AI's Influence in Employee Training, Business Efficiency, and Competitive Pressure
7.	12:40 – 13:00	*Slavka Silberg, Zdenko Metzker, Michal Silberg, Luděk Stehlík*	Bridging the Perception Gap: Analysing Discrepancies in Organisational Climate and Intergenerational Collaboration Between Managers and Older Workers
8.	13:00 – 13:20	*Marta Czyżewska, Elżbieta Szczygieł, Jason Papathanasiou, Georgios Tsaples*	Impact of the youth's knowledge and attitudes towards socially responsible investing on SRI intentions in Poland and Greece
9.	13:20 – 13:40	*Martina Jakubčinova, Jaroslav Belas, Alexandra Hotkova*	Perception of the Quality of Higher Education by University Students
	13:40 – 14:00	*Final discussion*	

7.7.2025: ***SPECIAL SECTION:*** **Doctoral students and young researcher:** *10:00 – 14:00, Adria conference room in Grand Hotel Bernardin*
Chief of the Section: prof. Ing. Jaroslav Belás, PhD.

No.	Time	Author	*Topic of the article*
1.	10:00 – 10:20	*Alexandra Hotkova, Jaroslav Belas, Jr., Martin Sramka*	ESG and Corporate Performance: A Systematic Literature Review
2.	10:20 – 10:40	*Marek Nagy*	The impact of Industry 4.0 on global value chains, employment, and lean manufacturing
3.	10:40 – 11:00	*Gabriela Michalec, Veronika László*	Building Organizational Trust in Competitive Environments: Insights from Hungary and Slovakia
4.	11:00 – 11:20	*Denis Juracka*	Changing Travel Behaviors in Central Europe: The Role of Shared Accommodation in V4 Countries
	11:20 – 11:40	*Mario Arturo Ruiz Estrada et al.*	Economic Dynamics of Territorial Military Conflict: The Case of Kashmir
	11:40 – 12:00	Coffee break	
5.	12:00 – 12:20	*Mario Arturo Ruiz Estrada, Evangelos Koutronas*	N-Non-Cooperative Games Under a Dynamic Multi-dimensional Graphical Prism
6.	12:20 – 12:40	*Subiya Rahman, Rohit Kumar Vishwakarma*	Analyzing the Gender Pay Gap: A Review
7.	12:40 – 13:00	*Ajay Kumar Jain*	Ecological costs of plastic pollution: Introduction to cheaper and safer packaging techniques in the tourism industry
8.	13:00 – 13:20	*Madhvendra Pratap Singh, Mridulesh Singh*	Exploring the Role of Behavioral Intention and Trust in Technology Adoption: A Meta-UTAUT Model Approach
9.	13:20 – 13:40	*Cyrus Isaboke, Frederik Rech, Hanying Xu*	The day-of-the-week effect in Stable coins
	13:40 – 14:00	*Final discussion*	

7.7.2025: ***SPECIAL SECTION:*** **Environment, Energy, and Society for the Twenty-First Century in frame of the program "HORIZON-MSCA-2022-SE-01" under the GA 101129820** *15:00 – 18:00*

Online

Chief of the Section: prof. dr. hab. Yuriy Bilan

No.	Time	Author	*Topic of the article*
1.	15:00 – 15:20	*Marcin Rabe*	Distributed energy management - model approach
2.	15:20 – 15:40	*Katarzyna Widera*	Carbon footprint intensity analysis for energy and mining companies listed on the Warsaw Stock Exchange as an aspect of non-financial ESG reporting
3.	15:40 – 16:00	*Halyna Mishchuk, Yuriy Bilan*	Migration of Ukrainian scientists in wartime: challenges and opportunities
4.	16:00 – 16:20	*Olena Oliinyk, Tomasz Pudlo*	The role of education in the social integration of IDPs: cross-national insights
5.	16:20 – 16:40	*Natalia Samoliuk, Monika Grabowska*	Opportunities for improving combatants' human capital management based on the assessment of their needs satisfaction
6.	16:40 – 17:00	*Ganna Kharlamova, Andriy Stavytskyy, Svitlana Bilan*	Sustainable Development Goal No. 7 – Affordable and clean energy - the case of Ukraine
7.	17:00 – 17:20	*Manuela Tvaronaviciene*	Challenges related to using of solar modules and batteries by households
8.	17:20 – 17:40	*Mantas Švažas*	Bioeconomy development in Lithuania – key elements and policy implications
	17:40 – 18:00	*Final discussion*	

List of Abstracts

Green Innovations and Their Barriers in Small and Medium-Sized Enterprises in Central Europe

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Abstract. The transition to a low-carbon economy presents significant challenges for Small and Medium-Sized Enterprises (SMEs) in Central Europe. Despite regulatory pressures and societal expectations, SMEs face numerous obstacles in implementing green innovations. This study examines key barriers hindering sustainable practices across different industries and firm sizes. A structured questionnaire was distributed to 184 SME managers in the manufacturing sector. Data analysis, using the Kruskal-Wallis and Dwass-Steel-Critchlow-Fligner tests, identified financial constraints, regulatory complexity, and limited technological expertise as primary challenges. Findings indicate that micro and small enterprises experience greater difficulties compared to medium-sized firms. The research paper highlights the necessity of targeted financial incentives, streamlined regulations, and enhanced access to technical knowledge to support SMEs in their transition toward sustainability. Collaboration between policymakers and industry stakeholders is essential to foster an enabling environment for green innovation adoption. Future research should explore the impact of government subsidies and market-driven incentives on overcoming these barriers.

Keywords: green innovations, small and medium enterprises, barriers

Inter-Organizational Knowledge Transfer Practices for SMEs

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Abstract. The study of knowledge management system design and operation has a history of several decades, yet several research gaps can be found in the literature. Prominent among these is research among SMEs, particularly concerning knowledge management processes that influence their successful operation. This research aimed to explore which factors most influence the success of SMEs through knowledge transfer. The quantitative research, conducted in 2023-24, asked managers of Hungarian and Slovak SMEs about business-to-business knowledge transfer solutions and their impact on business success. This paper presents a part of the research, which investigated the prevalence of knowledge transfer (knowledge acquisition and transfer) between organisations using PLS-SEM path analysis. A total of 442 enterprises were involved in the two countries. The results show that SMEs have a limited amount and quality of internal knowledge and therefore acquire much of the new knowledge they need from external sources. Nevertheless, they are willing to share a small part of their knowledge with other market players. They are reluctant to share knowledge related to their activities and the characteristics of their products and services. The impact of knowledge transfer on success is not valued. Confidence is significantly more influential than communication in influencing external and internal knowledge transfer on the success of the enterprise.

***Keywords*:** knowledge management, knowledge sharing, SME, trust, communication

Improving the organization's microclimate based on communication technologies

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Abstract. Today, it is generally accepted that the commercial success of an organization is determined not by technology, but by people. In this situation, the organizational microclimate (OMC) takes on special significance. This is a term that describes the general mood and working environment in an organization. It includes relationships between employees, communication style, working conditions, leadership style, general employee satisfaction with work, etc. Thus, it has a significant impact on their motivation, productivity and overall success of the organization. Despite this, in many cases too little attention is paid to the analysis, assessment and improvement of its condition. This problem can be successfully solved on the basis of communication technologies. The communication model consists of the sender of the message (the organization's management); the message (information that the sender of the message transmits to the recipient of the message through media channels; it consists of questions reflecting the essential aspects of the OMC); the recipient of the message is the organization's personnel. The second stage of communication is based on feedback, i.e. the sender of the message receives answers to the questions asked. When they are summarized, interpersonal communication occurs, i.e. The sender of the message discusses the current situation in an immediate discussion with the recipients of the message and proposes measures to improve it. The result of such a communication process is the clarification of the reasons for the unsatisfactory OMC , as well as its index, on the basis of which the monitoring of the improvement of the situation is carried out.

Keywords: organizational microclimate (OMC), communication technologies, OMC index

Does Size Really Matter? A Comparative Study on AI's Influence in Employee Training, Business Efficiency, and Competitive Pressure

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Abstract. This study examines how company size influences AI adoption, focusing on workforce training, operational efficiency, and perceived competitive pressures. Survey data from 269 Hungarian and Slovak firms, analysed via structured questionnaires and Chi-Square tests, indicate that larger enterprises are more likely to implement AI, invest in employee upskilling, and attain notable efficiency benefits. In contrast, micro and small firms often lack sufficient resources or a strategic focus, leading to lower AI adoption and fewer efficiency gains. Medium-sized businesses fall in between, recognizing AI's advantages but facing continued resource constraints. Interestingly, concerns about AI-driven competitive disadvantages did not vary significantly by company size, hinting that industry-specific factors may play a stronger role. Overall, these findings highlight the need for targeted support for smaller firms, while underscoring that larger companies must keep aligning AI initiatives with workforce development to maintain competitiveness.

Keywords: firm size, technology adaption, operational efficiency, artificial intelligence

Going green or going broke? The price of sustainability

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Abstract. Despite the growing demand for environmentally friendly products, sustainable consumption still faces many barriers, in particular in terms of price sensitivity and income. This study examines how income levels and price sensitivity influence sustainable consumer behavior in Slovakia. The research focuses on two hypotheses: (H1) a significant relationship exists between income and the selection of eco-friendly products or services, and (H2) the high price of green products delays the adoption of sustainable consumption habits. To explore participants' views, a questionnaire survey was conducted in the spring of 2024. The questionnaire was distributed online, receiving 228 responses, of which 212 were retained for analysis. SPSS software was used to evaluate the results. The findings indicate that while income correlates with a greater emphasis on sustainability, wealthier consumers are less likely to purchase eco-friendly products, contradicting previous studies that suggest a positive link between income and sustainable consumption. Additionally, the study found that price sensitivity does not affect the adoption of green purchasing habits, aligning with research indicating that consumers are willing to pay more for environmentally friendly products. The results underscore the importance of understanding the complex relationship between income, price sensitivity, and sustainable behavior for marketers and policymakers.

Keywords: sustainable purchasing, green consumer behavior, price sensitivity, income

Intentions to consume dietary supplements among Gen Y: Extended Planned Behaviour Model

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Abstract. Dietary supplements consumption has gained attention as a way of improving individual health since the onset of COVID-19. It is considered a means to enhance immune systems and support overall physical health. The purpose of this study is to investigate the factors that influence intention to consume dietary supplements among Gen Y. This study adopted the extended theory of planned behavior to develop the study framework. An empirical study was conducted using primary data collected from Gen Y individuals aware of dietary supplements consumption. A sample of 449 respondents was gathered and data were analyzed using structural equation modeling (SEM). The results indicated that five factors-perceived behavioral control over supplement use, perceived need for supplements, health information-seeking behavior, perceived social pressure, and trust in the supplement brand-have a positive and significant influence on Gen Y dietary supplements consumption. Additionally, attitude towards dietary supplements significantly mediates the relationship between social media subjective norm, health information seeking, and the intention to consume dietary supplements. Despite growing research on dietary supplement consumption, limited studies have focused on the factors influencing Gen Y's intention to consume dietary supplements. This study fills this gap by examining the critical role of various factors in shaping Gen Y's consumption behavior, with particular emphasis on attitudes, social media, and trust in supplement brands.

Keywords: Dietary Supplements**,** Gen Y**,** Consume**,** Supplements Use**,** Health Information

Impact of the youth's knowledge and attitudes towards socially responsible investing on SRI intentions in Poland and Greece

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Abstract. This study examines the impact of youth knowledge and attitudes towards socially responsible investments (SRI) in Poland and Greece. Utilizing a sample of university students, the research aims to understand the level of knowledge, awareness of SRI concepts, and the factors influencing young investors' decisions to engage in SRI practices. The findings indicate that while there is a moderate level of awareness about SRI among the youth, there are significant gaps in the knowledge of SRI concept and its practical future application. The study reveals that personal values, ethical considerations, and perceived financial benefits play crucial roles in shaping youth attitudes towards SRI. The research highlights the necessity for enhanced education programs and greater access to SRI information to foster more informed and responsible investment behaviours among the youth.

Keywords: attitudes towards SRI, impact investing, socially responsible investments, SRI intentions

Environmental, social and governance model in context of sustainability of the small and medium-sized enterprises of business environment of V4 countries

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Abstract. Environmental, Social and Governance (ESG) measures are a key topic of strategic conversations among senior business leaders, particularly when it comes to meeting consumers' and investors' expectations, ethics and values. With small to medium-sized enterprises (SMEs) accounting more than 95.0% of the private business sector, they have a vital role in implementing ESG for both its impact on economic success and for the wellbeing and environment of the local communities they serve. The aim of the article is identify, quantify and verify the key factors of the strategy of implementation ESG which have effect on sustainability of SME segment. Quantitative research was realised in the year 2025 in the business environment of V4 countries. The questionnaire was used on the finding of subjective perceptions of owners or top manager with using Computer Assisted Web Interview (CAWI) methodology. The research sample contains 1,549 answers. The data collection was realised in the four middle European countries – Slovakia, Hungary, Czechia and Poland. The statistical hypotheses were verified with application of the statistical methods, as is a descriptive statistic, confirmation factor analysis and structural equation modelling. The empirical results confirmed the structural equation model is a statistically significant. All aspect of ESG strategy are a statistically important. There are a positive effects of environmental, social and corporate governance aspects on the sustainable growth of small and medium-sized enterprises in the business environment of V4 countries. The key of practical implication are formulated for all stakeholders of the business environment. The knowledge of the effect of implementation of ESG strategy on the sustainable growth are important for Owners of SME enterprises.

Keywords: business environment, ESG model, quantitative research, V4 countries, structural equation modelling, sustainable growth

The future of education and work: Generation Z and their views on careers, family and education

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Abstract. This study examines the preferences of Generation Z in relation to education, teamwork and value systems, with a particular emphasis on the influence of family life, career aspirations and self-development. The study aims to examine the impact of gender and work status on this generation's attitudes towards education and preference for teamwork. The respondents were selected from Generation Z in Slovakia, and 318 individuals participated in the study. In order to achieve the objectives of the research, an electronic questionnaire was constructed, comprising 18 questions. The aim was to examine the relationship between gender and preferences in key areas such as life values, education, and teamwork. The statistical analysis of the data was conducted using chi-square tests, which were employed to test the formulated hypotheses. The findings revealed no statistically significant discrepancies between males and females in terms of their proclivity to pursue further education. However, there were notable differences in attitudes towards teamwork, with females demonstrating a stronger inclination towards autonomous work. Furthermore, correspondence analysis was employed to examine the interrelationships between respondents' employment and educational contexts and their values. The results of the correspondence map demonstrated that respondents who were students placed a particular emphasis on values such as education, career development and self-development. In contrast, respondents who were employed placed a greater importance on career and family life. This study offers significant guidance for employers and educational institutions striving to align their practices with the evolving needs of Generation Z.

Keywords: Generation Z, education preferences, teamwork, gender differences, work values

The Relationship Between ESG and Corporate Financial Performance: Bibliometric and Correlation Analysis

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Abstract. The concept of responsible business and the implementation of ESG principles is currently becoming an essential part of business management processes and affects the reputation of the company on the market and its financial performance. The study provides an overview of key milestones related to the development of responsible business and normative regulation of ESG. The aim of the study is to use bibliometric analysis to examine the development of research on the relationship between ESG and financial performance of the company from a thematic perspective and to identify the main thematic focuses at present. At the same time, using correlation analysis and Spearman's rho to identify the relationship between the value of the ESG score and the value of the score of its individual factors E, S, and G, and the company's financial performance, measured by the indicators ROA, ROE and ROS. The results of the solution indicate the existence of a very weak, respectively weak indirect dependence between the selected variables.

Keywords: ESG, corporate financial performance, bibliometrix, correlation analysis, Slovakia

The impact of perceived advantages and disadvantages on the start-up of entrepreneurship by university students

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Abstract. This study aims to define and quantify the impact of perceived advantages and disadvantages on university students' decision making about starting a business in Central European countries, specifically in Slovak Czech Republic, the Czech Republic and Hungary. The empirical research, carried out from March to June 2024, aimed at finding out the attitudes of university students' towards the advantages and disadvantages of entrepreneurship. The study uses a questionnaire survey that was conducted in June 2024 identifying factors that influence their attitudes towards entrepreneurship, including advantages such as improving career opportunities and leveraging their own skills, and disadvantages such as the risk of financial instability and lack of time family time. The study tested several hypotheses, using correlational and regression analysis. The results show that the most significant factors influencing students' decision to start a business after graduation are the perceived benefits of entrepreneurship, such as career growth and the ability to take full advantage of own skills. Based on of these results recommendations for the design of effective educational and incentive programmes to promote entrepreneurship that could help students help overcome or mitigate the identified disadvantages and strengthen their positive attitudes towards entrepreneurship.

Keywords: propensity to entrepreneurship, advantages and disadvantages of entrepreneurship, university students, Slovakia, Czech Republic, Hungary

ACKNOWLEDGEMENT

The paper is an output of the project VEGA: 1/0109/25 The theoretical model of ESG in the SME segment in the V4 countries.

Perception of the Quality of Higher Education by University Students

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Abstract: The role of the public sector should include providing high-quality and accessible higher education, which significantly influences students' entrepreneurial motivation. Offering a solid foundation for developing entrepreneurial skills, competencies, creativity, and self-confidence is an essential component of the quality of higher education. This study focuses on examining the perception of the quality of higher education by university students in selected Central European countries in the context of entrepreneurial intentions. It also highlights the role and importance of the public sector in shaping students' entrepreneurial intentions and attitudes, thereby providing new insights into the impact of the educational environment on entrepreneurial motivation. The research employed quantitative methods for data collection and analysis. The empirical research was conducted in May 2024 on a sample of 1,783 university students in Central European countries. The study included 576 respondents from Slovakia, 612 respondents from the Czech Republic, and 595 respondents from Poland. Scientific hypotheses were tested using chi-square and Z-score tests. Emphasis was placed on examining differences in attitudes across countries, genders, levels of study, and fields of study. The results confirm that the perception of educational quality and its impact on entrepreneurial intentions are relatively homogeneous, although certain regional differences exist among the studied countries, as well as when comparing countries by gender, level of education, and field of study. The findings contribute to original knowledge about regional differences and opportunities for improving educational policies, which is significant for policies and practices in higher education and entrepreneurship support.

Keywords: quality of education, student entrepreneurship, skills, university education

ACKNOWLEDGEMENT

The paper is an output of the project VEGA: 1/0109/25 The theoretical model of ESG in the SME segment in the V4 countries.

The paper is an output of the project APVV: VV-MVP-24-0299 New trends in human resource management in the context of the global challenges of the 21st century.

COVID-19 Pandemic as a volatility factor in the stock market: Case study of technological sector

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Abstract. The COVID-19 pandemic caused unexpected volatility in global financial markets, significantly impacting investor sentiment and stock price dynamics. This study examines how the technology sector evolved during the pandemic, focusing on market volatility and investor behavior across distinct pandemic waves. Using daily stock price data from Yahoo Finance and Nasdaq-100, this research employs descriptive statistical measures, including the coefficient of variation and kurtosis, to assess the sector's stability and response to macroeconomic shocks. The findings indicate that volatility surged during initial pandemic waves, driven by speculative trading, market corrections, and policy interventions. While the technology sector initially exhibited resilience due to rising digitalization trends, subsequent pandemic waves introduced heightened uncertainty linked to inflationary pressures, interest rate shifts, and regulatory interventions. The study highlights how investor sentiment evolved dynamically, shifting from optimism and aggressive risk-taking to a more cautious, risk-adjusted investment strategy in the post-pandemic period.

Keywords: stock market volatility, technology Sector, COVID-19 pandemic, investor sentiment

Sustainable Development Goal No. 7 – Affordable and clean energy - the case of Ukraine

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Abstract. Within the framework of the exploratory-analytical work, the dynamics of energy processes in Ukraine were studied in the context of achieving Sustainable Development Goal 7 (SDG 7). The main subject of the analysis was the indicator of Total Primary Energy Supply (TPES), considered a comprehensive measure of energy security, accessibility, and efficiency of resource use. The selected dependent variable – Total Primary Energy Supply (TPES) – allows for an integrated assessment of the state of the energy system and its capacity for adaptation. The study used annual data from the State Statistics Service of Ukraine for 2007–2020, and for 2020–2024 - data from international organizations and expert assessments. The aim of the study was to identify the key determinants of TPES by constructing econometric models in the EViews environment. Seven independent variables were considered: final energy consumption (FC), production (PR), import (IM), export (EX), international bunkering (IB), and stock change (SC). Several econometric models were developed using classical linear regression with stepwise modifications to ensure statistical reliability and eliminate multicollinearity. The approach is based on building linear regression models and testing them for adequacy, multicollinearity, heteroscedasticity, autocorrelation, parameter stability, and normality of residuals. In the initial model, all variables except FC were found to be statistically significant. Further VIF analysis revealed multicollinearity between PR and EX, which justified their exclusion from the final model. The final model, based on the variables IM, SC, and IB, demonstrated a high level of explanatory power: adj-R^2 = 0.9172. The residuals followed a normal distribution (Jarque-Bera test), showed no autocorrelation (Breusch-Godfrey test), and the model was homoscedastic (Breusch-Pagan, White, and Glejser tests). Elasticity analysis indicates that energy imports (IM) have the strongest positive impact on TPES (elasticity =

0.588), highlighting the country's critical dependence on external energy sources. Thus, Ukraine's energy system shows a high level of import dependency, which poses significant risks in the context of ongoing military aggression. A strategic focus on increasing domestic energy production, particularly from renewable sources. It is important to improve the reserve system and balance consumption. Between 2025 and 2030, a significant acceleration in the transition to renewable energy sources (RES), an increase in investments in green financing, and a stronger focus on energy efficiency are expected to become key priorities in the energy policies of many countries. According to analytical data, the growing share of RES is poised to drive economic growth, reduce CO_2 emissions, and decrease energy dependency. For the European Union, this presents opportunities to reduce reliance on imported energy, enhance energy security, and establish leadership in the global green transformation. However, the success of this transition will largely depend on the stability of the political environment, infrastructure modernization, and the ability to adapt regulatory frameworks to new challenges. Currently, the emphasis on RES, including areas such as electric vehicles and the broader European green agenda, is increasingly influenced by geopolitical tensions. In particular, the geopolitical decisions, statements, and positions of countries like China, the United States, and the Russian Federation introduce significant fluctuations in the implementation of the Sustainable Development Goals (SDGs). The Russian Federation, which possesses substantial reserves of traditional energy resources that form a critical part of its budget, has shown limited support for the green transition, prioritizing the sale of these resources on global markets instead. In this context, some analysts suggest that its current military actions, including the ongoing offensive, may also aim to undermine the green paradigm, which is a central trend for Europe. Meanwhile, the stability and progress of RES adoption will depend heavily on international cooperation and the ability to address these geopolitical challenges.

Keywords: econometric model, energy security, TPES, energy imports, sustainability, regression analysis, sustainable development

Funding

Research conducted as part of the project entitled "Cluster for innovative energy" under the "HORIZON-MSCA-2022-SE-01" program under the grant agreement No. 101129820.

Mapping the Landscape: A Bibliometric Analysis of AI and Data Mining in Bankruptcy Prediction

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Abstract. This study presents a bibliometric analysis of research concerning the application of Artificial Intelligence (AI) and Data Mining (DM) in the field of bankruptcy prediction. Disclosure of fundamental parts of financial stability and early default, distress, insolvency, and failure identification is crucial for each enterprise. Systematic exploration of the current trends in the prediction of corporate financial management is necessary. We meticulously collected data for this analysis from the Web of Science database, which yielded a comprehensive dataset of 636 articles. Utilising VOSviewer software, we performed advanced bibliometric analyses, including co-citation, co-authorship, and keyword co-occurrence, to visualise significant connections and identify key time dynamics and densities. Our findings reveal a significant increase in scholarly output, particularly recently, highlighting growing academic interest in the mentioned techniques for bankruptcy prediction. We identified dominant research themes, influential authors, and collaborative patterns, along with the most frequently applied AI and DM methodologies. This review provides the field's intellectual structure and its permanent evolution, offering valuable insights for researchers and practitioners by pinpointing knowledge gaps and current incentives and suggesting future ways in bankruptcy forecasting models.

Keywords: artificial intelligence, bankruptcy, bibliometric analysis, data mining

An evaluation of security systems' potential to provide income security for platform workers in the context of social risks

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Abstract. In the current period, a lot of attention is paid to the care of workers. Despite significant technological progress, human capital is an important aspect of the development of the socio-economic system in developed countries. The concept of Environmental, Social and Governance pays particular attention to the care of employees. Social protection of workers is one of the key areas. The paper emphasized that while platform workers (mostly the self-employed) in the Baltic countries have access to several social protection schemes, there are significant gaps, especially in unemployment, work injury, and disability benefits. A composite score was developed by using geometric mean for each country and for each social protection scheme. The variance and coefficient of variation were also calculated. The test concluded that the systems differed the most between Estonia and Latvia. Estonia's system was the most comprehensive, while Latvia and Lithuania offered less comprehensive coverage. The sickness, maternity/faternity, old-age and survivors' benefit systems achieved the highest composite scores for all three countries. The differences highlighted the need for further reforms to ensure more inclusive social protection for the self-employed workers in the Baltic region. In this context, it is essential that the government correctly understands the importance of these workers in the socio-economic system and makes fundamental legislative changes.

Keywords: platform workers, self-employed workers, social protection, Baltic countries

Proposal for the implementation of digitalisation in the creation of crisis scenarios for SMEs

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Abstract. Every owner or manager of a business should try to run the business in the best possible way, i.e. efficiently. For effective management of the enterprise it is necessary to develop a specific management system. The developed management system should include a plan for the management system in a crisis period (pandemic period). This involves developing and setting up certain crisis scenarios of how the enterprise will be managed and administered in individual crisis situations. The developed article deals with the issue of compiling crisis scenarios with a specific focus on the use of digitalization as one of the main tools of the crisis management system components. The aim of the article is to propose and elaborate for SMEs a specific principle and procedure for introducing digitalization into the process of crisis scenario development.

Keywords: crisis management, COVID crisis, SMEs, digitalization into the crisis management, crisis scenarios

Gender Differences in Consumer Engagement with Circular Economy Practices in Slovakia

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Abstract. The circular economy concept responds to the growing demand for raw materials. Its goal is to ensure that all product and material flows can be reused after their initial use, becoming resources for new products and services. This concept requires the participation of all stakeholders, including consumers, designers, materials experts, developers, companies, investors, non-profit organizations, academics, and policymakers. The aim of this study is to examine consumers' engagement in circular practices in Slovakia and to gain a better understanding of gender differences. Specifically, it investigates knowledge and awareness of the circular economy, the ability to recognize environmentally friendly products, willingness to engage in social activities that support circularity, and the preference for products designed with circular principles in mind. A T-test and Levene's test were used to analyse differences in opinions. The results suggest that while both females and males in Slovakia have similar levels of awareness of circular economy principles and the ability to identify environmentally friendly products, there are notable differences in their social engagement and purchasing behaviour. Although both genders recognize the importance of sustainable principles, effectively putting these principles into practice requires approaches that address the information needs, motivations, and preferences of different consumer groups.

Keywords: circular economy, consumer behaviour, consumer engagement, gender differences, T-test, Levene's test

Migration of Ukrainian scientists in wartime: challenges and opportunities

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Abstract. The war in Ukraine causes large-scale changes in intellectual capital development. Being a factor of extreme danger for life, the war pushed about 12% of Ukrainian scientists and university teachers to emigrate abroad or relocate internally according to UNESCO data for January 2024. Belonging to a group of intellectual migrants (based on OECD classification), scientists can shift significantly opportunities for economic development in hosting countries. Particularly, even though the professional motivations for academic and research staff are indeed very high, as evidenced by their readiness to continue professional activities, the overall estimates of finding appropriate job in hosting countries are rather low. Assessments of prospects for successful professional integration abroad, including at least additional income, were highly critical, with scores not even reaching 5 out of 10. In assessing migration prospects and career planning abroad, professional ambitions yield to the need for finding a new way of life. This leads to a conclusion about possibility of significant social and economic losses – both personal and societal for donor country. At the same time, these consequences could be quite opposite for hosting countries in a case of successful integration of this group of the highly skilled migrants. The integration of scientists with appropriate engagement in R&D projects allows to get a new source of talents and innovative development without significant expenses for professional growth. However, according to our survey, till Ukrainian scientists hold pessimistic expectations regarding the demand for their intellectual capital abroad and engagement in a new scientific community. In this regard, the effective support for Ukrainian scientists abroad can be realized in the development of joint scientific and educational programs and projects, international cooperation culminating in joint employment in projects, not just experience sharing. Due to the significant number of Ukrainian refugees in European countries, an important role in Ukrainian scientists' integration can have social nets. This requires investigation of readiness to help and participate in inclusive processes.

Keywords: higher education, migration policy, students' migration.

Acknowledgement

Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V01-00013.

To What Extent Can Spreadsheets Shape Sustainability? A Machine Learning Approach to ESG Score Prediction

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Abstract. Whereas ESG scores have been widely used to forecast financial performance, investment risk, and firm robustness, surprisingly little research has turned the question on its head and asked what predicts ESG? The paper closes the gap through an investigation into whether historical financial data can be used to predict ESG ratings using machine learning. Focusing on 974 Slovak manufacturing firms with 2023 ESG ratings, we apply XGBoost with recursive feature elimination and SHAP analysis to identify significant predictors from 2018–2022. We find that higher indebtedness and poor liquidity are systematically associated with lower ESG scores, whereas successful management of debt—through interest cover, repayment of debt and liabilities to EBITDA ratios—and higher effective tax rates have positive impacts on ESG performance and reflect stronger financial discipline and rule-following. Interestingly, the most informative features were 3–5 years old and so imply that long-term financial trends have higher impact than recent change. Although the models had high train accuracy, test accuracy was low and suggestive of overfitting and the intrinsic complexity in ESG ratings. Prediction was best in mid-range ESG scores and worse at extremes. The findings serve to underscore the utility and limitations of financial metrics in ESG modeling and to reinforce the need to include qualitative and non-financial data to better capture the multi-dimensional nature of ESG ratings.

Keywords: ESG, Financial Indicators, Machine Learning, Gradient Boosting, Manufacturing Companies, Slovakia

Transition to climate neutrality: Is the EU Green Deal enough?

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Abstract. Decarbonising the energy system requires a fundamental transformation in the way societies provide, transport and consume energy. Disagreement exists over how this system should look by 2050. The large-scale expansion of low-carbon electricity, phase-out of unabated fossil fuels, and widespread direct electrification are uncontroversial. On the other hand, the deployment of hydrogen and synthetic methane are more controversial areas, therefore, policy should explore options. This study discusses policy options for the transition to climate neutrality process in the EU. Multi-disciplinary research from multiple perspectives was carried out based on research questions to get comprehensive views of transition to climate neutrality in the EU. By pursuing decarbonization, the EU could become effectively energy independent by 2050. Although the EU would no longer depend on fossil fuel imports, it might develop new dependencies on imports of technologies vital to a zero-emissions economy (solar panels, cobalt for batteries or iridium for electrolyzers). Without decarbonising transport, the EU will not be able to reach its climate neutrality target by 2050. Views on what the system should or would look like in 2050 still strongly diverge. Electrification of transport and heating will require a massive build-up of renewable electricity generation. Current national energy and climate plans are insufficient to achieve an EU-wide climate neutrality by 2050. A strong commitment is needed to ensure that Member States' policies are aligned with the European targets. The results suggest that without behavioural change, the dependency of Europe on carbon removal technologies for its net-zero ambitions increases. Structural changes will be necessary to achieve full decarbonisation by 2050, yet changes in lifestyles are crucial, contributing to achieving climate targets sooner. Climate and energy policies have potentially disruptive consequences on societies and economies. A successful transformation can only happen if Member States act together to ensure convergence between Member States and increasing market access for clean technologies. Further research must include the social, economic and security aspects of decarbonisation because the transition to climate neutrality will create significant implications for the economic, social and ecological development in the new Member States that are highly dependant on energy imports from Russia.

Keywords: European Green Deal, climate neutrility

The role of education in the social integration of IDPs: cross-national insights

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Abstract. In today's globalized world, where wars, armed conflicts, natural disasters, and political instability are becoming increasingly common, the integration of internally displaced persons (IDPs) has emerged as a matter of critical importance. One of the most powerful tools for addressing the challenges of social integration is education, which not only equips IDPs with new skills, knowledge, and competencies but also facilitates their socialization and development as active members of society. Access to education plays a pivotal role for IDPs – not only in terms of acquiring essential skills for personal and professional growth but also as a fundamental instrument for integration into new living environments. Educational opportunities, including vocational training, reskilling programs, and participation in both formal and non-formal learning, significantly enhance the employability of IDPs, thus contributing to their economic independence and broader social stability. Moreover, participation in educational processes helps overcome cultural and language barriers, fosters a sense of belonging within host communities, and strengthens civic identity. Education also serves as a vital means of psychological support, assisting displaced individuals in coping with the trauma of forced migration and the loss of familiar social networks. As such, educational initiatives aimed at supporting IDPs play a decisive role in facilitating their integration and adaptation to new societal contexts. International experience reveals a diversity of approaches implemented across different countries, shaped by national circumstances, policies toward displaced populations, available resources, and educational priorities. Despite this diversity, several key areas consistently emerge in most education-focused strategies for IDPs: language training, vocational education and skills development, access to education for displaced children, and the cultivation of personal and social competencies. Overall, effective educational policy for internally displaced persons must adopt a comprehensive and inclusive approach, integrating both formal and non-formal education components while addressing the varied needs of different age and social groups.

***Keywords**:* education, migration, social integration, IDPs.

Acknowledgement

Funded by the National Research Foundation of Ukraine under project No.2021.01/0343 "Ensuring social protection of ATO / JFO participants and social integration of IDP under the condition of increasing threats to social security".

The Dynamics of Key SWOT Factors Influencing the Resilience of Family Businesses

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Abstract. The study emphasizes the uniqueness of FBs, characterized by specific values and business strategies, and evaluates the evolving trends in factors that impact their long-term success. Special attention is paid to ambivalent factors, which may simultaneously represent both strengths and weaknesses. The research was conducted using a combination of theoretical scientific methods, including analysis, synthesis, analogy, comparison, generalization, and deduction, supplemented by expert judgment. The quantitative analysis was based on data collected from surveys conducted among Czech family businesses in 2022 and 2024. Approximately 3,700 statements were analysed. Data were further examined using regression analysis, correlation matrices, and frequency analysis of key SWOT factors, with attention paid to trends over time. The objective of the study is to provide a new perspective on the dynamic development of factors affecting the resilience of FBs. The research maps not only the past and current state but also the trend trajectory and changes in the intensity of these factors over time. Emphasis is placed on identifying newly emerging factors or those whose influence is intensifying within the business environment. Their impact on competitiveness, resilience, and long-term stability is assessed. The results show that key strengths of FBs include their socioemotional wealth (SEW), stable values, and long-term customer relationships. However, weaknesses related to management, digitalization, and strategic development are deepening. The most significant opportunities lie in the growing demand for sustainable, high-quality products, digital transformation, and the use of artificial intelligence. Conversely, threats include economic uncertainty, legislative changes, and a shortage of qualified labor. Ambivalent factors such as innovation, flexibility, and digitalization can provide a competitive advantage if managed properly—but if neglected, they may threaten business stability. This study contributes to expanding the theoretical framework of dynamic SWOT factor development in family businesses and offers a new perspective on their strategic management. The identification of trends and the unique characteristics of FBs show that their long-term resilience depends on balancing traditional values with modern managerial approaches and technological innovation. The results provide a foundation for further research and strategy development aimed at enhancing business resilience in times of dynamic change.

Keywords: family business, resilience, SWOT analysis, uniqueness, trends, innovation strategy, business environment, technology

Distributed energy management - model approach

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Abstract. The transformation of energy systems towards distributed generation models represents a response to global challenges related to climate neutrality, energy efficiency, and energy security. This study focuses on both theoretical and practical aspects of managing Distributed Energy Resources (DER), integrating resource-based approaches (RBV/KBV) with mathematical optimization tools. Based on linear programming methods, a decision-support model was developed to aid in the planning, coordination, and operation of DER systems at the regional level. Empirical research conducted in the West Pomeranian Voivodeship demonstrates a significant relationship between technological, organizational, and economic conditions and the effectiveness of distributed energy implementation. The proposed model can serve as a decision-making tool for local governments, grid operators, and institutions involved in shaping energy policy.

***Keywords**:* distributed energy, resource management, DER (Distributed Energy Resources), linear programming, energy transition, energy aggregator, optimization model, RBV (Resource-Based View), KBV (Knowledge-Based View), energy self-sufficiency

Funding

Research conducted as part of the project entitled "Cluster for innovative energy" under the "HORIZON-MSCA-2022-SE-01" program under the grant agreement No. 101129820.

Assessment of the impact of financial fraud on state tax revenue

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Abstract. After examining the theoretical aspects of the relationship between financial fraud and tax revenue, to assess the impact of financial fraud on tax revenue in the EU Member States The study used a mixed-methods approach to assess the impact of financial fraud on tax revenue in EU Member States. Panel data from international databases were analyzed using Gretl software for econometric analysis. Secondary data from OLAF reports (2018-2022) were also examined. Additionally, a questionnaire survey of seven experts in financial fraud prevention provided insights, with responses analyzed using descriptive analysis in MS Excel. The paper highlights the negative impact of financial fraud on tax revenue in EU Member States, showing that as the number of financial fraud cases increases, tax revenue tends to decrease. Countries with high fraud rates, such as Hungary, Italy, Romania, Poland, Bulgaria, and Slovakia, are urged to enhance international cooperation, improve information dissemination, and share knowledge, as financial fraud is often systemic. Preventive measures must be prioritized, and effective law enforcement, alongside the implementation of OLAF's guidelines, is essential for tackling fraud. The research calls for a focus on strengthening regulations, sharing best practices, and learning from successful models in countries like France, Belgium, and the Netherlands, which have implemented effective asset recovery agencies and public awareness campaigns. This research offers a novel, evidence-based perspective on the relationship between financial fraud and tax revenue in the EU, incorporating both quantitative data analysis and expert insights. By integrating panel data analysis, secondary data from OLAF reports, and expert evaluations, the paper provides comprehensive, cross-jurisdictional recommendations to enhance anti-fraud measures and improve tax revenue collection.

Keywords: financial fraud, tax revenue, EU Member States

Opportunities for improving combatants' human capital management based on the assessment of their needs satisfaction

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Abstract. The war in Ukraine is leading to a growing number of military personnel who have obtained the status of war veterans and the category of combatants. According to the Ministry of Veterans Affairs of Ukraine, in 2024, the country had 1.3 million veterans. Preliminary estimates suggest that after the war ends, the number of veterans, including their family members, may reach 5–6 million people, representing approximately 20% of the projected population of the country. The aim of the research is to identify the current needs of combatants and to analyse the effectiveness of existing tools for their social protection. The study was conducted using a nationally representative sociological survey of combatants (500 respondents). The results revealed that the most pressing needs for combatants include medical assistance and physical health recovery, access to housing and land, psychological support and rehabilitation, material provision, and social respect and recognition. These needs were reported by nearly 90% of respondents. Meanwhile, less urgent and significant needs were identified as legal assistance in obtaining combatant status and accessing social benefits, employment, education and professional development, business support, and caregiving services. Respondents also noted problems with the extent to which their needs are met by various social protection tools. The most unmet needs include access to housing and land (38.4% of respondents), business support (36.7%), legal assistance in obtaining combatant status and social services (22.2%), and psychological support and rehabilitation (20.6%). The analysis of respondents' awareness of available combatant social protection tools showed that while some are widely known, others are known to less than half of the respondents. This indicates a need to intensify efforts towards individualised information dissemination to combatants — for example, during the final interview — and to ensure legal support for all discharged personnel. Addressing the identified shortcomings in the current veteran support system will directly influence the increase in veterans' trust in the state and society, thereby contributing to the effective use of existing human capital.

***Keywords**:* needs, combatants, social protection, social protection tools, human capital

Funded by the National Research Foundation of Ukraine under project No.2021.01/0343 "Ensuring social protection of ATO / JFO participants and social integration of IDP under the condition of increasing threats to social security".

Bridging the Perception Gap: Analysing Discrepancies in Organisational Climate and Intergenerational Collaboration Between Managers and Older Workers

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Abstract. An ageing workforce, intergenerational teamwork, collaboration, and diversity present challenges in every workplace, making these issues particularly topical. The aim of this article is to analyse the potential discrepancies in perceptions of organisational climate, grow opportunities, intergenerational collaboration, and practices between managers and older workers, as these discrepancies can lead to lower work engagement, job dissatisfaction, and reduced employee performance. The data was collected in various industries in the Czech Republic by a panel provider using the Qualtrics survey tool (N = 303, M = 56.46, SD = 5.57, min = 40, max = 80, Mdn = 56). To compare the scores, we used the Welsch´s t-test for two independent samples and Cohen's d (effect size). The data shows that employees scored lower than managers on each item. The greatest discrepancies were found in the items: Inter-generational collaboration, Institutional knowledge transfer, Enabling development steps and job changes, Appreciation, Continuous development planning, Availability of physical exercise and nutrition opportunities. Managers generally perceive workplace aspects more positively than employees, except for Flexible work time arrangements item. This study highlights the need to address perception discrepancies between managers and older workers to foster a more inclusive and effective organisational climate. Future research should investigate targeted interventions to bridge this perception gap and enhance intergenerational collaboration. The implications for human resource management (HRM) and work and organisational psychology (WOP) in relation to the ageing workforce are discussed.

Keywords: aging workforce, diversity, intergenerational collaboration, knowledge transfer, LLWI questionnaire, L&D, organisational climate, perceived congruence.

Experience of Companies with Agile Approach in the Context of Coping with Corona Crisis

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Abstract. The coronacrisis period and the consequences of restrictive anti-epidemiological measures have shown that the ability to be prepared to implement changes, to react in a timely and effective manner to changes in the environment, which means applying an agile approach, is becoming an essential prerequisite for both survival and success. For this reason, we conducted research aimed at finding out how the manufacturing enterprises of the Slovak Republic coped with the changes caused by the pandemic COVID 19. The aim of the paper is to highlight the experience of manufacturing enterprises of the Slovak Republic with the agile approach, to analyse their reactions and measures taken overcoming the crisis pandemic situation through guided interviews with managers and by linking them with the development of financial indicators. Using the methods of summative content analysis, cluster analysis and box plots, the research results were evaluated. The results showed that the ability to be agile was demonstrated most by small and medium-sized manufacturing enterprises owned by Slovak owners and large enterprises with foreign ownership. The ability to be agile enabled these enterprises to use the crisis as a business opportunity and to achieve significantly better financial results than in the pre-crisis period. The main contribution of the paper is to extend the empirical knowledge by examining the resolution of the obstacles and challenges of the pandemic period in manufacturing firms in the context of corporate agility.

Keywords: anti-pandemic measures, agile change management, manufacturing enterprises, cluster analysis.

The research was supported by the grant scientific project VEGA 1/2024/25.

Circular Behaviours of households members - evidence from Poland

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Abstract. The aim of the study was to identify the factors and mail motives (environmental vs. savings) that significantly influence the adoption of circular behaviours by households. Based on the assumptions of the Theory of Planned Behaviour, a structural model was developed whose latent variables were attitude (AT), subjective norms (SN), perceived behavioural control (PBC), intention (INT) and circular behaviours (CB). For each item, a set of statements presented to respondents for rating was used. Based on the responses of 1,200 respondents from Poland (representative sample), a CB-SEM model was developed. The model demonstrated the significance of the effects of attitude and perceived behavioural control on the intention to perform the behaviour and the significance of intention on the behaviour itself. As a result, detailed variables shaping individual latent variables were identified. The environmental motive investigated was shown to be superior to the financial (savings) motive of the circular behaviours undertaken.

Keywords: circular behaviours, CB-SEM, TBP, households, Poland

A survey on socially responsible activities of business companies in Central Europe

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Abstract. The social pillar of Corporate Social Responsibility (CSR) ensures a positive impact of business activities on the well-being of stakeholder communities, mainly employees and customers, by complying with fair and non-discriminatory practices. The article deals with the socially responsible activities of business companies in Central Europe (Czechia, Poland, and Slovakia) to identify specifics in the socially responsible activities of surveyed business companies of different industries, sizes, and regional coverage. The analysis is founded on the results of a questionnaire survey of representatives of 300 business companies operating in Czechia, Poland, and Slovakia (100 from each country). The evaluation of responses on the country, industry, size, and regional coverage is included in the analysis. The findings showed that more or less a third of surveyed business companies in Czechia, Poland, and Slovakia are engaged in strategic planning of CSR activities, including socially responsible activities from the compliance of business ethics and equal job opportunities through the contribution to employee work-life balance and voluntary activities to the employee care beyond legal obligations and the cooperation with local communities. The findings illustrate the development of socially responsible activities of business companies regardless of their industry, size, and regional coverage.

Keywords: corporate social responsibility, social pillar, business companies, Czechia, Poland, Slovakia

Bioeconomy development in Lithuania – key elements and policy implications

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Abstract: The green transformation, drastic effects of climate change, and the emerging challenge related to food security have substantially accelerated the development of bioeconomy sectors. The use of fossil resources is abandoned, replacing them to renewable sources, including bio-resources. Observing the trends of climate change every year and moving to more sustainable agricultural production, it is obvious that Lithuania has and will have a great potential of bio-resources in the future. Today, bio-resources are often used and processed in traditional ways, without developing value chains, then the added value of the final products is relatively low. It is clear that the available bio-resources must be used as efficiently as possible in order to create a higher added value. In order to make the bioeconomy sector more efficient, it is necessary to find out the biomass flows and potential that have formed in Lithuania and to perform economic calculations and environmental impact analyzes in order to find out which directions of biomass processing would give the greatest economic, social and environmental benefits.

***Keywords**:* bioeconomy, rural development, energy transformation, bioenergy solutions

Funding

Research conducted as part of the project entitled "Cluster for innovative energy" under the "HORIZON-MSCA-2022-SE-01" program under the grant agreement No. 101129820.

Challenges related to using of solar modules and batteries by households

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Abstract: Despite numerous attempts to transition towards renewable sources, this process is problematic. Governments in many countries support households intending to install solar modules and batteries and obtain other devices using solar energy (e.g., chargers for electric cars). Those essential tools of economic policies are partly wasted since many barriers still exist. One such barrier is the absence of available digital solutions that allow the efficient use of solar batteries. Analysis of numerous cases revealed that solar batteries can be charged just using energy generated by solar modules. It is a pity, alas, that their function finishes here. Solar power is not always the cheapest one. The market price of electric energy in grids during some periods is negative. It would be reasonable to have an innovative battery charging system to take surplus energy from grids and store it for later use. Solar energy could be used when energy prices in grids are unfavourable. Alas, batteries lack a smart system allowing them to choose between energy sources for their charging since they can be charged just from one source selected in advance. The described barrier hinders the effective use of electric energy. It seems that creating a simple program would solve the issue. Alas, the challenge is deeper: state infrastructure is devised in a way that does not allow consumers to use different electrical energy supply channels simultaneously. Hence, on the one hand, subsidies are provided for renewable energy consumers; on the other hand, monopolistic suppliers possessing grids hinder the efficient use of electricity.

***Keywords**:* solar module, solar batteries, innovative solutions, renewable energy

Funding

Research conducted as part of the project entitled "Cluster for innovative energy" under the "HORIZON-MSCA-2022-SE-01" program under the grant agreement No. 101129820.

Carbon footprint intensity analysis for energy and mining companies listed on the Warsaw Stock Exchange as an aspect of non-financial ESG reporting

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Abstract: The environmental impact assessment of organizations listed on the Warsaw Stock Exchange in the energy and mining industry is a very important aspect of their compliance with the principles of sustainable development. Carbon footprint analysis through information on LCA (life cycle assessment) data is therefore an issue of great importance for the organization. The legal conditions are related to the adoption by Poland of the EU Directive 2014/95/EU on non-financial information. In November 2022, the European Parliament adopted the Corporate Sustainability Reporting Directive (CSRD). In October 2024, the Sejm received a government bill implementing the CSRD directive, and on December 6, 2024, the act was adopted. The obligation to report environmental aspects in the so-called non-financial ESG reports will apply to a larger number of organizations, as it was currently imposed only on Public Interest Entities (as defined in the Act on Statutory Auditors). According to the classification of sectoral indices on the Warsaw Stock Exchange, the following organizations were analyzed: energy and renewable energy; extraction, production and distribution of fuels and gas; metal mining and coal mining. The aim of the article is to analyse the CO2 emission intensity index from non-financial data of companies from the energy and mining industries subject to this obligation and listed on the Warsaw Stock Exchange.

***Keywords**:* carbon footprint, energy and mining, ESG, sustainable development

Funding

Research conducted as part of the project entitled "Cluster for innovative energy" under the "HORIZON-MSCA-2022-SE-01" program under the grant agreement No. 101129820.

Articles by doctoral student and young researcher

Economic Dynamics of Territorial Military Conflict: The Case of Kashmir

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Abstract: This paper intends to establish conceptual foundations of analyzing the economic dimensions of warfare. The Post-War Final Economic Damage Simulator (PFEDS) attempts to estimate the heterogeneous macroeconomic effects of a potential military conflict. The model suggests nine different indicators: (i) the territorial dispute tension, ΔT; (ii) the territorial dispute strategy, S_n; (iii) warfare dimension, A_k; (iv) warfare losses, $-\pi$, (v) warfare economic leaking, $-\Psi$, (vi) warfare economic desgrowth, $-\delta_w$; (vii) the post-war economic damage, $-\Pi$; (viii) the post-war reconstruction plan, R_t; (ix) and the Mega-Disk Networks Analysis. The PFEDS model integrates dynamic, multidimensional variables to simulate conflict outcomes, utilizing both deterministic equations and fuzzy logic simulations. The model investigates the territorial dispute between India and Pakistan (1946-2016) about Kashmir. Research findings indicate asymmetric economic effects, with Pakistan bearing heavier opportunity costs in warfare losses and economic desgrowth. The model suggests that warfare not only disrupts short-term growth but also has prolonged effects on reconstruction and stability.

Introduction

Conventional wisdom in economic history suggests that territorial disputes are poised to flare into military conflict (Diehl & Goertz, 1988; Evera, 1999; Klare, 2001; Reed & Chiba, 2010; Senese & Vasquez, 2005). Fueled by ethnic animosity, geopolitical shifts, resource competition, environmental degradation or normative reasons, border disputes have endangered peace, stability, and prosperity of the involved parties as well as the entire region (Mancini, 2013). The cartographic representation of state territory has formed a deterministic frame of ownership and sovereignty for the assortment and settlement of territorial claims[1] (Black, 1997). A potential conflict between countries can be enormously disruptive to their economic activity, including large trade debts, high debt in the balance of payments, rapid currency

[1] Territory is perceived as a non-changing element; nevertheless, this element undergoes modifications in shape or size at a given point in time as a result of wars, accretions, cessions or even earthquakes.

depreciation, taxation problems, high military expenditures, and high inflation, which in turn can collectively cause a slowdown in economic growth in the short- and medium-term (Friedman, 1984).

The academic research on territorial disputes varies in respect to approach and methodology, revealing the broader concept of military conflict (Gardeazabal, 2012). The heterogeneity and complexity in warfare dynamics are systemic in the sense that a military conflict is far from linear. The discrepancies of an economic assessment are rather a result of the multi-dimensionality in military conflict impact and their perplexed redistributive patterns. Depending on what is included or not, warfare cost assessments can vary greatly. The economic development of each country exhibits a spatial asymmetry in regions with comparative advantages on factors of production: geographical proximity, utilization of natural resources, availability of renewable and alternative energy sources, labor force prospects, capital availability, infrastructure dynamics and so on. Therefore, the economic impact of a military conflict become more perplexed at the time of impact, if we take into account the stage of economic development, the upturn or downturn of the business cycle, financial depth, governance, and trade openness. This explains to a great extent the disparities between pre- and post-war government expenditures.

Economic modelling provides insightful connotations into the outcomes of warfare assessment (Brandis, 1953; Koubi, 2005; Le Billon, 2005, 2013; Pasvolsky, 1942; Rosenbaum, 1942; Walker, 1944). Methodological standards of warfare assessment are based largely on cost accounting, cost-benefit analysis, comparative data, and correlations and time series. These methods can be broadly classified in two approaches: cross-country studies (Caplan, 2002; Glick & Taylor, 2010; Koubi, 2005; Murdoch & Sandler, 2002) and single country case studies (Arunatilake, Jayasuriya, & Kelegama, 2001; Collier, 1999; David, Murphy, & Topel, 2009).

However, the use of data of the conflicted economy undermined the reliability of warfare assessment. The main threats to assessment validity stems from the nature and context of the conflict situation and the lack of conventional counterfactual and baseline data for the conflicted economy. Furthermore, macroeconomic indicators might have been influenced by business cycles or shocks affecting the conflicted economy as well as others in the region or the entire world (Gardeazabal & Vega-Bayo, 2015). To reduce the prospect of conflict, and larger-scale war, peaceful and enduring resolutions to territorial problems are desirable. The process of conflict resolution should provide parties with a lasting, mutually agreeable outcome. Nash arbitration has the potential to determine the types of territorial disputes and may provide an optimal solution to both parties, forestalling conflict escalation (DeAngelis, 2012).

This paper formulates an analytical framework for estimating the economic consequences of territorial dispute, both in terms of immediate policy response in the aftermath of the military conflict and of medium-term policy implications for regulatory, trade and fiscal policy. The Post-War Final Economic Damage Simulator (PFEDS) attempts to estimate the heterogeneous macroeconomic effects of a potential military conflict. The model suggests nine different indicators: (i) the territorial dispute tension, ΔT; (ii) the territorial dispute strategy, S_n; (iii) warfare dimension, A_k; (iv) warfare losses, $-\pi$, (v) warfare economic leaking, $-\Psi$, (vi) warfare economic desgrowth, $-\delta_w$; (vii) the post-war economic damage, $-\Pi$; (viii) the post-war reconstruction plan, R_t; (ix) and the Mega-Disk Networks Analysis. The PFEDS model investigates the uncertainty and behavioral change under a new perspective within the

framework of a *Dynamic Imbalanced State*[2] (DIS) (Ruiz Estrada & Yap, 2013) and the *Omnia Mobilis*[3]assumption (Ruiz Estrada, 2011).

Theoretical part

Post-War Final Economic Damage Simulator *(PFED-Simulator)*

i. The Total Level of Territorial Dispute Tension (ΔT)

Assume we observe C_t countries over periods *t=1,…,T*. The first group of players C_{t_i}, where *i = (1, 2,…,n)*, is those countries that affected by an armed conflict, uninterruptedly, after the initial intervention period $T_0 \in \{1, \dots, T-1\}$. The second group of players C_{t_R}, where *R = (1, 2,…,∞)*, is the war regional countries. The last group of players C_{t_L}, where *L = (1, 2,…,∞)*, is the largest war partner countries. The territorial dispute tension, ΔT, is subject to the magnitude of territorial dispute tension at the first level, ΔT_{1_j}, and the magnitude of territorial dispute tension at the second level, ΔT_{2_K}. The magnitude of territorial dispute tension at the first level, ΔT_{1_j}, is equal to

$$\Delta T_{1_j} = \frac{\sum_{i=0}^{\infty} \Delta C_{t_i}}{n} \times 100\%, n \neq 0 \quad (1)$$

The historical military confrontation trend growth rate C_{t_i} is given by

$$\Delta C_{t_i} = \left[\frac{\sum C_{t_{t+1}} - \sum C_{t_{t-1}}}{\sum C_{t_{t-1}}}\right] \times 100\% \quad (2)$$

The first derivative of equation (1) in respect to C_{t_i} gives us its maximum

$$f'\left(\Delta T_{1_j}\right) = \sum_{j=0}^{\infty}\left[\left(\frac{\partial T_{1_0}}{\partial C_{t_0}}\right) + \cdots + \left(\frac{\partial T_{1_j}}{\partial C_{t_\infty}}\right)\right] \quad (3)$$

Accordingly, the application of a second derivative to observe the curve inflection point:

$$f''\left(\Delta T_{1_j}\right) = \sum\left[\left(\frac{\partial^2 T_{1_0}}{\partial C_{t_0}^2}\right) + \cdots + \left(\frac{\partial^2 T_{1_\infty}}{\partial C_{t_\infty}^2}\right)\right] \quad (4)$$

[2] *Dynamic Imbalance state* assumption incorporates internalities and externalities in the explanation of market behavior.
[3] *Omnia Mobilis* assumption suggests the simultaneous observation of changes in all variables in real time.

In a multidimensional coordinate plane setting, the graphical representation of the equation (4) findings exhibit mutual exclusivity. The magnitude of territorial dispute tension at the first level, ΔT_{1_j}, is expressed

$$\Delta T_{1_j} = \frac{\left[f'(\Delta T_{1_0}) \fatslash\!\!\!\fatslash \ldots \fatslash\!\!\!\fatslash f'(\Delta T_{1_\infty})\right]}{n} \times 100\% \quad (5)$$

where ($\fatslash\!\!\!\fatslash$) stands for the inter-linkage connectivity condition which joins all vertical axes simultaneously (Ruiz Estrada, 2012). In addition, the magnitude of territorial dispute tension at the second level, ΔT_{2_K}, has its roots in four factors of conflict:

$$\Delta T_{2_K} = f(\Delta H, \Delta E, \Delta R, \Delta M) \quad (6)$$

where ΔH, $\Delta H = \{0, 1, \ldots, \infty\}$, is the historical events growth rate; ΔE, $\Delta E = \{0, 1, \ldots, \infty\}$, is the economic expansion growth rate; ΔR, $\Delta R = \{0, 1, \ldots, \infty\}$, is the race and religious conflict events growth rate; and ΔM, $\Delta M = \{0, 1, \ldots, \infty\}$, is the military expansion events growth rate. The first derivative of the equation (7) gives us the minima and maxima of the magnitude of territorial dispute tension at the second level, ΔT_{2_K}, in continuous time:

$$f'(\Delta T_{2_K}) = \sum \left[\left(\frac{\partial T_{2_K}}{\partial \Delta H}\right) + \left(\frac{\partial T_{2_K}}{\partial \Delta E}\right) + \left(\frac{\partial T_{2_K}}{\partial \Delta R}\right) + \left(\frac{\partial T_{2_K}}{\partial \Delta M}\right)\right] \quad (7)$$

Then, the total magnitude of territorial dispute tension at the second level, ΔT_{2_K}, takes the form

$$\Delta T_{2_K} = \sum_{K=0}^{\infty} \left[\frac{f'(\Delta T_{2_K})}{n}\right] \times 100\ \% \quad (8)$$

Again, the application of a second derivative to observe the curve inflection point:

$$f''(\Delta T_{2_K}) = \left(\frac{\partial^2 T_{2_K}}{\partial \Delta H^2}\right) + \left(\frac{\partial^2 T_{2_K}}{\partial \Delta E^2}\right) + \left(\frac{\partial^2 T_{2_K}}{\partial \Delta R^2}\right) + \left(\frac{\partial^2 T_{2_K}}{\partial \Delta M^2}\right) \quad (9)$$

The final output of the magnitude of territorial dispute tension at the first level, ΔT_{1_j}, is based on the result of the Jacobian single determinant

$$\Delta T_{1_j}|J'| = \left[\frac{\left(\frac{\partial T_{1_0}}{\partial T_{t+1_0}}\right)}{\left(\frac{\partial T_{1_0}}{\partial T_{t-1_0}}\right)} \dots \frac{\left(\frac{\partial T_{1_\infty}}{\partial T_{t+1_\infty}}\right)}{\left(\frac{\partial T_{1_\infty}}{\partial T_{t-1_\infty}}\right)}\right] \quad (10)$$

Similarly, the final magnitude of territorial dispute tension at the second level, ΔT_{2_K}, between Country-1, C_1, and Country-2, C_2, is based on the result of the Jacobian determinant

$$\sum \Delta T_{2_K}|J'| = \begin{bmatrix} \left(\frac{\partial T_{2_0}}{\partial \Delta H_0}\right)\left(\sum \frac{\partial T_{2_0}}{\partial \Delta E_0}\right) & \cdots & \left(\frac{\partial T_{2_0}}{\partial \Delta H_\infty}\right)\left(\sum \frac{\partial T_{2_0}}{\partial \Delta E_\infty}\right) \\ \vdots & \ddots & \vdots \\ \left(\frac{\partial T_{2_\infty}}{\partial \Delta R_0}\right)\left(\sum \frac{\partial T_{2_\infty}}{\partial \Delta M_0}\right) & \cdots & \left(\frac{\partial T_{2_\infty}}{\partial \Delta H_\infty}\right)\left(\sum \frac{\partial T_{2_\infty}}{\partial \Delta E_\infty}\right) \end{bmatrix} \quad (11)$$

Finally, the total territorial dispute tension, ΔT, is given by

$$\Delta T = \sqrt{[|J'|\,\Delta T_1] \times [|J'|\,\Delta T_2]} \quad (12)$$

ii. The Harmonized Territorial Dispute Diplomatic Strategy (S_+)

The level of the territorial dispute tension, ΔT, determines the harmonized territorial dispute diplomatic strategy, S_+, and the different level territorial dispute set of diplomatic strategies, S_n, namely, S-Powerful Nations, S-National, S-Supranational, and S-Regional. The PFEDS model assumes that both countries will employ different diplomatic strategies exhausting all possible scenarios. As the negotiation game reaches its climax, the harmonized territorial dispute diplomatic strategy, S_+, prevails. Hence, the harmonized territorial dispute diplomatic strategy, S_+, and the different level territorial dispute set of diplomatic strategies, S_n, depend directly on the total level of territorial dispute tension, ΔT, in the short run.

$$S_+ \equiv S_+ \log_n S_n \implies \left\{\frac{S_n}{S_n} : S - powerful\ Nations \bigcap S - National \bigcap S - Supranational \bigcap S - Regional\right\} \quad (13)$$

Intuitively, if the total level of territorial dispute tension, ΔT, rises, then the different level territorial dispute set of diplomatic strategies, S_n, will play an important role in reducing territorial dispute tension between the two countries under the creation of the harmonized territorial dispute diplomatic strategy, S_+. The war stage consists of three phases – (i) the warfare economic desgrowth, $-\delta_w$; (ii) warfare losses, $-\pi$; and (iii) the effective warfare stage.

iii. Economic Desgrowth from War, $-\delta_w$

The concept of economic desgrowth, $-\delta$, (Ruiz Estrada, Yap, & Park, 2014) plays an important role in the construction of the PFEDS Model. The economic desgrowth, $-\delta$, analyzes how controlled and non-controlled shocks can adversely affect full potential gross city product, *G*, in the short run. Economic desgrowth, $-\delta$, is defined "as an indicator that can show different leakages that is originated from controlled and non-controlled events that can affect the performance of the final gross city product, *G*, formed in a period of one year". The model shares the view that the world economy is in a constant chaotic state susceptible to butterfly effects of initial-condition sensitivity (Gleick, 1988; LeBaron, 1994; Wilmott, 2009). Economic desgrowth, $-\delta$, employs systematic sampling for the assessment of the systemic risk of macroeconomic events. Lorenz transformation assumptions also facilitates to the analysis of economic desgrowth, $-\delta$. The calculation of economic desgrowth from war, $-\delta_w$, is based on full potential gross city product, *G*, and the total economic leaking from war, $-\Psi$ (Ruiz Estrada, Park, & Kim, 2016) under the *Omnia Mobilis* assumption.

The total warfare economic leaking, $-\Psi$, is based on nine sub-factors[4]: (i) the active working population, ΔF_{11}; (ii) the total capital formation, ΔF_{12}; (iii) the agricultural land, ΔF_{13}; (iv) external technology, ΔF_{21}; (v) the military expenditure growth rate, ΔF_{22}; (vi) the government income tax, ΔF_{23}; (vii) total population rate, ΔF_{31}; (viii) the national budget, ΔF_{32}; and (ix) international reserves, ΔF_{33}. The final measurement of total economic leaking from war (-Ψ) is derived by applying a large number of multi-dimensional partial derivatives on each factor (9 factors) to evaluate the changes of each factor between the present time (this year = t+1) and the past time (last year = t-1).

$$\Delta F_{mxn} = \sum \left(\frac{\partial \beta_{mxn_{t+1}^{\varepsilon}}}{\partial \beta_{mxn_{t-1}^{\varepsilon}}} \right) m = \{1, \dots \infty\} \vee n = \{1, \dots \infty\} \wedge t = \{1, \dots \infty\} \quad (14)$$

Next step is to verify each exponential factor

$$\Delta F_{mxn_{t-1}^{\varepsilon-1}} \dots \Delta F_{mxn_{t+1}^{\varepsilon-1}} \quad (15)$$

The parameter $\beta_{mxn^{\varepsilon}}$ can be replaced by any of the nine different exponents (ε) in equation (16).

$$\beta_{mxn^{\varepsilon=(-\alpha,-\beta,-\lambda,-\Phi,-\zeta,-\Omega,-\Xi,-\eta,-\omega)}} \quad (16)$$

where $-\alpha$ refers to unemployment growth rate, $-\beta$ refers to foreign capital formation, $-\lambda$ refers to agriculture resource demand, $-\Phi$ refers to technology rate, $-\zeta$ refers to military expenditures rate, $-\Omega$ refers to corruption rate, $-\Xi$ refers to poverty rate, $-\eta$ refers to international debt payments ratio, and $-\omega$ refers to exchange rate depreciation. Initial conditions *ex ante* are

$$-\alpha|_{t-1=0}, -\beta|_{t-1=0}, -\lambda|_{t-1=0}, -\Phi|_{t-1=0}, -\zeta|_{t-1=0}, -\Omega|_{t-1=0}, -\Xi|_{t-1=0}, -\eta|_{t-1=0}, -\omega|_{t-1=0} \quad (17)$$

Final conditions *ex post* are

[4] The calculation of economic leaking and economic desgrowth for both countries are originated by the construction of a large database that is formed by 9 sub-factors. The computation of each factor is based on the uses of a large number of sub-variables. Each sub-variable has its parameter, coded as binary (1 and 0). We also use multi-input tables consisting of a big pile of sub-variables.

$$\alpha|_{t-1=0}, -\beta|_{t-1=0}, -\lambda|_{t-1=0}, -\Phi|_{t-1=0}, -\zeta|_{t-1=0}, -\Omega|_{t-1=0}, -\Xi|_{t-1=0}, -\eta|_{t-1=0}, -\omega|_{t-1=0} \quad (18)$$

The observation of fixed-in-time infinitesimal changes of warfare economic leaking requires the simultaneous calculation of the nine partial derivatives:

$$\Delta F_{mxn} = \left[\frac{\frac{\left(n\beta_{mxn_{t+1}}^{n-1}\right)}{n-1}}{\frac{\left(n\beta_{mxn_{t-1}}^{n-1}\right)}{n-1}}\right] \quad (19)$$

The calculation of the total warfare economic leaking is given by

$$-\Psi = \frac{1}{(\Delta F^{-1})^2} \quad (20)$$

where ΔF^{-1} is the Jacobian matrix of the invertible ΔF[5]

$$\Delta F^{-1} = \begin{pmatrix} \Delta F_{11} & \Delta F_{12} & \Delta F_{13} \\ \Delta F_{21} & \Delta F_{22} & \Delta F_{23} \\ \Delta F_{31} & \Delta F_{32} & \Delta F_{33} \end{pmatrix}^{-1} \quad (21)$$

Finally, we can derive the warfare economic desgrowth, -δ_w, as in equation (22):

$$\Delta(-\delta_w) = GDP_{fmp} \times (-\Psi), \quad -1 \leq -\delta_w \leq 0 \quad (23)$$

where GDP_{fmp} reflects to country maximum potential production capacity, given a low inflation rate:

$$GDP_{fmp} = f(\Delta Labor_{max}, \Delta Land_{max}, \Delta Capital_{max}, \Delta Technology_{max}) \neq 0 \quad (24)$$

Boundary conditions for the warfare economic desgrowth, -δ_w, equals to

$$-\delta_w = \sum \left[\frac{\partial \delta_{w_0'}}{\partial(-\Psi_0)}\bigg|_{t=0}, \frac{\partial \delta_{w_1'}}{\partial(-\Psi_1)}\bigg|_{t=1}, \frac{\partial \delta_{w_2'}}{\partial(-\Psi_2)}\bigg|_{t=2}, \dots, \frac{\partial \delta_{w_\infty'}}{\partial(-\Psi_\infty)}\bigg|_{t=\infty}\right] \quad (25)$$

iv. Warfare Losses, -π

[5] According to the inverse function theorem, the matrix inverse of the Jacobian matrix of an invertible function is the Jacobian matrix of the inverse function.

We assume that the combined damages cannot consisted of complete destruction of the country factors of production, so the war effects to be particularly harmful for the country's creative potential in the long-run:

$$-\pi = f(-\pi_{maxLab}, -\pi_K, -\pi_{Land}, -\pi_{Tech}) \neq 0 \quad (26)$$

The first derivative of equation (24) in respect to $-\pi$ gives us its maximum

$$f(-\pi) = \sum \left\{ \left[\frac{\partial(-\pi)}{\partial(-\pi_{Lab})} \right] + \left[\frac{\partial(-\pi)}{\partial(-\pi_K)} \right] + \left[\frac{\partial(-\pi)}{\partial(-\pi_{Land})} \right] + \left[\frac{\partial(-\pi)}{\partial(-\pi_{Tech})} \right] \right\} \quad (27)$$

v. Effective War Stage.

In the effective warfare stage, we assume that both countries C_1 and C_2 exhibit warfare asymmetric conflict structures which have repercussions on different phases of the warfare stage:

$$P_1(-\delta_w) \neq P_2(-\delta_w) \quad (28)$$

As a result, the warfare economic leaking, -Ψ, for both countries will be

$$C_1(-\Psi) \neq C_2(-\Psi) \quad (29)$$

In the initial phases of warfare conflict, we assume that both countries fully reject any harmonized territorial dispute diplomatic strategy, S_+. Then, the total level of territorial dispute tension (ΔT) reaches its maximum limit

$$\Delta T_{max} = f'(S_+) = \frac{\partial S_+ \log_2(S_n)}{\partial S_+} > 0 \quad (30)$$

Accordingly, taking the second derivative to observe the estimate the inflection point

$$\Delta T_{max} = f''(S_+) = \frac{\partial^2 S_+ \log_2(S_n)}{\partial {S_+}^2} > 0 \quad (31)$$

A potential military conflict between C_1 and C_2 will have an asymmetric effect on economic desgrowth at an accelerated pace. The historical military confrontation trend growth rate C_{t_i} defines the focal ratio of the warfare economic leaking, -Ψ. The capacity military composition, A_K, is composed of nine factors: (i) the external military support growth rate, f_{11}; (ii) the technology infrastructure growth rate, f_{12}; (iii) military size growth rate, f_{13}; (iv) the military

intelligence growth rate, f_{21}; (v) natural and geographical conditions growth rate, f_{22}; (vi) society support growth rate, f_{23}; (vii) war R&D growth rate, f_{31}; (viii) military infrastructure systems growth rate, f_{32}; (ix) war industrial structures growth rate, f_{33}. The final calculation of the capacity military composition is shown in (31)

$$A_K = \frac{1}{|J'(\Delta f_{mxn})|} \tag{32}$$

where $J'(\Delta f_{mxn})$ is the Jacobian matrix of the Δf_{mxn}

$$|J'(\Delta f_{mxn})| = \begin{pmatrix} \frac{\partial \Delta f_{1_{t+1}}}{\partial \Delta f_{1_{t-1}}} & \frac{\partial \Delta f_{2_{t+1}}}{\partial \Delta f_{2_{t-1}}} & \frac{\partial \Delta f_{3_{t+1}}}{\partial \Delta f_{3_{t-1}}} \\ \frac{\partial \Delta f_{4_{t+1}}}{\partial \Delta f_{4_{t-1}}} & \frac{\partial \Delta f_{5_{t+1}}}{\partial \Delta f_{5_{t-1}}} & \frac{\partial \Delta f_{6_{t+1}}}{\partial \Delta f_{6_{t-1}}} \\ \frac{\partial \Delta f_{7_{t+1}}}{\partial \Delta f_{7_{t-1}}} & \frac{\partial \Delta f_{8_{t+1}}}{\partial \Delta f_{8_{t-1}}} & \frac{\partial \Delta f_{9_{t+1}}}{\partial \Delta f_{9_{t-1}}} \end{pmatrix} \tag{33}$$

Therefore, the final total warfare war damage, -Π, depends on the warfare economic desgrowth, -δ_w and warfare losses, -π:

$$-\Pi = f(-\delta_w, -\pi) \tag{34}$$

The final warfare total damage, -Π, is

$$-\Pi = \int_0^1 -\pi_t \left(-\pi_{t_{Lab}}\right)dt + \int_0^1 -\pi_t \left(-\pi_{t_K}\right)dt + \int_0^1 -\pi_t \left(-\pi_{t_{Land}}\right)dt + \int_0^1 -\pi_t \left(-\pi_{t_{Tech}}\right)dt + \int_0^1 -\delta_{w_t} \left(-\Psi_t\right)dt \tag{35}$$

Taking the firs order antiderivative, we calculate the marginal final war damage

$$-\Delta\Pi' = \frac{\partial(-\Pi_{t+1})}{\partial(-\Pi_{t-1})} \tag{36}$$

with inflection point

$$-\Delta\Pi'' = \frac{\partial^2(-\Pi_{t+1})}{\partial(-\Pi_{t-1})^2} \tag{37}$$

Hence, the boundary conditions for final war damage, *-Π*, are equal to

$$\Delta\Pi' = \frac{\partial(-\Pi_0)}{\partial(-\delta_{w_0}) \times \partial(-\pi_0)}\Big|_{t=0} = 0, \dots, \frac{\partial(-\Pi_\infty)}{\partial(-\delta_{w_\infty}) \times \partial(-\pi_\infty)}\Big|_{t=\infty} = \infty \quad (38)$$

iv. Post-War Economic Damage

In the given warfare setting, we arbitrarily identify country C_1 as the dominant of the military conflict. C_1 domination can be characterized as a *Pyrrhic* victory since the country experiences warfare economic leaking, *-Ψ*, warfare losses, *-π*, and warfare economic desgrowth, *-δ_w*, but relatively less in absolute numbers of human casualties, displacement of population, physical infrastructure destruction and material damages. The downfall of country C_2 involves severe consequences:

$$P_1[-\pi_1, -\delta_{w_1}(-\Psi_1)] < P_2[-\pi_2, -\delta_{w_2}(-\Psi_2)] \quad (39)$$

The economic recovery differs substantially for both countries. Military outcome may lead to not only confiscation of the *C_2*'s resources, but also to reparation payments for war damages. The transfer problem refers to the need for real resources to accompany the international transfer of financial resources between two countries in order for the latter to take place. Under standard assumptions, the problem is that for country *C_2* that loses a war to make reparations to country *C_1*, country *C_1* must reduce its expenditures by the same amount as the recipient increases theirs. Otherwise, the transfer would lead to one or the other country's terms-of-trade changing (the price of imports relative to exports) and the transfer would be under-effected or over-effected. We further assume that the country C_2 would require a multilateral reconstruction plan essential to maintain political and social stability financially supported by foreign aid

$$C_1[-\Pi_1(-\pi_1, -\delta_{w_1})] \neq C_2[-\Pi_2(-\pi_2, -\delta_{w_2})] \quad (40)$$

In the long run, both countries can experience magnitude asymmetries:

$$\Delta C_1\left[\frac{\partial(-\Pi_1)}{\partial(-\pi_1, -\delta_{w_1})}, \dots, \frac{\partial(-\Pi_\infty)}{\partial(-\pi_\infty, -\delta_{w_\infty})}\right] \neq \Delta C_2\left[\frac{\partial(-\Pi_2)}{\partial(-\pi_2, -\delta_{w_2})}, \dots, \frac{\partial(-\Pi_\infty)}{\partial(-\pi_\infty, -\delta_{w_\infty})}\right] \quad (41)$$

v. The Post-War Reconstruction Phase

The post war reconstruction phase, *R_t*, is directly connected to the final warfare economic damage, *-Π*:

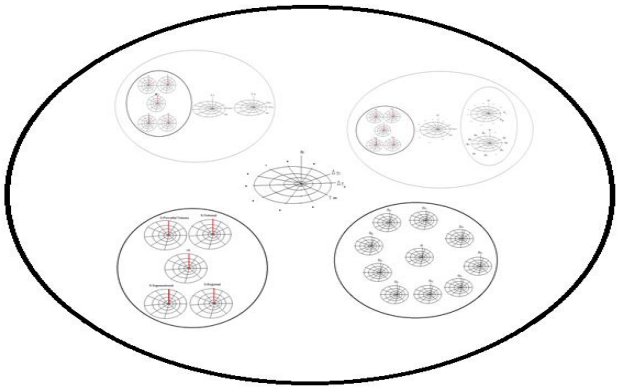
$$R_{t_1} = f(-\Pi_1) \neq R_{t_1} = f(-\Pi_1) \quad (42)$$

Economic reconstruction is fundamentally different from normal development. The primary objectives for both countries are: (i) the security transition by restoring security and safety among its citizens; (ii) the political transition by reforming both at the national and local level; (iii) the social transition by promoting the national reconciliation with the return, repatriation and resettlement of displaced population; and (iv) the economic transition by restoring economic ties between the conflict states. The multi-phase transition of post-war recovery requires a considerable period of peace (5 years minimum).

i. Introduction to the Mage-Space Disk Network Analysis

The graphical representation of PFEDS model is a multi-dimensional coordinate system based on Ruiz Estrada's (2011) Mega Time-Space Continuum Coordinate System. The mega-space disk network is a multidimensional group of mega-spaces within time-space continuum coordinate system. The crossover point is equal to zero, which is the epicenter of the coordinated system. All general spaces start from the general space 0 and take values in $[0,\infty]$. The graphical value representation takes place in the same general space. There are as many layers as there are dimensions, and the links between nodes within each layer are simply all the links for a given dimension. The chain of all values through strait lines generates a single a large manifold into the same graphical space and time (see Figure 1).

Figure 1: The Mega-Disk Networks Analysis



Source: Authors' Elaboration

Figure 1 shows the inter-connectivity between the post-war reconstruction phase, R_t and warfare total damage, $-\Pi$, in different periods of time $(t+1)$ for each antagonist. The mega-space disk refers to the total level of territorial dispute tension, ΔT. Mega-space disk is divided into five sub-space disks. The centered general-space disk estimates the magnitude of territorial dispute tension at the second level, ΔT_{2_K}, determined by the other four micro-space disks, the historical events growth rate, ΔH, the economic expansion growth rate, ΔE, the race and religious conflict events growth rate, ΔR, the military expansion events growth rate, ΔM. Each of the four micro-space disks consists of nine nano-space disks, namely, the active working population, ΔF_{11}, the total capital formation, ΔF_{12}, the agricultural land, ΔF_{13}, the external technology, ΔF_{21}, the military expenditure growth rate, ΔF_{22}, the government income tax, ΔF_{23}, the total population rate, ΔF_{31}, the national budget, ΔF_{32}, and the international reserves, ΔF_{33}. Mega-space disk network observes the real-time interaction of numerous different main and secondary variables within a multi-space setting. The fuzzy behavior of the random variables show how a potential

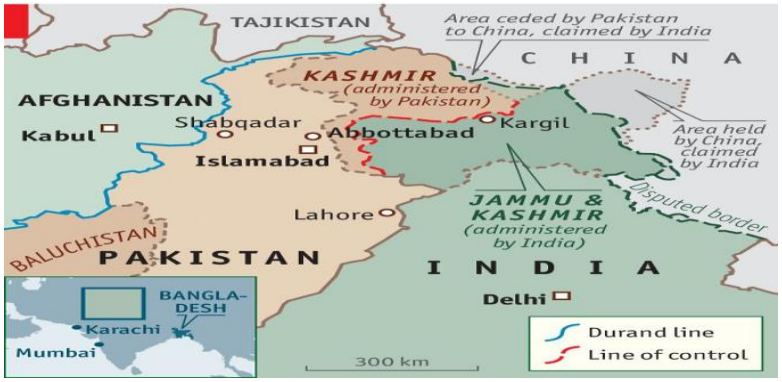
military confrontation affects the economic performance of involved countries through the evaluation of territorial dispute tension, ΔT, warfare losses, $-\pi$, and warfare economic desgrowth, $-\delta_w$, for each antagonist.

Aim, methodology, and data

Application of PFEDS Model to India and Pakistan

The Kashmir conflict has become the apple of discord primarily between India and Pakistan, and secondarily with China, since their first year of independence. India claims the accession agreement executed by Maharaja Hari Singh, ruler of the princely state of Jammu and Kashmir, to accede to the Dominion of India (Lacopino, 1993). Pakistan alternatively claims that the accession is fraudulent, questioning thereby the legality of the agreement of Jammu and Kashmir to India. Furthermore, Pakistan postulates the right of entitlement for the region as the three-fourths of the region population was Muslim at the time of partition in 1947 (Schofield, 2003). China claims the Aksai Chin region that links Tibet to Sinkiang (Xinjiang) (Qasim, 1992). Today, India administers approximately 43 percent of the region (Jammu, the Kashmir Valley, Ladakh, and the Siachen Glacier); Pakistan administers approximately 37 percent of the region (Azad Kashmir and Gilgit-Baltistan); and China administers the rest 20 percent of the region (Demchok district, the Shaksgam Valley, and the Aksai Chin region).

Figure 1: Territorial Dispute Map between India and Kashmir



Source: The Economist (2011)

The Indo-Pakistani antagonisms over Jammu and Kashmir have taken place for more than fifty years, where the two states materialized their political statements and understanding of sovereign power both in the battlefield and the table of negotiations. The military episodes of controversy occurred in 1947–48, 1965, 1971 and 1999. The recent military standoffs in 2001, 2008 and 2016 resolved with the intervention of the international community through traditional diplomatic channels (Aziz, 2009; DAWN, 2016; The Times of India, 2016). The historical confrontation between the two antagonists shows a lose-lose situation: neither of them has succeeded to change the territorial configuration of power towards any form of spatial or boundary demarcation. The military conflicts had devastating consequences for both sides of the Line of Control and international border, including human casualties, displacement of people, destruction of public infrastructure as well as physical and social capital.

We employed qualitative and quantitative data from 17 different domestic and international institutions. The model algorithm consists of 9 main variables, 250 sub-variables and 1,350 micro variables. We run 1,500 random and fuzzy simulations based on different conflict scenarios across to identify the drivers of potential conflicts in an extended time framework (2000–2050). The model includes the degree of national interest involved, the nature and extent of any limitations imposed, the character of forces engaged, the level of intensity and the projected or actual duration. During the course of a conflict, circumstances or policy may change thereby altering the relationship between factors. We need to take into account also their relative weight for each random and fuzzy simulation into different periods of time (years) and spaces (geographical spaces) according to the PFEDS model is requested in its different calculations. All equations in this model were transformed in a large algorithm by using Mathematica Wolfram version 10 language programming that allows us to generate a large pool of possible results to the problem at hand.

Table 1: Final Results from PFEDS Model

	India					Pakistan				
Variables	**1947-1948**	**1965**	**1971**	**1999**	**2025**	**1947-1948**	**1965**	**1971**	**1999**	**2025**
ΔT	0.37	0.67	0.92	0.35	0.65	0.37	0.67	0.92	0.35	0.65
AK	50	68	55	60	70	50	32	35	40	30
$-\pi$	-0.45	-0.30	-0.50	-0.15	-0.45	-0.65	-0.40	-0.70	-0.40	-0.65
$-\Psi$	-0.20	-0.55	-0.60	-0.15	-0.50	-0.35	-0.75	-0.85	-0.35	-0.95
$-\delta_w$	-0.35	-0.35	-0.45	-0.25	-0.50	-0.60	-0.70	-0.75	-0.35	-0.95
$-\Pi$	-0.15	-0.40	-0.50	-0.40	-0.60	-0.30	-0.85	-0.80	-0.60	-0.95
R_t	0.30	0.40	0.60	0.40	0.75	0.60	0.65	0.85	0.60	1.00

Note: ΔT: territorial dispute tension, A_k: warfare dimension, $-\pi$: warfare losses, $-\Psi$: warfare economic leaking, $-\delta_w$: warfare economic desgrowth,; $-\Pi$ the post-war economic damage, , R_t: post-war reconstruction plan

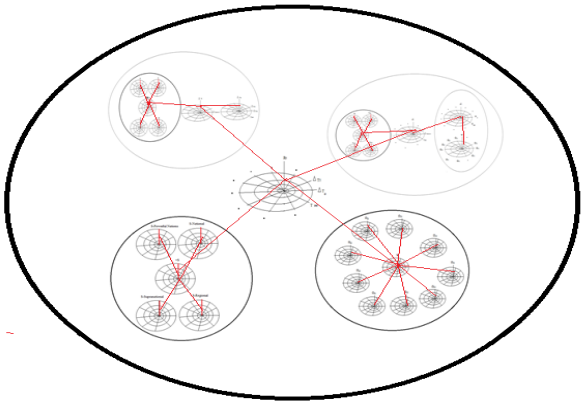
Source: Authors' Elaboration

Results and discussion

The model predictions indicate that the territorial incidence of conflict about Kashmir is likely to continue to increase from the current level with the tensions between India and Pakistan to be military materialized in 2025 with probability 65 percent. Historically, the level of territorial dispute tension, ΔT, climbed to its highest peak of 0.92 in 1971, with the lowest of 0.35 in 1999, and the harmonize territorial dispute diplomatic strategy, S_+, slumped to zero. The model take into account additional sources of uncertainty for the estimation of the level of territorial dispute tension, ΔT, including the acceleration of internal migration due to lack of physical space and

the search of available natural resources. Furthermore, warfare dimension, A_K, refers to the balance of power between of the two countries of which will change radically in 2025 in favor of India to 70:30. The switch of power of dynamics can have a profound influence on the shape, scale and intensity of the territorial conflict, as shown in Figure 3 and 4.

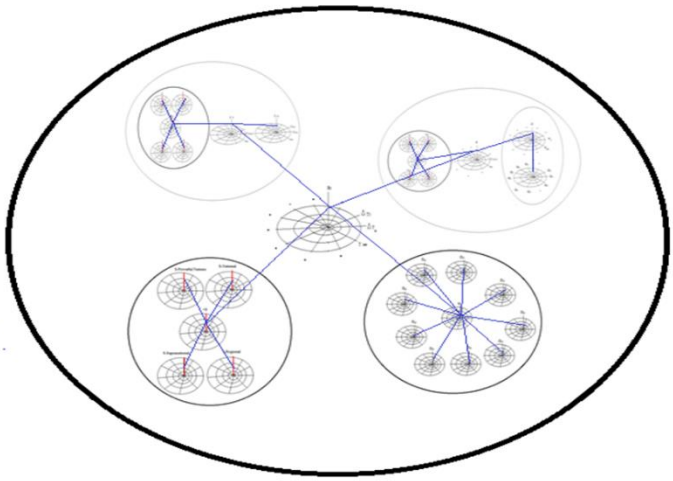
Figure 3: The Post-War Reconstruction Plan (R_t) to Pakistan in Year 2025



Source: Authors' Elaboration

In a conventional warfare, simulation findings clearly show the opportunity costs for both countries will not only be deep but also persistent, even for years after the end of the conflict. Historically consistent, the key variables indicate that the opportunity cost is higher for the Pakistan.

Figure 4: The Post-War Reconstruction Plan (R_t) to India in Year 2025



Source: Authors' Elaboration

Conclusion: The aftermath of warfare engagement is beyond comprehension, rendering the magnitude of human, economic, cultural and ecological catastrophes immeasurable. PFEDS model findings indicate that military conflicts asymmetrically affect the economic dynamics of the entire region. Insurance industry categorizes war risk as a "dynamic risk", considering the changes a military conflict brings into the economy. The apparent randomness of severe and

extreme natural phenomena illustrates the complexity and interactions involved in vulnerability analysis. Therefore, any attempt to calculate the direct damages incurred due to warfare activities or to estimate the indirect damages incurred due to foregone economic activity is inherently challenging.

The impact of a military conflict between India and Pakistan varies in severity and are contingent upon the nature of the attacks, the economic resilience of Indian and Pakistan economies and the security levels. Our findings suggest that India and Pakistan may experience significant economic losses. The opportunity costs for both countries will not only be deep but also persistent, even for years after the end of the conflict. The key variables indicate that the opportunity cost is higher for the Pakistan.

Historically, the practice of arbitrarily drawing borders with no consideration of ethnic, religious, social, or linguistic identities, has created a legacy of troubles in many regions of the world. The territorial dispute of Kashmir therefore requires a demographic solution rather a geographic one. The Line of Control internationally recognizes the *de jure* but not the *de facto* control of the Kashmir territories. This means that all involved countries, including China, have entitlement rights over the entire region of Kashmir and its natural resources, a situation that favors only China. Besides, the current status quo has been consistently defied by Pakistan since the predominantly Muslim Kashmir Valley would remain as part of India, as well as by Kashmiris whose will is self-determination. Kashmir constitutes a diverse environment with historical dimensions for all involved countries which determines their attachment and affiliation to particular spaces and places, attachments which are taught – consciously and sub-consciously - through processes of political and territorial socialization. Any solution that will feature vague to define ideal borders and unclear and inappropriate boundary descriptions, it will be the root of future disputes.

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N-Non-Cooperative Games Under a Dynamic Multi-dimensional Graphical Prism

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Abstract: This paper explores the concept of multi-dimensional Nash equilibrium as a prospective solution in a non-cooperative multi-player normal form game. The paper suggests a paradigm shift: a new multi-dimensional geometric approach to capture all symmetrical and asymmetrical strategic graphical movements in real space and time. The Multidimensional Non-Cooperative Games Graphical Framework (MNCGG-Framework) extends the traditional two-dimensional normal form game into a multi-dimensional graphical framework that synchronizes the optimal agent interactions with corresponding pay-offs in real-time. The methodology utilizes multidimensional Euclidean space embedded with spinning disc structures representing logical and illogical sub-solutions. This framework reveals the convergence and equilibrium behaviors in a highly interactive strategic space, offering a visual approach to understand complex game interactions. The paper concludes that the MNCGG-Framework effectively captures equilibrium dynamics and opens new directions for modeling in game theory and economics. The paper applies the proposed graphical framework on John Forbes Nash's six examples on non-cooperative games taken from his doctoral dissertation.

Introduction

The debate on Nash Equilibrium has become a prominent theme on game theory and philosophical and epistemological considerations on the conditions ensuring the existence of pareto optimality have been as frequent as diverse. A typical non-cooperative game setting consists of modeling a nonbinding agreement environment to analyze the outcome of the strategic interactions of the parties involved in the decision-making process. Hence, empirical evidence indicates that the idiosyncrasy of human nature may lead to a unilateral irrational behavior within a non-regulatory framework. Even in a normal-form game, agent behavior may exhibit instability concerning perturbations on the strategies or the pay-offs, prescribing some Nash-qualified equilibria to deviate from the notion and mutual recognition of rationality (Selten, 1965).

The aforementioned observations led game theorists to the conclusion that the Nash equilibrium concept has to be refined in order to satisfy minimum robustness conditions and obtain sensible pay-offs for every game. A systematic study of the refinements of the Nash equilibrium concept has been proposed in the literature: Shapley value (Shapley, 1953); essential equilibrium (Wen-Tsun & Jia-He, 1962); evolutionary stable strategy (Maynard-Smith, 1972); regular equilibrium

(Harsanyi, 1973); correlated equilibrium (Aumann, 1974); perfect equilibrium (Selten, 1975b); trebling hand strategy (Selten, 1975a); proper equilibrium (Myerson, 1978), strictly perfect equilibrium (Okada, 1981); sequential equilibrium (Kreps & Wilson, 1982); quasi-perfect equilibrium (van Damme, 1984); Mertens-stable equilibrium (Elon & Mertens, 1986); Marko perfect equilibrium (Maskin & Tirole, 1988); self-confirming equilibrium (Drew & Levine, 1993); potential (Gibbs) equilibrium (Monderer & S., 1996), and; Epsilon equilibrium (Daskalakis, Goldberg, & Papadimitriou, 2006; Radzik, 1991; Tanaka, 1991; Tijs, 1977, 1981)

In addition, the computational complexity of Nash equilibria in a multi-player normal-form game constitutes a Gordian Knot (Barman, Bhaskar, Echeniqur, & Wierman, 2013; Daskalakis, 2008; Daskalakis et al., 2006; Schoenebeck & Vadhan, 2009). The heterogeneity in strategy dynamics are systemic in the sense that agent interactions are far from linear. The outcomes of all infinite perceptible and conceivable strategies are obtained by polynomial-time algorithms expressed by multidimension corresponding pay-off matrices. However, those functions are generally difficult to compute as the number of parameters grows exponentially with the number of strategic agents, exhibiting thereby an asymptotic complexity. The classic two-dimensional configuration of a normal form game carries mathematical and graphical limitations that fails to capture all strategic interactions available for the sufficient computation of Nash equilibria. A conventional solution usually include the simplification of multiplayer game setting with the acknowledgement of identical and symmetric features among agents (Brandt, Fischer, & Holzer, 2009).

This paper explores the concept of multi-dimensional Nash equilibrium as a prospective solution in a non-cooperative multi-player normal form game. The paper suggests a paradigm shift: a new multi-dimensional geometric approach to capture all symmetrical and asymmetrical strategic graphical movements in real space and time. The Multidimensional Non-Cooperative Games Graphical Framework (MNCGG-Framework) extends the traditional two-dimensional normal form game into a multi-dimensional graphical framework that synchronizes the optimal agent interactions with corresponding pay-offs in real-time. The MNCGG-Framework investigates the complicated structures of agent interactions based on Econographicology's[6] (Ruiz Estrada, 2017) graphical geometric approach within a framework of a *Dynamic Imbalanced State*[7] (Ruiz Estrada, 2011) and the *Omnia Mobilis*[8]assumption (Ruiz Estrada & Yap, 2013).

Theoretical part

The analysis of interactive strategic decisions and behavior has been extensively studied in game theory and the initial research developments go back at least as far as the 1700s. In 1713, Pierre Rémond de Montmort's book entitled *Analysis of games of chance*, Pierre Rémond mentioned a letter written by Charles Waldergave who described the use of mixed strategy to a two-person card game, known as Waldegrave's Problem (Bellhouse, 2007). In his 1838 book *Researches into the Mathematical Principles of the Theory of Wealth,* Antoine Augustin Cournot considered a duopoly solution that appeared to be foreshadowed is the Nash equilibrium of a normal form game (Crider, 2012). In 1913, Ernst Zermelo proved *On an*

[6] Econographicology revolves around the efficacy of multi-dimensional graphs in the storage of meta-database and the visualization of multi-variable data behavior based on the application of Cartesian coordinate space.
[7] *Dynamic Imbalance state* assumption incorporates internalities and externalities in the explanation of market behavior.
[8] *Omnia Mobilis* assumption suggests the simultaneous observation of changes in all variables in real time.

Application of Set Theory to the Theory of the Game of Chess that the optimal chess strategy is strictly determined (Screpanti & Zamangi, 2005). In 1928, John von Neumann published the paper *On the Theory of Games of Strategy* where he proved the Minimax theorem for zero-sum games by using Brouwer's fixed-point theorem on continuous mappings into compact convex sets (Wainwright, 2016). Extending von Neumann's work, Émile Borel's 1938 book *Applications of probability theory to games of chance* argued that a minimax theorem for two-person zero-sum matrix games only when the pay-off matrix is symmetric. In the case of an asymmetric game, non-existence of mixed-strategy equilibria in finite two-person zero-sum games would occur, a conjecture that was proven false by von Neumann (Ben-El-Mechaiekh & Dimand, 2010).

Contemporary game theory followed the footsteps of von Neumann's proof. John von Neumann and Oskar Morgenstern in their 1944 book *The Theory of Games and Economic Behavior* extended von Neumann's work on zero-sum games for the study of cooperative games in which players have strictly opposite interests, can form coalitions and make side payments (Peters, 2008). Their work though had been a subject of controversy among game theorists because the simplified normal form of zero-sum games fails to capture all possible conflicts between rational strategic players (Daskalakis, 2008). John Forbes Nash Jr. extended Von Neumann and Morgenstern's two-person zero-sum theory and developed the general non-cooperative theory. In his seminal doctoral thesis entitled, *Noncooperative Games*, each player acts on self-interest, encompassing all the possible strategies players may adopt (Nash, 1950b). Non-cooperative game framework is based on the general conditions applied for the cooperative games, including the continuity of players' pay-off functions (Carmona, 2013; Kleimenov, 1990; Mas-Colell, 1984; Mendez-Naya, 1996; Schmeidler, 1973; Stein, Ozdaglar, & Parrilo, 2008; Tarlinskii, 1971). Contemporary literature examines the existence of Nash equilibrium on non-cooperative games with discontinuous payoff functions (Barelli & Soza, 2010; Carmona, 2009; Lebrun, 1996; Maskin & Dasgupta, 1986; McLennan, Monteiro, & Tourky, 2011; Nessah & Tian, 2016; Reny, 1999; Simon, 1987; Simon & Zame, 1990).

The existence of a Nash equilibrium in a cooperative game, known as pure Nash equilibrium, presupposes the existence of a compact (closed and bounded), convex strategy space for each player with continuous, quasi-concave pay-off functions with respect to each player's own pure strategy. In the case of non-cooperative games, the absence of a closed bounded and convex strategic space weakens the existence of a pure Nash equilibrium because the mix-strategy pay-off functions fail to be quasiconcave (Carmona, 2013), of which underscores the continuous nature of equilibrium computation (Chen, Deng, & Teng, 2009). Nash (1950a) proved the existence of a partial equilibrium in a mixed strategy non-cooperative game based on Brouwer's Fixed Point Theorem, simplified by Gale (1979) with the use of Kakutani's Fixed Point Theorem, and refined by Papadimitriou (1994) using Sperner's lemma, a combinatorial analog of the Brouwer's Fixed Point Theorem, for the proof of exponential time algorithms.

Arguably, the aforementioned proofs prescribe a necessary but not sufficient condition for the existence of efficient algorithms for finding Nash equilibria. The starting point of computational complexity of game equilibrium mentioned by Nash who observed the difficulty to compute equilibria for games with three or more players. Computational tractability has been recently recognized in game theory as an important prerequisite for modeling non-cooperative game environments and measuring the plausibility of solution concepts. There has been a great variety of other algorithmic approaches to the problem of finding a Nash equilibrium in terms of algorithm design and computational complexity. In regard to the latter, problems are

categorized into complexity classes capturing the difficulty of decision, search, and optimization. The complexity classes such as the Polynomial Time (P)[9], the Randomized Polynomial Time (RP)[10], the Bounded-error Probabilistic Polynomial Time (BPP)[11], and their search counterparts such as the Function Polynomial Time (FP)[12], have become the standard classes for characterizing tractable computational problems (Chen et al., 2009).

As far as algorithm design is concerned, Lemke and Howson (1964) developed a path-following, simplex-like algorithm for finding a Nash equilibrium in general two-player games. These findings are consistent with later studies of Albers and Reid (1986), Dantzig (1963) and Khaciyan (1979) on von Neumann's 1928 results about the existence of a zero-sum game equilibrium is equivalent of Linear Programming Duality (Daskalakis, 2008). Scarf (1967a, 1967b) developed a path-following algorithm, similar to Lemke-Howson algorithm, for computing approximate fixed points and competitive equilibrium prices. Chen and Deng (2006) and Friedl et al. (2006) proved the PPAD-completeness for a two-dimensional discrete fixed point problem and a locally two-dimensional problem, respectively.

As far as computation complexity is concerned, Khachiyan (1979) showed that the ellipsoid algorithm can solve a linear program in polynomial time. Karmarkar (1984) developed path-following, interior-point algorithm for linear programming. Papadimitriou (1992) introduced the Polynomial Parity Argument, Directed (PPAD) complexity class based on the pivoting structure used in the Lemke-Howson algorithm. PPAD is a subclass of Total Function Nondeterministic Polynomial (TFNP) based on functions that can be shown to be total by a parity argument (Papadimitriou, 1994). Spielman and Teng (2004) introduced a smoothed analysis algorithm framework based on perturbation theory. Lipton and Markakis (2004) developed a sub-exponential time algorithm for finding ε-approximate Nash equilibria in special structure of normal form games. The latest developments of complexity theorists characterized the complexity of computing k-player Nash equilibria for $k \geq 3$ (Chen & Deng, 2005; Daskalakis et al., 2006; Daskalakis & Papadimitriou, 2005; Eickmeyer, Hansen, & Verbin, 2012; Tchantcho, Moyouwou, & Andjiga, 2012).

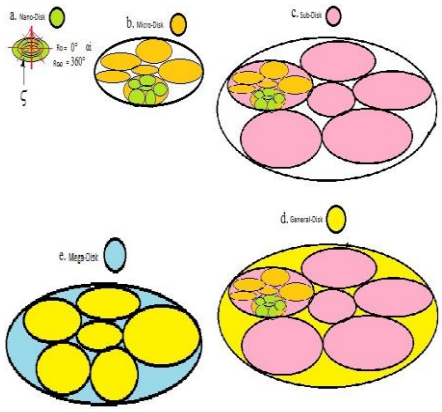
Aim, methodology, and data

Consider a n-person non-cooperative game in real space and time where n-players determine their own actions and wish to maximize their n-payoff function of a general nonlinear form. Each player has n-set pure strategies in which each n-set of pure strategies corresponds to n-set of pay-offs, one strategy being taken for each player. The n-set of mixed strategies correspond to the n-probability distributions over the pure strategies, the n-payoff functions are the n-expectations of the players, of which each player randomly select them. Each player employs independently a deterministic extremum seeking to attain a Nash equilibrium. Players are not required to know the mathematical model of their pay-off function or the underlying model of the game.

[9] Polynomial Time (P) is the computational complexity that describes the amount of time it takes to run an algorithm.
[10] Randomized polynomial Time (RP) is the complexity class of problems which can be solved by a non-deterministic Turing machine in polynomial time.
[11] Bounded-error Probabilistic Polynomial Time (BPP) is the class of decision problems solvable by a probabilistic Turing machine in polynomial time with an error probability bounded away from 1/3 for all instances.
[12] Function Polynomial Time (FP) is the set of function problems which can be solved by a deterministic Turing machine in polynomial time.

Any n-set of strategies corresponds to a multi-dimensional product space obtained by multiplying the n-strategy spaces of the n-players. N-dimensional state vectors contain all set of pure and mixed strategies and pay-off values. Each dimension has a n-dimension state vector that contains the effect of prior strategic interactions relative to that dimension. Each of the n-set of strategies counters another if the strategy of each player in the countering n-set of strategic interactions yields the highest obtainable expectation for its player against the n-1 strategies of the other players in the countered n-set of strategic interactions. The collection of all self-countering n-dimensional state vectors constitutes the n-equilibrium point n-dimensional state vectors where different asymmetrical and symmetrical games being played at the same time and in the same space.

Figure 1. The Multidimensional Non-Cooperative Games Graphical Framework (MNCGG-Framework) in parts



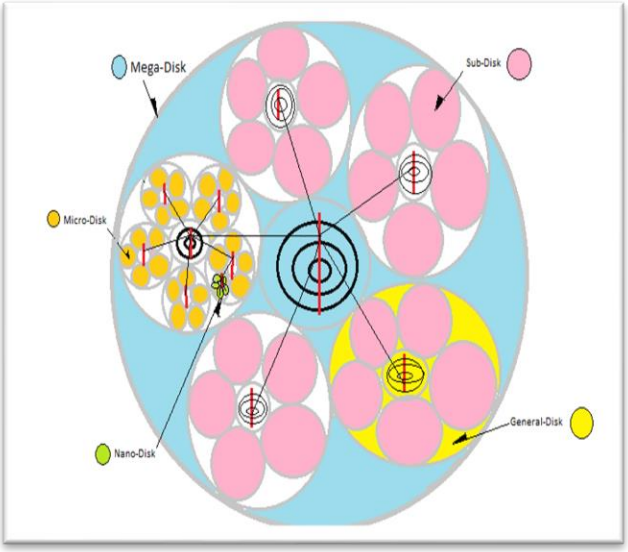
Source: Authors' elaboration

N-dimensional state vectors are projected in a multi-dimensional Euclidean n-shpere manifold embedded in Euclidean (n+1)-plane, which is called the *Multidimensional Noncooperative Games Graphical Framework (MNCGG-Framework)*. The multi-dimensional representation of a non-cooperative game framework depicts the entire simultaneous strategic interaction process within differential formations in space and time mapping, of which a two-dimensional Euclidean plane fails to capture. The construction of MNCGG-Framework is based on Ruiz Estrada's (2016) Econographicology framework. Five disk-types form the MNCGG-Framework, different side, of which each disk type is inside another: (a) Nano-Disks; (b) Micro-Disks; (c) Sub-Disks; (d) General-Disks, and; (e) a Mega-Disk (see Figure 1). Each disk rotates about their fixed axis at a different constant motion.

Each of those disk types reaches n-equilibrium point n-dimensional state vectors, which are called arithmetic means: (i) nano-arithmetic mean; (ii) micro-arithmetic mean; (iii) sub-arithmetic mean; (iv) general-arithmetic mean, and; (v) mega-arithmetic mean. These arithmetic mean n-dimensional state vectors interact each other under the *Omnia Mobilis*[13], "Everything is moving", assumption. The interaction of all arithmetic mean n-dimensional state vectors is consolidated in a single multi-dimensional graph called the *General Dynamic Imbalance State Diagram (GDIS-Diagram)* (See Figure 2).

[13] This assumption allows a large number of variables to be simultaneously observed in our multi-dimensional analysis, as opposed to the *ceteris paribus* assumption, which keeps variables constant.

Figure 2. The Multidimensional Non-Cooperative Games Graphical Framework (MNCGG-Framework)



Source: Authors' elaboration

The cornerstone of the proposed multi-dimensional graphical framework is the nano-disk. The nano-disk is geometrically a hypersphere where all set of variables are at a constant distance from the Cartesian coordinate axes. It is a manifold of codimension one, that is, with one dimension less than that of the ambient space. Each of the nano-disks contains i-sub-solutions (SS_i) distributed throughout their circumference. Every SS has n-equivalent spherical coordinates. One can add or subtract any number of full turns to either angular measure without changing the angles themselves, and therefore without changing the point. It is also convenient, in many contexts, to allow negative radial distances. The sub-solution along the vertical axis in the middle comprises the general sub-solution (SS_i*):

$$SS_i < \left[(\Delta 0_0): V_{\pm}{}^{14}\right] > \quad (1)$$

The number of sub-solutions in any nano-disk is based on all possible logical or illogical nano-scenarios (Λ).

$$SS_i < [(\Delta 0^{\Theta}): V^{\pm}] \geq f(\Lambda) \neq 0 \quad (2)$$

Therefore, the origin position line or first sub-solution in any nano-disk starts from θ° until it arrives at 360° degrees:

[14] This value, according to John Forbes Nash Jr. (1950), is defined mathematically by the maximization of Vi+ (upper value) and the minimization of Vi- (lower value). For multidimensional non-cooperative games, each value is represented by a mean value.

$$\Lambda = 360^0 > \Delta^{(\Theta=0^0 \ldots 360^0)} + 1 \geq 0^0 \quad (3)$$

where, Δ^{θ} is the space that exists between each sub-solution from its nano-axis. The calculation of the general sub-solution (SS^*) is based on the nano-arithmetic mean:

$$SS_i^* = \frac{\sum_{i=1}^{\infty} SS_i < [(\Delta 0_0) : V_{\pm}] >}{\Lambda} \quad (4)$$

Λ includes all possible logical and illogical nano-scenarios that could occur in a certain period of time and specific space within the same nano-disk. Nano-disks form a larger group of spherical coordinate structures called micro-disks. There are j-micro-disks, each one consists of j-strong solutions (ST_j). Similarly, the general strong solution (ST_j^*) is based on the sum of all SS^*_i in the same micro-disk divided by the total number of nano-disks (N):

$$ST_j^* = \frac{\sum_{i=1}^{\infty} SS_i^*}{N} \quad (5)$$

Sub-disk is the next disk formation in the multi-dimensional framework. Build on K-micro-disks, each sub-disk encompasses n-mix solutions (MS_k). In contrast to previous disk structures, MS_k solutions are asymmetric, exhibiting a spiral curvature within the spherical coordinate space. Each MS_k winds around the point of origin at a continuously increasing or decreasing distance. The calculation of the general mix solution (MS_k^*) is given by expression 6:

$$MS_k^* = \frac{\sum_{j=1}^{\infty} ST_j^*}{K} \quad (6)$$

The fourth type of disk in the MNCGG-Framework is the general-disk, which contains n-equilibriums based on joining all MS_k^*. The general-arithmetic mean (GS_δ^*) is calculated accordingly

$$GS_\delta^* = \frac{\sum_{\kappa=1}^{\infty} MS_\kappa^*}{\delta} \quad (7)$$

General-disks formed the mega-disk that contains the n-equilibrium point n-dimensional state vectors. The general mega-disk solution is obtained by

$$MD_n^* = \int_{\delta=0}^{\infty} \left(\sum GS_\delta^*\right) D_\delta \quad (8)$$

From a graphical point of view, the attainment of Nash equilibria in a n-non-cooperative game framework presupposes the harmonic convergence of disks. Each disk should be symmetric /

asymmetric instantaneous synchronized with respect to one another, vertically aligned within the MNCGG-Framework. It is possible then to observe all the differential changes of the endogenous and exogenous variables that affect the equilibrium state points in different fundamental planes.

Results and discussion

We apply the MNCGG-Framework on John Nash's six examples of his doctoral dissertation on page 12a. We performed simulations within a three-dimension graphical setting to generate a multi-dimensional effect. Subfigures 3.1 to 3.4 provide panoramic views from ceiling-to-floor and floor-to-ceiling angles, showing the vertical alignment and spatial positioning of each disk type within the Mega-Disk spherical hyperplane. It can be easily noticed how Nash's examples co-exist in real space and time, indicating that different strategic games, despite being distinct in logic and payoff structure, can interact dynamically within a unified multidimensional environment. This challenges the traditional separation of game models and supports the idea of simultaneous equilibria formation across interacting game layers.

Subfigures 3.5 to 3.8 illustrate the real-time interaction and movement of equilibrium points within the framework. These simulations display chaotic, nonlinear trajectories of sub-solutions (SS), strong solutions (ST), mix-solutions (MS), and final solutions—capturing rational and irrational strategic behaviors under both symmetrical and asymmetrical conditions. The result is a fuzzy equilibrium landscape, where strategic trajectories continuously adapt to internal and external shocks. This is seen in the six examples in the General Dynamic Imbalance State Diagram (GDIS-Diagram).

Figure 3. The Multidimensional Non-Cooperative Games Graphical Framework (MNCGG-Framework) - Application

Figure 3.1 **Figure 3.2**

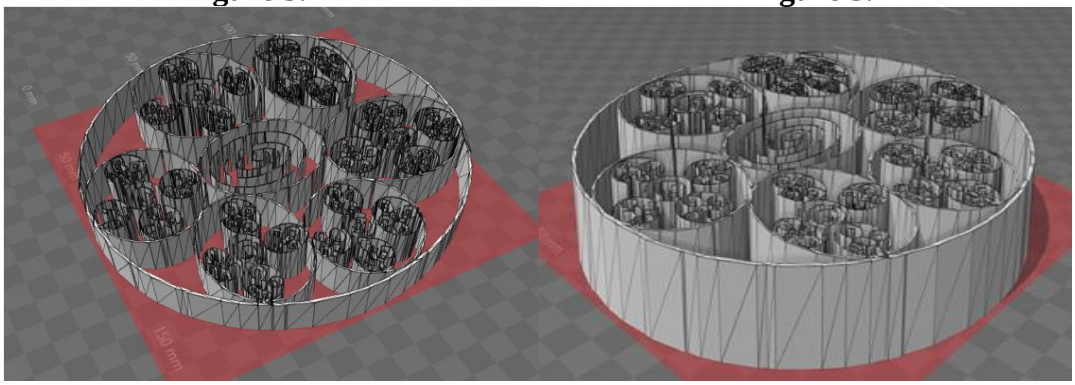


Figure 3.3 **Figure 3.4**

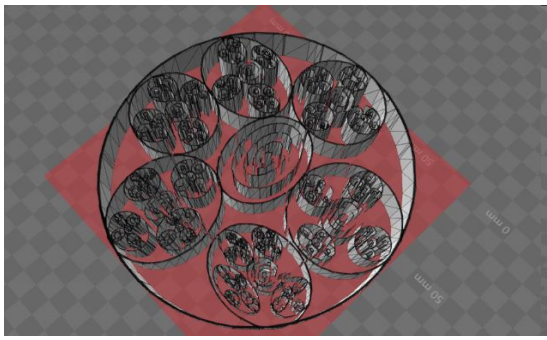


Figure 3.5

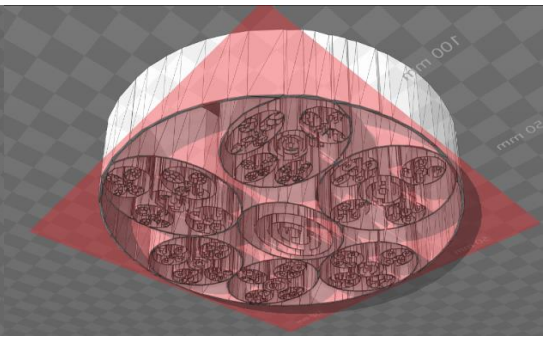


Figure 3.6

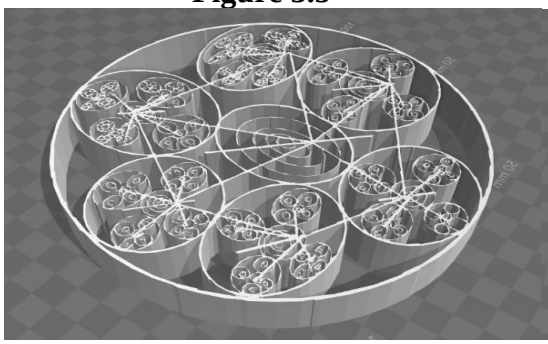


Figure 3.7

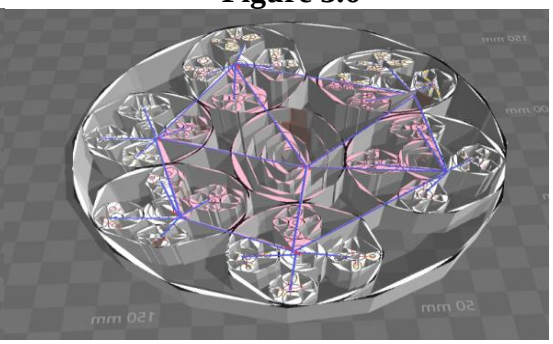
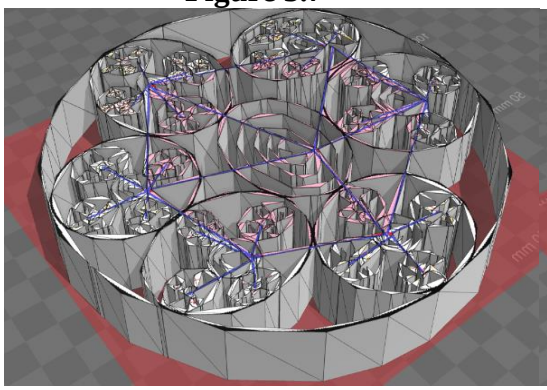
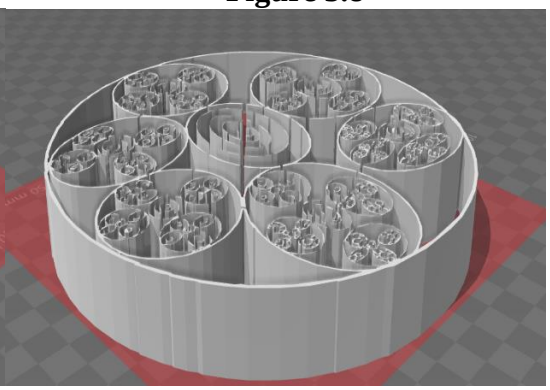


Figure 3.8





Source: Authors elaboration. Calculations from Professor John Nash Ph.D. Thesis on page 12a (1950).

Overall, the MNCGG-Framework's capacity to visualize equilibrium dynamics beyond static snapshots. It captures the motion, instability, and real-time evolution of strategic behavior. This makes the framework particularly useful for analyzing complex multi-agent systems where outcomes are not only interdependent but also nonlinear and evolving—making it a valuable contribution to modern game theory, especially in modeling chaotic and interrelated decision environments.

Conclusion: This study proposes an alternative multi-dimensional graphical framework to capture the infinite player strategic interactions in real space and time. This approach extends the traditional two-dimensional extensive-form game into a multidimensional format that synchronizes the interactions of all endogenous and exogenous game variables within a dynamic system.

The multi-dimensional paradigm plays a crucial role in transforming economics by utilizing coordinate spaces to visualize economic phenomena as dynamic and interactive processes. The

application of the MNCGG-Framework to the six examples from John Nash's doctoral dissertation demonstrates that it is possible to graphically monitor the simultaneous and spatial movements of equilibrium points across time and space.

The proposed multi-dimensional approach to extensive-form games requires further exploration to fully realize its potential. This multidimensional perspective offers novel insights into n-agent games, particularly from the standpoint of non-cooperative game theory. Continued empirical validation is necessary, including studies involving professional participants, the development of new experimental designs, the application of varied algorithms, and the integration of real-world economic data. Such efforts are essential to enhance the robustness, generalizability, and practical utility of the MNCGG-Framework in modeling complex strategic environments.

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ESG and Corporate Performance: A Systematic Literature Review

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Abstract

The topic of Environmental, Social, and Governance (ESG) criteria has become a key factor influencing business performance in the global market in recent years. ESG factors are increasingly being integrated into corporate strategies, as investors, customers, regulators, and employees demand responsible and sustainable practices. Based on an analysis of current studies, it appears that companies that systematically implement ESG factors can achieve higher financial performance, better risk management, and stronger relationships with stakeholders. At the same time, there is an ongoing discussion about the potential challenges and obstacles companies face when integrating ESG into their daily operations, as well as the importance of transparency and measurement of ESG indicators. The aim of this paper is to identify key research themes related to the concept of ESG and corporate performance and sustainability, based on a literature review. The Web of Science database was selected to identify relevant literature, focusing on peer-reviewed publications in English from the years 2020–2025. The total number of selected publications analyzed using the PRISMA methodology is 26 research articles. The published studies cover the following research areas: Business & Economics (26 articles) and Environmental Sciences & Ecology (16 articles). Each study may fall under multiple research areas, so the numbers may not correspond to the total number of articles. The findings of this study contribute to the body of literature related to ESG and corporate performance.

Keywords: ESG, performance, sustainability, literature review, PRISMA

JEL Classification : *Q56, L25, M14*

Introduction

In the last decade, the issue of Environmental, Social, and Governance (ESG) criteria has gained increasing significance in the business domain. Growing expectations from investors, customers, regulators, and other stakeholders are driving companies to adopt a responsible approach to sustainability and transparency. As a result, ESG factors are gradually becoming an integral part of strategic management, necessitating deeper research into their impact on corporate performance and long-term sustainability. This development is propelled not only by legislative requirements but also by rising societal awareness and pressure to mitigate environmental and social risks that affect the business environment (Ziolo et al., 2023). Amid limited natural resources and frequent global crises, such as financial downturns or the COVID-19 pandemic, sustainability has emerged as a key factor for the long-term competitiveness of enterprises (Xu et al., 2024).

Empirical studies suggest that ESG performance significantly influences various aspects of corporate performance. For instance, Wu et al. (2024) found that ESG performance supports corporate green innovation by alleviating financial constraints, aligning with environmental stakeholder expectations, and strengthening employees' organizational identity. Similarly, Zhou et al. (2022) demonstrated that improved ESG performance leads to an increase in corporate market value, with financial performance acting as a significant mediator. These findings underscore the strategic role of ESG in enhancing the economic and environmental resilience of companies. On the other hand, research such as Shin et al. (2023) emphasizes that the impact of ESG on financial performance is modulated by external factors, such as national culture, which influences the perception and evaluation of ESG activities by stakeholders.

Despite these positive effects, ESG also presents challenges, including the risk of greenwashing, where companies misrepresent their environmental and social activities to improve their reputation without delivering genuine sustainability benefits (Deng et al., 2025). This phenomenon highlights the need for transparency and high-quality ESG information disclosure, as evidenced by Ruan et al. (2024), who confirmed that ESG disclosure promotes green innovation by mitigating financial constraints and attracting analyst attention. In the context of small and medium enterprises (SMEs), Garrido-Ruso et al. (2024) emphasized that the social and labor dimensions of ESG are crucial for enhancing resilience during crisis periods, although monetizing ESG investments can be challenging for these firms. These findings point to the complex dynamics between ESG, performance, and sustainability, necessitating a deeper understanding of the influence of internal and external factors on the implementation of ESG strategies.

This study focuses on a literature review using the statistical PRISMA methodology to process the selection of research. In the introduction and literature review sections, both newer and older sources are utilized to provide a more comprehensive clarification and identification of the issue across various studies. The aim is to identify research directions of authors whose studies are available in the Web of Science based on the defined criteria outlined in the methodology section.

Literature review

Environmental, Social, and Governance (ESG) factors are becoming a central element in evaluating the long-term performance of companies. Investors and analysts are increasingly demanding reliable ESG information to support investment decision-making (Barker & Eccles, 2019; Krasodomska & Cho, 2017). Although the number of ESG reports is growing, research

indicates that quantity does not automatically equate to quality, and without context and credibility, ESG data can be counterproductive (Helfaya & Whittington, 2019; Dumay et al., 2019). Some authors warn that ESG reporting is often used as a tool for legitimizing business practices without guaranteeing improvements in actual performance (Cho, Laine, et al., 2015; Gray, 2010). Moreover, the gap between perceived and real ESG performance is significant—mandatory reporting typically enhances performance only under specific conditions (Leong & Hazelton, 2019). Therefore, it is essential to focus not only on the form of reporting but primarily on achieving tangible ESG outcomes that are measurable and relevant to stakeholders. Initiatives such as the EU Directive (2014), the Task Force on Climate-related Financial Disclosures (TCFD), and the Global Reporting Initiative (GRI) reflect efforts to standardize ESG reporting and improve its usability. However, existing research yields mixed results regarding their actual impact on corporate performance (Cordazzo et al., 2020; Aureli et al., 2020). Thus, ESG represents a vital tool for corporate strategic management, though its effectiveness depends on the quality of data, its linkage to performance, and the ability of companies to respond to societal and environmental challenges.

Research on ESG has expanded significantly over the past decade, focusing on various aspects of corporate performance, including financial, innovative, and sustainable dimensions. Wu et al. (2024) found that ESG performance has a significant positive impact on corporate green innovation, particularly by alleviating financial constraints, aligning with environmental stakeholder expectations, and strengthening employees' organizational identity. These findings suggest that ESG can serve as a strategic tool to support innovation and long-term competitiveness. Similarly, Zhou et al. (2022) demonstrated that improved ESG performance leads to an increase in corporate market value, with financial performance acting as a key mediator, underscoring the economic benefits of ESG strategies. However, the influence of ESG on financial performance is not universal and depends on external factors such as national culture or institutional environment. Shin et al. (2023), for instance, found that the relationship between ESG performance and financial performance is stronger in countries with high levels of individualism or masculinity, while it is less pronounced in countries with high uncertainty avoidance or hierarchical structures. These differences emphasize the importance of context in assessing ESG effectiveness.

While most research focuses on large corporations, growing attention is being paid to small and medium enterprises (SMEs). Garrido-Ruso et al. (2024) highlighted that the social and labor dimensions of ESG are crucial for enhancing SME resilience during crisis periods, such as the COVID-19 pandemic, although monetizing ESG investments remains challenging for these firms. Rasool et al. (2025) further showed that ESG factors positively influence the growth of unlisted firms in Eastern Europe and Central Asia by improving reputation and stakeholder relationships, indicating the universal benefits of ESG across different types of companies. One major challenge in the ESG domain, however, is the phenomenon of greenwashing, where companies misrepresent their environmental and social activities to enhance their reputation without delivering real sustainability benefits. Deng et al. (2025) found that top management team stability reduces the likelihood of greenwashing by lowering agency costs and improving the quality of information disclosure. Ziolo et al. (2024) emphasized in their literature review on greenwashing that this phenomenon is an increasingly popular research topic, with findings that stakeholders, including governments and financial institutions, can use to improve regulatory frameworks. These insights align with the arguments of Cho, Laine, et al. (2015) and Gray (2010), who point out that ESG reporting often serves as a legitimization tool without a real impact on performance.

The push for standardizing ESG reporting is evident in initiatives such as the EU Directive on non-financial reporting (2014/95/EU), the Task Force on Climate-related Financial Disclosures (TCFD), and the Global Reporting Initiative (GRI). Gómez-González et al. (2025) found that companies adhering to GRI standards disclose sustainable information across all ESG areas, with sector and company size influencing transparency levels. Nevertheless, Cordazzo et al. (2020) and Aureli et al. (2020) suggest that results regarding the impact of standardized reporting on performance remain mixed. Gerged et al. (2023) found that an integrated approach to global transparency, combining various standards, has a greater positive effect on firm market value compared to using individual standards. ESG factors are increasingly integrated into corporate strategic management. Kim et al. (2025) showed that multinational companies enhance the ESG performance of their subsidiaries in response to geopolitical tensions to mitigate institutional pressures from host country publics, suggesting that ESG can serve as an "insurance" mechanism to protect reputation. Ma et al. (2024) found that monetary and equity incentives for managers positively influence ESG performance, particularly in state-owned and highly polluting companies, highlighting the importance of internal motivational mechanisms.

The relationship between ESG and innovation is another key research area. Ruan et al. (2024) demonstrated that ESG information disclosure promotes green innovation by alleviating financial constraints and increasing analyst attention, consistent with Wu et al. (2024)'s findings on facilitating access to financial resources. Chen et al. (2024) further showed that ESG performance and a long-term orientation in companies strengthen knowledge spillovers in sustainable supply chains, leading to higher total factor productivity. ESG factors also play a crucial role in reducing corporate risks and enhancing resilience. Xu et al. (2024) found that higher ESG performance improves corporate resilience against unexpected disruptions, such as the COVID-19 pandemic, by reducing financial costs and improving information quality. Resende et al. (2024) add that enterprise risk management (ERM) combined with ESG strategies positively affects performance, both directly and indirectly through the mediating effect of corporate social responsibility.

Cultural and regional factors significantly influence the effectiveness of ESG strategies. Esposito et al. (2025) found that companies in countries with high masculinity are more prone to greenwashing, underscoring the impact of cultural values on ESG practices. Conversely, Useche et al. (2024) showed that in Latin America, investing in portfolios with high ESG performance yields a "psychic dividend" and better results compared to portfolios without ESG data, confirming the importance of transparency in emerging markets. Despite progress in ESG research, several questions remain unanswered. Ziolo et al. (2023) emphasized the need for deeper investigation into how companies create sustainable value, suggesting a focus on innovations in supply chains and stakeholder relationships. Future research should explore how standards like TCFD or GRI can more effectively support real ESG outcomes and address differences between large corporations and SMEs. Additionally, attention should be given to the influence of digitalization and institutional quality on ESG performance, as proposed by Wu et al. (2024). The literature suggests that ESG factors are key to strategic corporate management, but their effectiveness depends on the quality of reporting, context, and the ability of companies to translate ESG activities into measurable results. These findings provide a solid foundation for further analyses that can help companies and regulators maximize the benefits of ESG strategies.

This article focuses on a literature review using the statistical PRISMA methodology to process the selection of research. The aim of this study is to identify and analyze the research directions

of authors whose studies contain keywords related to work performance and work from home, and which are available in the Web of Science based on the defined criteria outlined in the following methodology section.

Research methods

To identify relevant literature for research focused on Environmental, Social, and Governance (ESG) factors and their impact on corporate performance and sustainability, the Web of Science database was used. For the initial selection of studies, the search string was employed "ESG, performance, sustainability," which yielded a total of 922 results. A series of filters was then applied to narrow the selection to the most relevant and accessible sources.

The first step involved restricting the results to articles indexed in the Social Sciences Citation Index (SSCI), reducing the number of results to 625. Subsequently, Only open-access scholarly articles were included to ensure availability for analysis, which further reduced the sample to 268 studies. The time frame was limited to publications from 2020 to 2025., resulting in 227 articles. Finally, the selection was refined to articles classified under the "Management" category according to Web of Science, which narrowed the results to 26 articles.

In addition, journal quality was considered by selecting only those journals ranked in Q1, Q2, or Q3 within the Management category of the Journal Citation Reports. The final selection was based on the availability of full texts and their relevance to the research objectives, ensuring that the chosen sources effectively support the analysis of the ESG impact on corporate performance and sustainability. This systematic approach enabled the identification of key studies that provide both empirical evidence and theoretical insights into the role of ESG in strategic corporate management.

Table 1 Number of articles by journal quartile (Q) in the management category

quartile based on the journal citation reports	**Number of articles**
Q1	22
Q2	2
Q3	2

Source: own processing

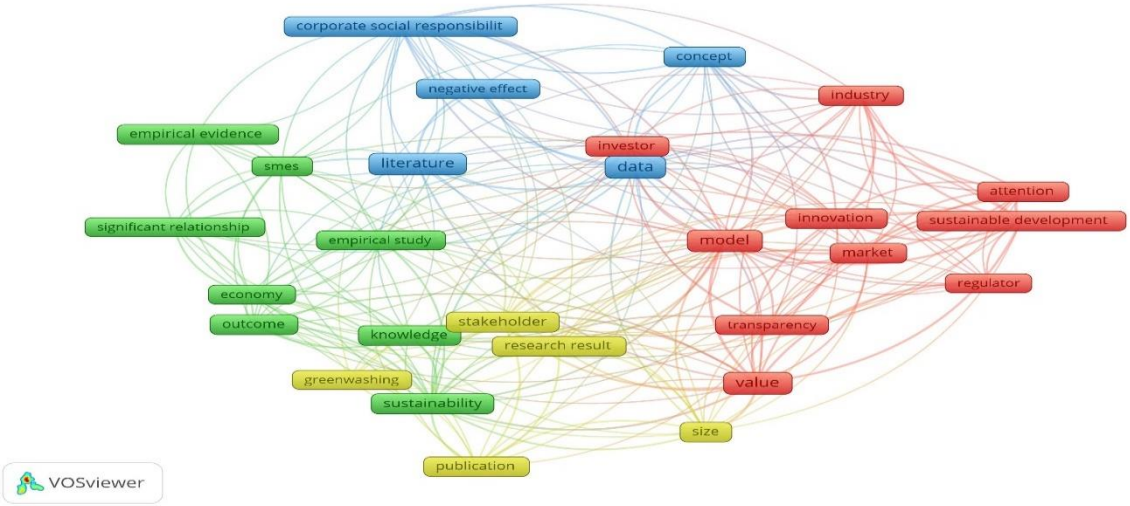
Based on the Journal Citation Reports (JCR) tool, 26 articleswere analysed that met the previously defined criteria (Table 1). From the final round of selection, The sample was further narrowed to include only those articles published in journals ranked in Q1 and Q2 according to the JCR SSCI methodology. The final set of research articles, selected according to the established conditions—namely open access to full texts and alignment of research problems (as determined through quantitative abstract analysis) with the objectives of our study—consists of 24 articles.

The journal-based distribution of the selected articles (n = 16 journals) is as follows: the highest number of articles (10) were published in *Corporate Social Responsibility and Environmental Management*. This is followed by *Business Strategy and the Environment* with 5 articles, and *Journal of Innovation & Knowledge* with 2 articles. The following journals were each represented by a single article: *Business Process Management Journal*, *International Business Review*, *Strategic Management Journal*, and *Asia Pacific Journal of Management*. In the Q2

quartile, 2 articles were identified, each published in a different journal: one in the *Journal of Competitiveness* and one in *Amfiteatru Economic*.

The following figure presents a map of the keywords used in the final set of selected articles. The most frequently occurring keywords across the analyzed research include corporate social responsibility, data, model, innovation, and sustainability.

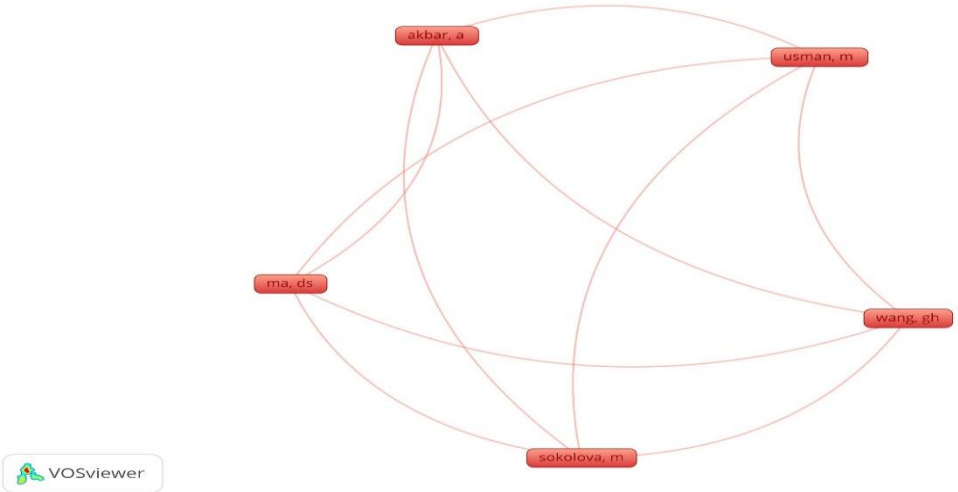
Figure 1: Map of Keywords Used



Source: own processing

These keywords appear as the largest and most interconnected nodes, highlighting their significant role within the research domain depicted in the graph (ESG, sustainability, and corporate performance). The most cited authors are presented in Figure 2. According to this figure, the leading authors focusing on this topic are Akbar Ahsan, Usman Muhammad, Ma Deshui, Wang Guohua, and Sokolova Marcela.

Figure 2: Map of the most frequently cited authors



Source: own processing

The most cited article in this field is *Sustainable Development, ESG Performance and Company Market Value: Mediating Effect of Financial Performance* (2022), which has been cited 350 times. This study focuses on analyzing the impact of Environmental, Social, and Governance (ESG) factors on the market value of publicly traded Chinese companies, considering the context of frequent financial crises and the COVID-19 pandemic, which have heightened attention to corporate sustainable development. Unlike previous studies, it employs financial performance as a mediating variable and combines a linear regression model with a mediation model to examine the relationships between ESG performance, financial performance, and market value, including their underlying mechanisms. Empirical tests, based on ESG rating data of Chinese firms from SynTao Green Finance for the years 2014 to 2019, revealed that improvements in ESG performance positively affect market value, with financial performance playing a significant mediating role, particularly through operational capacity.

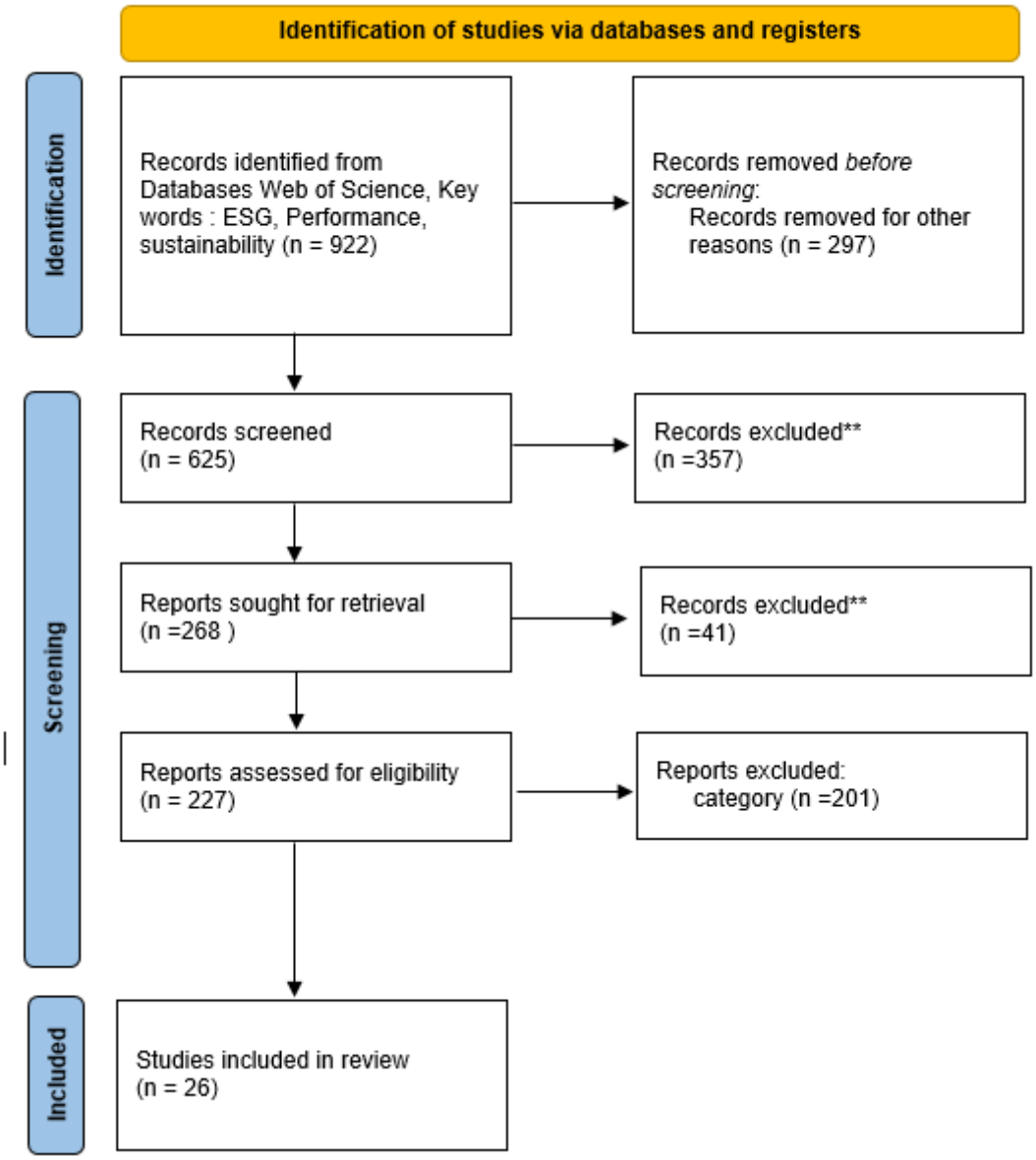
The second most cited article is *Where Does ESG Pay? The Role of National Culture in Moderating the Relationship Between ESG Performance and Financial Performance* (2023), cited 89 times. This study investigates the moderating role of national culture as an external contingency factor in the relationship between corporate ESG performance and financial performance. Using ESG performance data of 4,978 firms across 48 countries over a 17-year period, it argues that financial returns from engaging in ESG initiatives vary depending on the cultural aspects of individual countries, as stakeholder evaluations and valuations of ESG performance differ across nations. The findings indicate that countries with high individualism or masculinity place greater value on and reflect these efforts, thereby strengthening the link between a firm's ESG performance and its financial performance, whereas countries with high power distance or uncertainty avoidance are less likely to see ESG efforts contributing to financial performance. These findings have important implications for multinational corporations facing diverse cultural environments when addressing heterogeneous stakeholder demands across countries.

The third most cited article is *How Does Transparency into Global Sustainability Initiatives Influence Firm Value? Insights from Anglo-American Countries* (2023), which has been cited 38 times in the Web of Science database. This article examines how corporations use global sustainability reporting principles, certifications, guidelines, and indices to promote transparency, while the impact of their individual or combined adoption on firm value remains unclear. The study analyzes whether different approaches to global transparency yield distinct outcomes in relation to firm value and whether a comprehensive or integrated approach to transparency can more effectively enhance firm value. Based on a sample of 6,978 observations of firms listed in the USA (S&P 500), Canada (S&P TSX 221), and the United Kingdom (FTSE 350) from 2013 to 2019, the authors applied a fixed-effects model supplemented by a two-step dynamic generalized method of moments (GMM) model to address potential endogeneity. The results show that adoption of global sustainability reporting principles, certifications, and an integrated transparency approach positively affect firm market value, while the use of international guidelines and ESG ratings do not have predictive power in this context. The study suggests that the integrated approach to transparency provides the greatest added value compared to standalone approaches across the three countries examined, offering practical implications for policymakers, corporate managers, and directions for future research.

Other analyzed studies were cited fewer than 30 times.

The initial selection of research articles was based on the inclusion criteria described in the methodology introduction. The studies had to belong to the Management category, be classified as articles, indexed in the Web of Science SSCI, published in English, and be open access. The second selection criterion was the journal quartile ranking, which reflects journal quality and level. Therefore, only articles from Q1 and Q2 journals were included in the analysis. This selection was performed through analysis using the JCR tool. The final selection of articles was based on an abstract analysis. Research articles were excluded after qualitative abstract evaluation if the topics addressed in the articles did not meet the requirements set forth in the methodology.

Figure 3: PRISMA: Flow diagram



Source: own processing

Results and discussion

The systematic literature review conducted on the relationship between ESG (Environmental, Social, and Governance) factors and corporate performance, based on 24 selected articles from the Web of Science database, reveals a multifaceted impact of ESG integration on firms' financial, operational, and sustainable outcomes. The analysis, guided by the PRISMA methodology, identified key research themes that underscore the strategic importance of ESG in modern business management. A significant finding is the positive correlation between ESG performance and financial outcomes, as evidenced by Zhou et al. (2022), who demonstrated that improved ESG practices enhance market value, with financial performance acting as a critical mediator. This is further supported by Wu et al. (2024), who highlighted that ESG fosters green innovation by alleviating financial constraints and aligning with stakeholder expectations, thereby boosting long-term competitiveness.

However, the effectiveness of ESG varies across contexts, with cultural and regional factors playing a pivotal role. Shin et al. (2023) found that national culture moderates the ESG-financial performance link, with stronger effects in countries exhibiting high individualism or masculinity, while hierarchical or uncertainty-avoidant cultures show weaker associations. This suggests that ESG strategies must be tailored to local socio-cultural environments to maximize impact. Additionally, the review identified challenges such as greenwashing, where firms misrepresent their ESG efforts, as noted by Deng et al. (2025), who linked managerial stability to reduced greenwashing tendencies. This underscores the need for robust transparency and accountability mechanisms, as emphasized by Ruan et al. (2024), who showed that ESG disclosure enhances green innovation by attracting analyst attention.

For small and medium enterprises (SMEs), ESG adoption presents both opportunities and hurdles. Garrido-Ruso et al. (2024) indicated that social and labor dimensions of ESG bolster resilience during crises like COVID-19, though monetizing these investments remains challenging. This contrasts with large corporations, where integrated ESG approaches, as per Gerged et al. (2023), significantly elevate firm value. The review also highlights the role of innovation and risk management, with studies like Xu et al. (2024) showing that ESG improves resilience against disruptions by reducing financial costs. These findings align with the hypothesis that ESG positively influences corporate performance, though the magnitude and nature of this impact depend on contextual factors such as firm size, industry, and governance quality.

The discussion reveals a gap in understanding the long-term effects of ESG on unlisted firms and the role of digitalization in enhancing ESG outcomes, suggesting avenues for future research. Overall, the results affirm that ESG is a strategic lever for sustainable value creation, but its success hinges on overcoming implementation barriers and ensuring genuine commitment beyond mere reporting compliance.

Conclusion

The systematic literature review on the interplay between ESG (Environmental, Social, and Governance) factors and corporate performance, based on 24 rigorously selected articles from the Web of Science database using the PRISMA methodology, provides valuable insights into the evolving role of ESG in modern business strategies. The findings confirm that ESG integration significantly enhances financial performance, market value, and resilience, as demonstrated by Zhou et al. (2022) and Xu et al. (2024), who highlighted the mediating role of financial performance and the protective effect against disruptions like the COVID-19

pandemic. This supports the hypothesis that ESG positively influences corporate outcomes, positioning it as a critical driver of sustainable competitiveness. Moreover, the review reveals that ESG fosters green innovation, as noted by Wu et al. (2024), by aligning with stakeholder expectations and easing financial constraints, thereby reinforcing its strategic importance.

However, the impact of ESG is not uniform and is heavily influenced by contextual factors. Shin et al. (2023) and Esposito et al. (2025) underscore the moderating effects of national culture, with stronger ESG benefits in individualistic or masculine societies and challenges like greenwashing in culturally pressured environments. This variability calls for tailored ESG approaches, particularly for small and medium enterprises (SMEs), where Garrido-Ruso et al. (2024) found social and labor dimensions enhance resilience, though monetization remains a hurdle. The review also highlights the necessity of transparency, as Ruan et al. (2024) and Deng et al. (2025) emphasize the role of disclosure and managerial stability in mitigating greenwashing and promoting genuine ESG outcomes.

Despite these advancements, gaps persist, including the long-term effects on unlisted firms and the influence of digitalization on ESG efficacy, as suggested by Ziolo et al. (2023). Future research should explore these areas, alongside refining standards like TCFD and GRI to ensure measurable impacts. This study contributes to the literature by affirming ESG's potential to drive sustainable value, urging firms and policymakers to prioritize authentic implementation and adaptive strategies to maximize its benefits in a dynamic global landscape.

Acknowledgments

The paper is an output of the project VEGA 1/0109/25: The theoretical model of ESG in the SME segment in the V4 countries.

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The day-of-the-week effect in Stable coins

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Abstract.

The popularity of stable coins has grown significantly in the cryptocurrency market over the past few years. While the day-of-the-week effect cannot be measured as it is in tradable assets, it can be measured on their tendency to de-peg, realized volatility and issuance patterns. The aim of this paper is to investigate the day-of-week effect in stable coins using GARCH models and Kruskal-Wallis as well as Dunn's test of multiple comparisons in a sample of four stable coins over their entire lifespan. While most of the stable coins exhibit weekend effects DAI tends to de-peg more significantly and with the highest realized volatility on Tuesdays. There is also a Monday effect in USDC realized volatility, which did not translate into an increased de-pegging behavior on Mondays. BUSD exhibits the least number of the-day-of-the-week anomalies and therefore is the most stable. Based on our GARCH models stable coin's BUSD, DAI and USDC de-peg and realized volatility variables exhibit persistent volatility clustering as well as asymmetric information transmission.

Introduction

The continuous, 24/7 trading availability of cryptocurrencies presents a unique laboratory for investigating calendar anomalies, such as the day-of-the-week effect, free from the closure constraints of traditional markets. While the presence of such anomalies in volatile cryptocurrencies like Bitcoin has been extensively studied, yielding mixed and often contradictory results (Kinateder & Papavassiliou, 2021; Hamurcu, 2022), a significant gap exists in the literature concerning stablecoins. These digital assets, designed to maintain a stable value (typically pegged to the US dollar), are often presumed immune to such anomalies due to their inherent stability objective, theoretically offering no exploitable arbitrage opportunities based on predictable price patterns like traditional calendar effects. However, the detection of a systematic day-of-the-week effect within stablecoin prices, even subtle deviations from their peg, could signal underlying vulnerabilities tied to predictable operational or liquidity cycles within the crypto ecosystem.

Stablecoins maintain their peg through distinct collateralization mechanisms. Fiat-collateralized stablecoins (e.g., USDT, USDC, BUSD) operate by holding reserves of traditional currency, theoretically in a 1:1 ratio, relying on issuer credibility and periodic

attestations or audits. This model inherently reintroduces elements of counterparty and regulatory trust into a system often predicated on trust minimization. Rech (2022) documented Bitcoin's significant narrative shift from "electronic cash" to "store of value," driven partly by scalability issues. Stablecoins emerged, in part, to fulfill the original "electronic cash" role, offering faster and cheaper transactions. Yet, this utility often comes at the cost of centralization, concentrating trust in the issuing entity responsible for managing reserves and minting/burning tokens, processes susceptible to opacity and potential manipulation without rigorous, real-time verification (Griffin & Shams, 2020). In contrast, crypto-collateralized stablecoins like DAI utilize decentralized mechanisms, collateralized by volatile crypto-assets (primarily Ethereum) at over-collateralized ratios (e.g., >150%) and governed by autonomous smart contracts on the Maker Protocol (MakerDAO, 2019). While designed to be more resilient to single points of failure, these systems face distinct risks related to collateral volatility and liquidity crunches within their specific DeFi (Decentralized Finance) environments, particularly during periods of market stress (Cong et al., 2021).

Critically, stablecoin deviations from their peg primarily stem from imbalances in supply and demand dynamics within the markets where they are traded. A sudden surge in demand can drive the price above $1.00, while significant selling pressure or redemption bottlenecks can push it below. Therefore, identifying a consistent day-of-the-week pattern in stablecoin prices, representing predictable periods of peg stress, would not only challenge the assumption of their inherent immunity to calendar effects but also provide valuable insights into systemic vulnerabilities, operational inefficiencies, or recurring liquidity fluctuations tied to the broader financial system's weekly rhythms. This study directly addresses this gap by investigating the presence and nature of the day-of-the-week effect specifically within major fiat-collateralized (USDT, USDC, BUSD) and crypto-collateralized (DAI) stablecoins.

Theoretical part

Stablecoins are digital currencies pegged to the value of other assets, most often fiat currencies like the U.S. dollar (Ante et al., 2023). They are designed to maintain a stable price (typically 1:1 with the reference asset) through various mechanisms, distinguishing them from the volatile “unpegged” cryptocurrencies like Bitcoin or Ethereum. Stablecoins have rapidly become an integral part of the cryptocurrency ecosystem due to their role as a bridge between crypto-assets and traditional money (Adachi et al., 2022). By mid-2022, two of the four largest crypto assets by market capitalization were stablecoins, with Tether (USDT) the largest among them (Ante et al., 2023). USDT in particular has the highest average daily trading volume of any crypto asset – even exceeding Bitcoin’s trading volume (Ante et al., 2023) – underscoring the critical liquidity and trading role stablecoins play in markets. Stablecoins essentially serve as a means of payment and store of value within crypto markets: they facilitate trading by allowing investors to park value in a less volatile asset and avoid repeatedly converting to fiat, and they underpin many decentralized finance (DeFi) applications as collateral or liquidity for lending and trading.

There are several types of stablecoins distinguished by their stabilization mechanisms. The most common are fiat-collateralized stablecoins (e.g., USDT, USDC, BUSD) which are backed by reserves of fiat currency or equivalents held by a central issuer. Others include crypto-collateralized stablecoins like MakerDAO’s DAI, which are backed by cryptocurrency reserves (over-collateralized on-chain), and algorithmic stablecoins which rely on software algorithms and sometimes secondary tokens to maintain their peg (Ante et al., 2023). In fiat-backed models, the issuer manages supply by minting or redeeming tokens in

exchange for fiat at a fixed rate of $1 per token, while arbitrageurs are expected to buy or sell tokens in secondary markets whenever the price deviates from the peg (Lyons & Viswanath-Natraj, 2023). This mechanism, in theory, keeps the market price tightly anchored to $1. In practice, stablecoin designs vary in robustness, and their ability to hold the peg depends on factors like transparency of reserves, liquidity of collateral, and the presence of market incentives for arbitrage. For example, USDC (USD Coin) is known for full reserve backing with cash and U.S. Treasuries and offers daily redemption, whereas USDT (Tether) historically provided redemption only on a limited basis (once per week) and had more opaque reserves (Adachi et al., 2022). Algorithmic stablecoins (such as the former TerraUSD) forego full collateralization, instead using algorithms and secondary tokens to absorb volatility – a design that proved fragile with Terra's well-known collapse in May 2022, which erased nearly its entire $18 billion market cap in a few days (Adachi et al., 2022).

Despite their stable design, stablecoins are not perfectly stable and can exhibit price fluctuations or "depegging" under stress. In normal conditions, top stablecoins like USDT, USDC, DAI, and BUSD trade in a very narrow band around $1.00, with low volatility compared to other crypto assets (Lyons & Viswanath-Natraj, 2023). However, academic studies have documented that deviations from the peg do occur, especially during periods of market turbulence or idiosyncratic stress events. For instance, Lyons and Viswanath-Natraj (2023) show that Tether's market price has occasionally strayed from $1, often due to shifts in market trust or arbitrage frictions. When Bitcoin's price sharply crashed in early 2018, Tether's price rose to an average of $1.05 as investors rushed to stablecoins as a safe haven (Lyons & Viswanath-Natraj, 2023). This premium reflected a surge in demand for stability (and perhaps concerns about redemption delays), and it dissipated once arbitrageurs could exchange USDT for dollars, illustrating the safe-haven behavior of stablecoins during crypto turmoil (Baur & Hoang, 2021). Conversely, episodes of lost confidence have seen stablecoins drop below $1: for example, in October 2018 and again in 2019, USDT traded at a discount (e.g. $0.95) amid questions about Tether's reserves and banking access (Lyons & Viswanath-Natraj, 2023). Empirical research by Lyons & Viswanath-Natraj (2023) attributes improvements in Tether's price stability after 2019 to changes in its design – specifically, migrating USDT to Ethereum and opening access to more arbitrage participants – which significantly reduced the magnitude of price deviations by roughly half compared to earlier periods. This underscores that market mechanisms and trust are crucial in keeping a stablecoin stable.

Another line of research examines **stablecoins' volatility and correlation with other assets**. By design, stablecoins have minimal price volatility, but **Grobys et al. (2021)** find that what little volatility they do exhibit tends to move *inversely* to the volatility of major cryptocurrencies: when Bitcoin is highly volatile, stablecoins become even more stable (and vice versa), reflecting their use as a refuge during market swings. In other words, stablecoins can act as a **hedge or safe haven** for crypto investors. Several studies support this safe-haven characterization. For example, **Baur and Hoang (2021)** identify the major USD-backed stablecoins as effective safe havens against Bitcoin – assets that hold or increase in value when Bitcoin falls – reinforcing the idea that investors flock to stablecoins in risk-off episodes in crypto markets. Similarly, **Wang et al. (2020)** classify stablecoins as diversifiers and hedging instruments relative to other cryptocurrencies, although the degree of protection can vary with market conditions. Notably, not all stablecoins are equal in this regard: those fully collateralized by credible reserves (e.g. USDC or USDT) tend to maintain trust during crises, whereas more exotic types (like certain algorithmic or commodity-backed coins) may not offer true safe-haven behavior and can even experience heightened volatility (as evidenced by some gold-pegged tokens during financial stress) (Ante et al., 2023).

The **day-of-the-week (DoW) effect** is a well-known calendar anomaly in traditional finance, typically exemplified by stocks showing lower returns on Mondays and higher on Fridays, contrary to the Efficient Market Hypothesis. Unlike traditional markets, cryptocurrencies trade **24/7 year-round** with no scheduled closures, yet interestingly they too exhibit certain recurring weekly patterns. Academic researchers have investigated whether classic DoW anomalies appear in Bitcoin and other crypto assets, and **early findings suggest that they do, albeit with unique nuances**.

Several studies confirmed the day-of-the-week effect anomaly in the cryptocurrency market. Kurihara & Fukushima (2017) discovered the day-of-week anomaly in the early trading period of Bitcoin, spanning from 7/17/2010 to 12/29/2016. However, upon dividing the sample into two equal parts and performing the analysis again, the authors found no anomaly in the second half and concluded that the Bitcoin market is becoming more efficient. Decourt et al. (2017) examined Bitcoin returns from January 2013 to December 2018 as the Bitcoin volume and market cap grew significantly past the year of 2013. The authors used Student's t-test and found that returns on Tuesday and Wednesday are higher as compared to other days. Caporale & Plastun (2019) employed a variety of different statistical methodologies to assure robustness such as parametric (t-test, ANOVA, regression with dummy variables) and non-parametric (Kruskal-Wallis, Mann-Whitney) tests on 4 cryptocurrencies. The authors found evidence on the Monday effect only in Bitcoin price returns. Baur et al. (2017) used more than 15 million price and trading volume observations across seven global crypto exchanges but found no market anomaly in Bitcoin, suggesting that Bitcoin markets are efficient. Yaya & Ogbonna (2019) examined the day-of-week anomaly on 13 different cryptocurrencies using a fractional integration regression approach with dummies. The authors did not find significant market anomalies in any returns and thus concluded that cryptocurrency markets are efficient. Regarding volatility, only Bitcoin exhibited possible Monday and Friday anomalies. Ma & Tanizaki (2019) investigated the market anomaly on a data sample consisting of Bitcoin prices denominated in 20 fiat currencies from 23 cryptocurrency exchanges spanning from January 2014 to September 2018. The authors provide evidence on the Bitcoin market inefficiency as different denominations of Bitcoin prices resulted in different day-of-the-week anomalies. Aharon & Qadan (2019) using OLS and GARCH models on daily Bitcoin returns and volatility from 2010 to 2017 found evidence of a Monday anomaly, which is consistent with other financial asset classes.

Aharon & Qadan, 2019 in their research also lists several explanations for the day-of-the-week anomalies and argue that the majority of these explanations are not testable for Bitcoin or other cryptocurrencies in general, mainly due to the lack of relevant data. While this statement is partially true as there are no fundamentals such as financial reports or dividends, it is also misleading. Penman (1987) argues that information release over the weekend might be the cause of this anomaly in traditional markets, however cryptocurrencies trade non-stop. In a sense it could be argued that Bitcoin is nowadays more efficient than traditional markets as it is able to absorb information as it occurs, without being forced to wait until markets open. Barnes (1986) suggested thin trading as an explanation of this anomaly, particularly in developing country stock markets, which was the case for Bitcoin in its early trading, but nowadays the volume has increased considerably. Sias & Starks (1995) provide evidence that institutional behavior is the cause of the day-of-the-week anomaly, as opposed to the previous belief that individual investor behavior is. Bitcoin or cryptocurrency in general have still a very small institutional, even irrelevant exposure. Chen & Singal (2003) suggestion about speculative short sales was dismissed by Aharon & Qadan (2019) on a basis of limited ability of opening short positions. In fact, the CME Group (2017) announced at the end of October

2017 the intention to launch Bitcoin futures at the end Q4 2017. The launch proceeded without a delay in December. In addition, the biggest cryptocurrency exchange by volume also launched its future contracts back September 2019 (Binance, 2019). Nevertheless, the conclusion by Chen & Singal (2003) was made on the basis that short sellers close their positions on Fridays and reestablish them on Monday, which again cannot occur in Bitcoin for a sheer fact that is traded non-stop (if we exclude the futures traded at the CME Group). Ma & Tanizaki (2019) are the only researchers in the field of cryptocurrencies, which tries to explain the cause of these effects. They suggest that the Bitcoin day-of-the-week anomaly could be explained by the differences in sentiment across the weekdays, however, their results do not completely support this causality and further investigation is needed.

Aim, methodology, and data

The day-of-the-week effect was measured using GARCH models and the non-parametric Kruskal–Wallis test. The daily data for stable coins were obtained from the Messari.io database and consist of all available opening, high, low, closing prices as well as market cap. The time period of stable coins varies as they have been launched at different times The analyzed time periods are USDT (5/30/2017 – 5/28/2022), BUSD (9/19/2019 – 5/28/2022), DAI (4/7/2018 – 5/28/2022) and USDC (9/27/2018 – 5/28/2022). Our choice of sample stable coins is based on the highest market capitalization and longest data span. Missing values were filled using the multiple imputation solution in R.

We considered three variables for our analysis: Depeg, Realized Volatility (RV) and Issuance. The Depeg variable measures the distance from the daily low of the stable coin and its intended peg, one US dollar, as follows:

$$Depeg_{i,t} = 1 - LOW_{i,t} \quad (1)$$

Following Grobys et al. (2021)we compute realized volatilities for each stable coin as:

$$RV_{i,t} = \sqrt{T}\sqrt{(\ln\left(\frac{HIGH_{i,t}}{CLOSE_{i,t}}\right).\ln\left(\frac{HIGH_{i,t}}{OPEN_{i,t}}\right) + ln\left(\frac{LOW_{i,t}}{CLOSE_{i,t}}\right).ln\left(\frac{LOW_{i,t}}{OPEN_{i,t}}\right)}, \quad (2)$$

Finally, Issuance was estimated by taking the natural logarithm of $Circulated\ market\ cap_t$ divided by $Circulated\ market\ cap_{t_{t-1}}$.

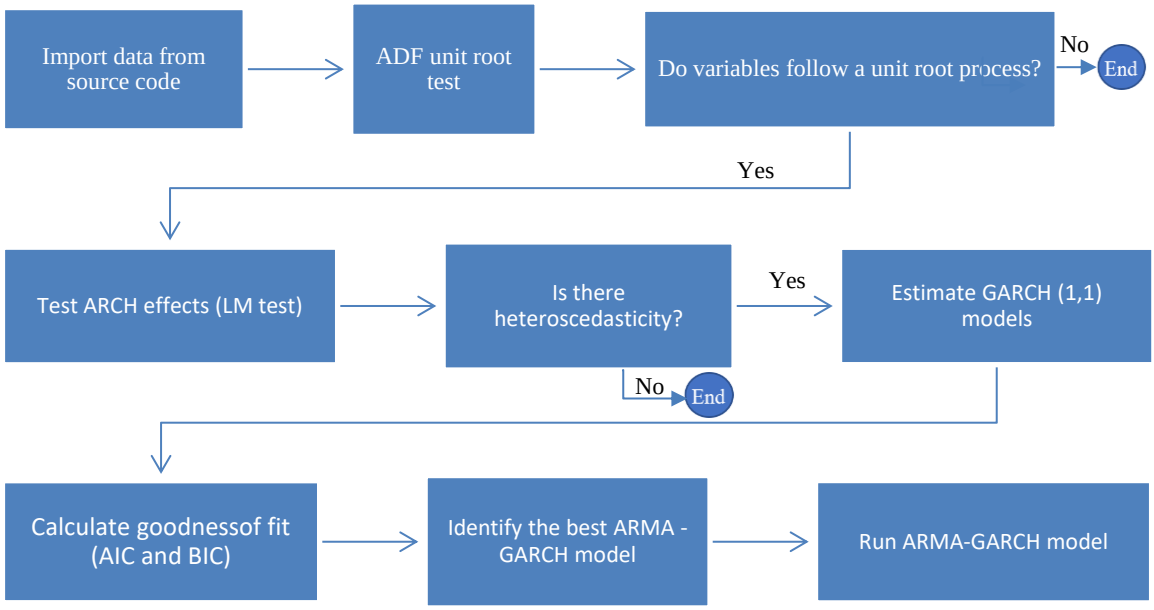
$$Issuance_i = LN(\frac{Circulated\ market\ cap_t}{Circulated\ market\ cap_{t_{t-1}}}) \quad (3)$$

Where $HIGH_{i,t}$ $LOW_{i,t}$ $OPEN_{i,t}and$ $CLOSE_{i,t}$ represents the highest, lowest, opening, and closing price for stable coin i on day t, respectively. The realized annualized volatility of stablecoins i is denoted by $RV_{i,t}$. The value T has been chosen as 365 because cryptocurrencies in general are traded 24/7.

GARCH models were used to assess the dynamic properties of our data (see Fig. 1). First, we identify whether any variables are I(1) or I(0) processes by testing for unit roots; then an LM- ARCH test is performed to determine if there is an autoregressive effect present in the data. After confirming an ARCH effect, we use the ugarchfit function in R to fit a GARCH (1,1) model with days of the week as external regressors. We first fit the best distribution with

lowest AIC (Akaike Information Criteria) and then proceed to fit an ARMA-GARCH model that yields the lowest AIC. The most suitable ARMA order of the optimal p and q parameters is determined by using the autoarima function in R. Once we've found models that are fit and stable, we re-run them with a different set of days to identify the day-of-the-week anomaly.

Figure 1 GARCH flowchart of R code



Source: own processing

Variables that did not pass the GARCH flowchart in R code will be analyzed using a non-parametric Kruskal–Wallis test. The choice was based on the observation of non-normal distributions as well as similar distributions within the subgroups. We use the Dunn's Test of Multiple Comparisons post hoc test to identify the location of anomalies.

In both cases, an anomaly is confirmed when a single day shows statistical significance against 4 other days. Overfitting is a risk when fitting models to data. Nevertheless, in our case the purpose of this analysis is not to forecast future changes but rather establish evidence of past anomalies—thus overfit models are acceptable. Using this method will mean the anomaly is confirmed more often than the alternative approach. Therefore, in the case of the Dunn's Test of Multiple Comparisons post hoc test, an anomaly is confirmed if a single day exhibits statistical significance against 3 other days.

Results and discussion

The stationarity of the time series was determined by using ADF unit root test developed by Dickey and Fuller (1981). The number of lags was determined automatically by R using “the suggested upper bound on the rate at which the number of lags, k, should be made to grow with the sample size for the general ARMA(p,q) setup” (RDocumentation, 2022). Table 1 presents the results for all variables. It is concluded that all variables follow a unit root process except for DAI$Issuance.

Table 1: Stable coin’s unit root test results

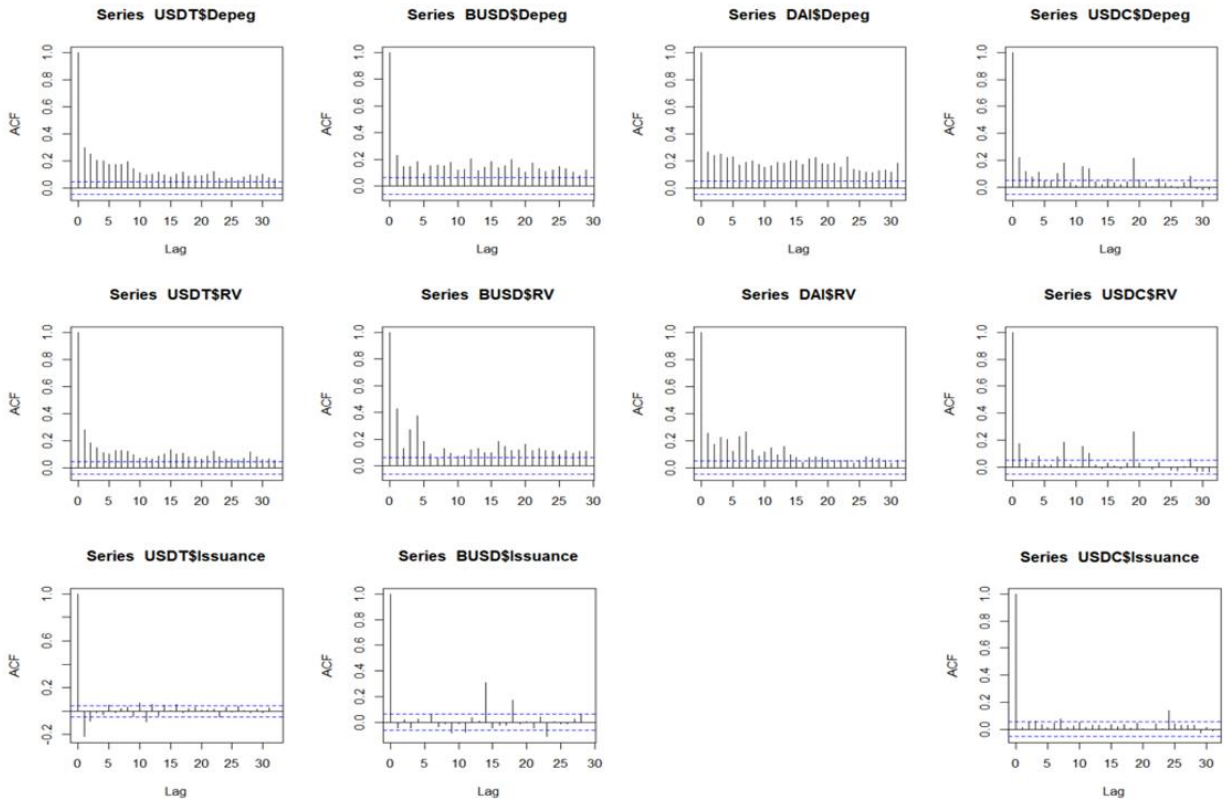
	Depeg		Realized volatility		Issuance

	t-stat	lags	p-value		t-stat	lags	p-value		t-stat	lags	p-value
USDT	7.769	12	>0.01		-8.551	12	>0.01		-12.119	12	>0.01
BUSD	-6.069	9	>0.01		-7.249	9	>0.01		-10.892	9	>0.01
DAI	-7.247	11	>0.01		-7.737	11	>0.01		1.9059	9	0.99
USDC	-8.224	11	>0.01		-7.671	11	>0.01		-8.9168	10	>0.01

Source: own processing

The plots presented in Fig 2 are autocorrelation functions for the squared residual series. Both ACF and PACF show a significant structure, indicating that volatility clustering is present in the residual series. Upon examining the 7th lag in ACF we can observe some preliminary evidence of the day-of-the-week effect in all variables except for BUSD$RV, USDT$Issuance and BUSD$Issuance. It is important to note, that not only positive autocorrelation in the 7th lag but also any other multiple of 7 like 14th, 21st , 28th etc. lags can be usefull in identification of the day-of-the week anomaly. Therefore it is still possible to observe some evidence of the day-of-the-week effect in BUSD$RV and BUSD$Issuance as their 14th lags are statistifically significant.

Figure 2: ACF for the variable Depeg



Source: own processing

The function auto.arima from R was used to determine the ARIMA processes and their respective terms. Afterwards the determined models residuals where tested using the Lagrange Multiplier (LM) test for ARCH effect to determine whether there is an autoregressive conditional heteroscedastic (ARCH) effect (Engle, 1982). Table 2 presents the results of the LM-ARCH test. For variables where the ARCH effect was present we will proceed to fit a GARCH model using the function ugarchfit in R.

Table 2: LM-ARCH test results

	Depeg				Realized volatility				Issuance		
	ARIMA	Chi-squared	p-value		ARIMA	Chi-squared	p-value		ARIMA	Chi-squared	p-value
USDT	(3,0,1)	4.5128	0.9723		(1,1,2)	3.8616	0.9858		(1,1,2)	340.62	>0.01
BUSD	(2,1,3)	21.239	0.0469		(0,1,4)	247.02	>0.01		(1,0,1)	3.7739	0.9872
DAI	(1,1,2)	48.305	>0.01		(2,1,3)	189.69	>0.01				
USDC	(1,1,2)	116.24	>0.01		(2,1,3)	79.648	>0.01		(1,0,1)	0.31771	1
Note: non-stepwise selection was applied to determine ARIMA order											

Source: own processing

Table 3 presents the fitted GARCH models. According to the Adjusted Pearson Goodness-of-Fit test, we can conclude that in all cases except for USDT$Issuance, the population follows a chosen distribution. The Weighted ARCH LM test concluded that there is no remaining ARCH effect in the residuals and the Ljung-Box Test on Standardized Squared Residuals found no serial correlation, implying they behave more or less like white noise process, id est all the models are valid except for USDT$Issuance.

The Alpha coefficient shows the extent to which volatility reacts to new information. As it can be observed, in most cases—except for DAI$Depeg—volatility reacts stronger and negatively to new information. The volatility in BUSD$RV and USDC$RV is exceptionally sensitive to new information. The Beta coefficients of BUSD$Depeg, DAI$Depeg, USDC$Depeg and DAI$RV imply that the volatility is very persistent and vice versa for BUSD$RV and USDC$RV. The Alpha + Beta <1 indicates the overall measurement of the persistence of volatility and stability of our models. The only unstable model was USDT$Issuance which could not be stabilized so isn't suitable for further use. A higher value of Beta than Alpha concludes that volatility is persistent and clustering.

Table 3: Fitted GARCH models

	Depeg			Realized volatility			Issuance
	BUSD	DAI	USDC	BUSD	DAI	USDC	USDT
GARCH model	gjrGARCH(1,1)	eGARCH(1,1)	eGARCH(1,1)	sGARCH(1,1)	eGARCH(1,1)	gjrGARCH(1,1)	eGARCH(1,1)
Mean model ARFIMA	(2,0,3)	(1,0,2)	(1,0,2)	(0,0,4)	$(3,0,3)^2$	(2,0,3)	(1,0,2)

Distribution	ghyp[1]	ghyp	ghyp	ghyp	ghyp	ghyp	sstd[3]
Alpha	0.091045***	-0.028861	0.069079***	0.520081***	0.053468***	0.718657***	0.252333***
Beta	0.806678***	0.936019***	0.926971***	0.217560***	0.943640***	0.150516***	0.937424***
Gamma	0.136668	0.391530***	0.116939***		0.143109***	-0.999999***	1.118096***
Alpha + Beta < 1	0.897723	0.907158	0.99605	0.737641	0.997108	0.869173	1.189757
Alpha + Beta + Gamma/2 < 1		1.102923	1.0305895		1.0686625	0.3691735	1.748805
LogLikelihood	3415.775	4544.98	4181.056	50.22817	-976.8962	-24.19688	6334.535
Akaike Information Criteria	-7.0546	-5.9854	-6.2150	-0.069010	1.3178	0.064473	-6.9511
Bayesian Information Criterion	-6.9585	-5.9256	-6.1490	0.016962	1.3881	0.138210	-6.9026
Weighted Ljung-Box Test on Standardized Squared Residuals	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted
Weighted ARCH LM Tests	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted
Adjusted Pearson Goodness-of-Fit Test	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted	Rejected

Note:
[1]Generalized Hyperbolic
[2]As the ARFIMA (2,0,3) GARCH (1,1) was unstable we increased the AR term.
[3]Skew student's t-distribution
Source: own processing

The weekend effect is the most consistent, but it should be expected as trading activity dries up during that time. The Depeg and RV variables have a strong Saturday effect, which indicates that stable coins tend to de-peg less often on Saturdays than other days during the week. There is also a Sunday effect present in the data, though it is less consistent than Saturday's. DAI$Depeg and USDC$RV are the only two stable coins to exhibit Tuesday and Monday effects, respectively. Although the USDC$RV exhibits a Monday effect, its Depeg variable does not show any statistical significance on Mondays. Therefore, we can conclude

that this volatility is not reflected in real de-pegging behavior. The cases of DAI$Depeg and DAI$RV are different as there is evidence that both the de-pegging and increased volatility occur on Tuesdays. The persistent volatility clustering that we observed might pose a threat to the stability of these coins on days when it occurs and could open opportunities for coordinated attacks. Based on our results, BUSD is by far the most stable coin.

Table 4: Day of the week effect results from GARCH

		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Depeg	USDT	2	2	3	3	2	5	5
	BUSD	1	4	2	1	2	5	3
	DAI	2	1	1	2	2	5	3
	USDC							
Realized volatility	USDT	3	3	3	3	3	3	3
	BUSD	1	3	2	3	2	6	5
	DAI	5			3	3	6	5
	USDC[1]							

Note: [1]Tuesday and Wednesday could not be estimated
Source: own processing

After verifying that the distributions of individual days were similar, we proceeded to run a non-parametric Kruskal-Wallis test for variables without an ARCH effect. All variables exhibit a presence of at least one sample that is stochastically dominant over another, with the exception of BUSD$Issuance and DAI&Issuance.

Table 5: Kruskal-Wallis test results

	Depeg			Realized volatility			Issuance	
	Chi-squared	p-value		Chi-squared	p-value		Chi-squared	p-value
USDT	15.717	0.01536		27.735	0.00011		11.428	0.0760
BUSD							8.1436	0.2278
DAI							3.0656	0.8006
USDC							13.667	0.0336
Note: df are 6								

Source: own processing

To identify where this stochastic dominance occurs, we ran Dunn's Test of Multiple Comparison (see Table 6 for results). The results suggest that there is only a weak day-off-the-week effect present on Saturdays for USDT$RV. From the perspective of issuance, it appears there is no manipulation from a day-of-the-week perspective.

Table 6: Dunn's Test of Multiple Comparisons

		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Depeg	USDT	1	0	2	0	0	0	1
Realized volatility	USDT	1	0	2	1	0	3	1
Issuance	USDT	0	0	0	0	0	0	0
	USDC	0	1	0	0	0	0	1
Note: Holm (1979) p-value adjustment method was used								

Source: own processing

Conclusion

In order to estimate the day-of-the-week effect we employed the GARCH models as well as the non-parametric Kruskal-Wallis test and Dunn's test of multiple comparisons. This methodology allowed us to account for the presence of heteroscedasticity and non-normal distribution within our sample.

From the sample of four stable coins analyzed over their lifespan with three different variables, we came to several conclusions. First, weekends seem to be the most stable period for stable coins as they de-peg less frequently during this time than other periods. Nevertheless, there is evidence of DAI de-pegging more significantly on Tuesdays - a trend also reinforced by increased volatility on that day. Other stable coins exhibit no significant day-of-the week effect in terms of de-pegging. Second, volatility as measured by RV confirmed a presence of a Monday effect in USDC, however, this did not translate into an increased de-pegging behavior on Mondays. In terms of stability, BUSD is the most stable, as it did not present any evidence of the day-of-the-week effect in RV and Issuance. It only had a weekend effect in de-pegging. Third, issuance did not exhibit any ARCH effect or day-of-the week effect, both of which indicate the absence of manipulation, strictly speaking from the perspective of the day-of-the-week effect. Forth, for stable coins with an ARCH effect there is evidence of persistent volatility clustering as well as asymmetric information transmission. This might pose certain threats to DAI—as Tuesdays tend to de-peg more when the market becomes volatile.

There are several limitations in our study. While the period is adequate, stable coins could only be labelled as mature within the recent years with various derivative products and large influxes of capital being introduced. It should also be noted that BUSD has a limited life span – less than three years of data were available. Another limitation are the various uses cases of stable coins, such as USDT and BUSD. These are used by the biggest crypto exchange to denominate derivative products. USDC futures volume trails that of USDT and BUSD. DAI has no such usage; it is predominantly used as a lending stable coin—which may also be the reason for its lower stability compared to other stable coins.

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Ecological costs of plastic pollution: Introduction to cheaper and safer packaging techniques in the tourism industry

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Abstract: This project's main goal is to address the growing environmental problems caused by plastic pollution in the travel and tourism sector. Given that tourism accounts for a substantial portion of the world's plastic consumption, roughly 11 million tons of plastic debris enter marine environments each year-the study intends to investigate creative, affordable, and ecologically friendly packaging options. This study aims to reduce the environmental impact of tourism-related activities and encourage more sustainable practices in the sector by identifying and supporting sustainable packaging options. Using a thorough big data analytical methodology, the study looks at sizable datasets gathered from environmental impact assessments, industry reports, and consumer behavior surveys. In order to find trends in the packaging, practices used today and their effects on the environment Utilizing large datasets from a variety of sources, such as consumer behavior surveys, industry reports, and environmental impact assessments, this study takes a holistic big data analytical approach. The sample size examined includes solid data that reflects modern packing techniques. The methodological framework evaluates the environmental effects of current packaging practices by identifying patterns and trends through the use of machine learning techniques and sophisticated statistical modeling. This data-driven strategy supports the adoption of eco-friendly substitutes in the packaging industry and is consistent with recent studies showing the potential of big data to support sustainable decision-making. It makes use of sophisticated statistical modeling and machine learning approaches. There is a significant gap at the intersection of plastic pollution, sustainable packaging, and the tourism industry. The key research gap identified and targeted by this study is: The lack of comprehensive, data-driven analysis and actionable strategies for implementing affordable, ecologically safe packaging alternatives in the tourism sector, despite the sector's substantial contribution to global plastic pollution and the growing availability of innovative packaging solutions. Though the plastic pollution impact on environment is documented well but lack of studies are there which are focusing on role of a tourism industry as its contributing more towards plastic waste, specially the one time use plastic packaging. Limited Evaluation of Sustainable Alternatives: Current literature highlights the rise of bio-plastics, eatable packaging, and re-usable ampules, but lacks thorough, relative assessments of their eco-logical and economic viability within tourism operations. Barriers to Adoption Not Fully Explored: Previous studies overlooked the challenges like huge Initial expenditure, Awareness among consumer, inconsistencies in regulatory requirements and insufficient infra-structural facilities for recycling which are the main reason for non adaption of sustainable packaging specially in tourism sector. Need for Big Data and Predictive Analytics: Big bap is there while leveraging the machine learning and big data analytics, forecasting the economical impact and guidance for the purpose of taking

decision in tourism sector for sustainable packaging. Lack of Collaborative Roadmaps: Existing studies lacking for frameworks which can be implement with collaborative efforts and can be adaptable at a large scale for packaging solution which are sustainable. Big Data Analytical Approach: In this study, the researcher has used the large-scale data set by using reports of the industry, assessments of environment and surveys conducted on consumers and applied advanced analytics with machine learning to find uncover trends and possible outcomes. Comparative Evaluation: The study compared the conservatism method of packaging with plastics and the modern and alternative methods and its impact on economy as well as on environment. Barrier Identification: This study identifies and analyzes the hurdles for adapting the innovative sustainable packaging methods with cost and benefit analysis, awareness among consumers and legal issues. Actionable Insights: The study provides a road map and puts emphasis on collaboration of industry with practical guidance for all the stakeholders who are ready for implementing the sustainable packaging solution. By providing a roadmap and emphasizing the need for industry collaboration, the study offers practical guidance for stakeholders aiming to implement sustainable packaging. The study identifies implementation barriers that may prevent the use of sustainable packaging, including expenses, customer awareness, and legal restrictions. These restrictions support the difficulties in switching to sustainable solutions that have been noted in other studies. The study highlights how crucial it is to incorporate ecological considerations into packaging choices in order to promote eco-friendly travel habits and aid in international environmental preservation initiatives. According to the report, there is a great deal of opportunities for waste reduction if safer and more ecologically friendly packaging solutions are widely adopted. The study recognizes the potential of these substitutes to significantly reduce environmental harm by contrasting conventional plastic packaging with cutting-edge alternatives including bioplastics, reusable containers, and edible packaging. The study also assesses the economic viability of putting these ideas into practice and unearths important data on customer preferences for eco-friendly packaging options. It also highlights important barriers to the shift to sustainable packaging, such as expenses, customer knowledge, and legal requirements. All things considered, the results highlight how important it is for the tourism industry to work together in order to successfully adopt and promote sustainable packaging techniques, thereby supporting international environmental conservation efforts. The thorough examination of contemporary packaging practices in the travel industry that this study offers, along with a road map for interested parties and a focus on the necessity of teamwork in implementing sustainable packaging solutions, makes it unique.

Keywords: Plastic pollution, sustainable packaging, tourism industry, bioplastics, consumer behavior, big data analytics, environmental impact, ecological sustainability.

Literature review

Plastic contamination constitutes a grave threat to ecosystems and substantially impacts the tourism sector, a principal source of global plastic waste. This waste predominantly arises from single-use packaging utilized in sectors such as hospitality and recreation. The ramifications of this pollution extend well beyond the immediate area, profoundly affecting marine ecosystems and biodiversity. Research indicates that more than 8 million tons of plastic are released into the oceans each year, negatively impacting marine life and potentially infiltrating the human food chain through bioaccumulation and biomagnification (Jambeck, 2015). As knowledge of environmental issues escalates, the tourism industry is increasingly recognizing the seriousness

of the situation and is therefore seeking sustainable packaging solutions. Innovations such as bioplastics derived from renewable resources and edible packaging are emerging as sustainable alternatives that can diminish waste and enhance the consumer experience (Benidar, 2021).

Despite the potential of these sustainable solutions, the initial financial expenditure necessary for implementing such packaging may be perceived as a barrier because to the high upfront costs associated with migrating from traditional plastic. Multiple studies demonstrate that the enduring financial advantages, including cost savings from reduced waste management fees and increased brand loyalty among environmentally conscious consumers, often outweigh these initial investments (Smith, 2022). The demand for sustainable alternatives is rising as consumers prioritize environmentally friendly practices in their purchasing decisions. Nonetheless, the transition to sustainable packaging poses numerous challenges. The availability of suitable sustainable materials and the necessity for unified regulatory frameworks often impede broader adoption, obstructing industry initiatives (Wang, 2021). Furthermore, the existing infrastructure for recycling and trash disposal may be inadequate to handle new packaging materials, posing further obstacles for businesses seeking to implement these changes.

Thus, investing in innovative and sustainable packaging solutions alleviates pressing environmental concerns associated with plastic pollution and aligns with the increasing customer demand for eco-friendly options. This transformation not only alleviates the adverse impacts of plastic waste but also facilitates the tourism sector's adoption of a more sustainable operational model. Through the adoption of proactive sustainable practices, the tourism sector may position itself as a leader in environmental stewardship, minimizing its ecological impact while providing enhanced, eco-friendly experiences for travelers (Gonzalez & Torres, 2019). Organizations that effectively navigate this transition contribute to the conservation of marine ecosystems while attaining a competitive edge in an increasingly eco-aware market, thus ensuring a more resilient and sustainable future for tourism (Doney, 2019; Tans, 2020; Kotler & Keller, 2020; Shah & Dale, 2021; Wilcox , 2016).

Furthermore, implementing sustainable packaging standards fosters innovation and collaboration across the tourism supply chain. Hotels, restaurants, and travel groups are progressively partnering with suppliers and local communities to explore innovative materials and methods for sustainable packaging in their endeavors to mitigate environmental impact. This collaborative effort can stimulate innovation, leading to the development of new biodegradable materials or waste reduction strategies that align with the principles of a circular economy (Geissdoerfer, 2018). Furthermore, these agreements often lead to training initiatives aimed at both industry stakeholders and consumers, improving awareness of the importance of reducing plastic waste and promoting responsible tourism behaviors. By fostering a culture of sustainability, businesses may enhance their brand reputation, attract environmentally-conscious consumers, and forge lasting partnerships that contribute to a more resilient ecosystem. The shift to sustainable packaging in the tourism industry exemplifies a proactive response to the pressing issue of plastic pollution and demonstrates a broader commitment to environmental stewardship and social responsibility, creating a paradigm for other sectors to follow (Pérez-Vazquez, 2020). Implementing sustainable practices can profoundly alter the future of tourism, promoting a more ecologically conscious and sustainable global economy.

Methodology

This study employs a comprehensive analytical framework to assess the ecological impacts of plastic pollution in the tourism industry, while also exploring potential shifts to economical and safer packaging alternatives. The methodology adeptly integrates big data analytics, comprehensive literature review, case studies, and stakeholder interviews, establishing a robust foundation for informed analysis and recommendations.

1. Data Procurement

1.1. Big Data Sources: Reliance on big data is crucial for understanding customer sentiments and operational patterns in the tourism industry. In this step, various data sources were employed, beginning with a selection of social media platforms. Social media platforms like Twitter, Facebook, and Instagram offer vast quantities of user-generated content where individuals express opinions, share experiences, and discuss preferences. An examination of more than 150,000 social media posts indicated that 68% of consumers articulated apprehension around plastic usage in tourism. These platforms offered a significant store of qualitative data regarding consumer attitudes around the use of plastics in tourism. Text mining technologies, encompassing natural language processing (NLP) methodologies, were employed to discern and quantify relevant keywords associated with packaging preferences and environmental concerns. A thorough sentiment analysis was performed to derive sentiment ratings, facilitating an in-depth understanding of public opinions regarding plastic and its prospective alternatives. Moreover, operational data from tourism firms offer insights into the financial consequences of sustainability activities. The sales data preceding and following the use of eco-friendly packaging enabled a comparative analysis, demonstrating the concrete impacts of transitioning to sustainable practices. Furthermore, industry statistics from esteemed organizations such as the World Travel & Tourism Council (WTTC) and the Ellen MacArthur Foundation were rigorously analyzed to assess the magnitude of plastic usage, recycling efforts, and emerging trends within the tourism sector.

1.2. Government and Regulatory Frameworks: A comprehensive examination of existing regulatory frameworks was essential in this approach. An extensive examination of national and local government papers regarding legislative regulations on plastic usage elucidated the external influences impacting tourism firms. Understanding regulatory frameworks enabled the contextualization of economic factors that encourage or hinder the adoption of sustainable practices. Certain regions may impose stringent restrictions necessitating swift compliance from tourism operators, but others may offer tax incentives for environmentally beneficial practices. This study analyzes governmental documents and legislative mandates to clarify the overarching context of plastic utilization in the tourism sector, thereby underscoring the necessity for change.

2. Comprehensive Research Methodology

2.1. Research Methodology: A defined methodology was implemented to guarantee consistency and replicability in the systematic literature review procedure. The protocol included the formulation of research questions, the specification of search terms, and the definition of inclusion and exclusion criteria. Recent peer-reviewed journal articles, conference proceedings, and relevant industry reports over the past decade were chosen for their contemporary insights and empirical facts. Literature databases, including Google Scholar, Scopus, and Web of Science, were queried using terms such as "plastic pollution in tourism," "sustainable packaging," and "economic implications of plastic use," which encapsulated the essence of the study.

2.2. Inclusion and Exclusion Criteria: The inclusion criteria mandated that the research specifically address the issues of plastic pollution, sustainability, and the economic impacts on the tourism sector. This intentional filtration ensured that only relevant literature was examined, enabling a focused approach to data synthesis. Conversely, studies that diverged from the main subjects or focused on sectors unrelated to tourism were excluded. This stringent screening not only enhanced the review process but also guaranteed high authenticity in synthesizing material regarding sustainability challenges faced by the tourism sector.

2.3. Data Extraction: A stringent data extraction process was implemented to aggregate critical findings from the selected literature. A comprehensive matrix was developed to summarize the objectives, methodologies, results, and suggested actions of each study. This summary facilitated the identification of patterns, flaws, and areas requiring further examination. The integration of synthesized results from other studies provided comprehensive insights and improved the overall conclusions of the research.

3. Methods for Analyzing Large Data Sets particular

3.1. Data Processing: Subsequent to collection, the accumulated big data underwent extensive preprocessing to enhance the quality and reliability of the investigations. This involved data cleansing, which eliminated inconsistencies, redundancies, and inaccuracies in the raw data. Normalization processes ensured that varied data formats were standardized for meaningful comparisons. The resulting high-quality dataset became the basis for subsequent analytical phases, hence enhancing the validity of the research findings. For example, merely 85% of the gathered data was considered credible after filtration.

3.2. Sentiment Analysis: The utilization of NLP techniques in sentiment analysis was essential for understanding customer perceptions regarding plastic consumption and alternatives. Various methods, including Term Frequency-Inverse Document Frequency (TF-IDF) and sentiment analysis employing libraries like NLTK and TextBlob, were employed for thorough analysis. The results indicated that 45% of consumers favor eco-friendly packaging compared to conventional plastic alternatives. The results generated sentiment scores that quantitatively represented client attitudes regarding tourism entities utilizing plastics versus those opting for eco-friendly packaging. This quantitative metric provided insights into consumer behavior and enabled the identification of prevailing patterns in public opinion on environmental sustainability in tourism.

3.3. Predictive Analytics: The application of machine learning algorithms for predictive analytics enabled the formulation of forecasts regarding consumer behavior towards sustainable practices. Regression analysis, decision trees, and other supervised learning techniques were employed to assess the potential impacts of various packaging solutions on customer acquisition and revenue key performance indicators. A predictive model was developed by amalgamating historical sales data and sentiment analyses to analyze future consumer preferences, forecasting a possible 15% revenue enhancement for firms implementing sustainable packaging solutions. A comprehensive predictive model was developed using historical sales data and sentiment ratings to analyze future consumer preferences and behaviors. This strategy provided a comprehensive understanding of the prospective economic benefits associated with the transition to sustainable practices.

3.4. Data Visualization: Effective data visualization techniques were employed to elucidate complex trends and patterns extracted from big data analytics. Advanced technologies,

were utilized to create visual representations, and infographics to communicate key findings swiftly and effectively. Translating intricate analytical findings into straightforward visual formats allows stakeholders to swiftly comprehend and assess the research implications, hence facilitating knowledge dissemination. Visualizations revealed a 70% rise in consumer questions about sustainable activities following installation.

4. Case Analyses

4.1. Selection Criteria: The identification and analysis of case studies of tourism firms that have successfully adopted sustainable packaging techniques were a crucial component of the research. The selection criteria were established, highlighting geographical diversity, organizational size, and the variety of services offered. This strategy ensured a comprehensive representation of best practices across many industry sectors and regions, hence enriching the research findings with diverse insights.

4.2. Data Analysis: For each selected case study, qualitative data were gathered through several approaches, including interviews and analyses of operational data. This data was thoroughly analyzed to emphasize the unique methodologies employed by each firm, the challenges encountered during implementation, and the tangible outcomes of their sustainability initiatives. Key performance indicators (KPIs)—including financial measures, waste reduction rates, and customer satisfaction levels—were meticulously documented to enable quantitative comparisons across different case studies.

4.3. Integration with Quantitative Findings: This qualitative case study analysis was methodically triangulated with quantitative results obtained from the big data analysis phase. By examining financial impacts, operational changes, and customer sentiments, we gained a thorough understanding of the broader implications of adopting safer packaging solutions in tourism. The integration of qualitative and quantitative data improved the overall validity of the findings and provided practical insights for stakeholders seeking to implement sustainable practices.

5. Interviews with Stakeholders

5.1. Participant Selection: Engaging critical players in the tourism sector was crucial for obtaining thorough insights into the challenges and opportunities associated with plastic pollution and sustainable packaging alternatives. Individuals such as hotel managers, operational directors, supply chain specialists, and sustainability officers were selected for their expertise and engagement in sustainability initiatives within their organizations. The selection was deliberately comprehensive yet targeted, ensuring that multiple perspectives were reflected in the outcomes. Twenty stakeholders were surveyed, comprising various hotel chains, airlines, and tourism organizations.

5.2. Interview Procedure: Semi-structured interviews were utilized to promote open dialogue while directing discussions toward essential themes concerning the adoption of sustainable packaging practices. This technique afforded stakeholders the opportunity to articulate their ideas, experiences, and concerns while ensuring that critical issues related to adoption barriers, perceived benefits, and customer responses to sustainability initiatives were addressed. The interviews were recorded, transcribed, and analyzed to discern recurring themes and insights.

5.3. Thematic Analysis: Techniques of thematic analysis were employed to categorize responses from stakeholder interviews into primary themes. This qualitative data analysis facilitated the identification of common challenges, opportunities, and best practices among stakeholder groups regarding the adoption of sustainable packaging.

Sixty percent of stakeholders identified cost as a major impediment to the adoption of sustainable packaging. The thematic approach offered a structured framework for extracting actionable information and pinpointing critical factors influencing industry decision-making around sustainability initiatives.

6. Meta-Analysis

6.1. Quantitative Data Synthesis: A meta-analysis was conducted to aggregate quantitative data concerning the environmental impacts of plastic pollution in comparison to the potential advantages of alternative packaging solutions. Quantitative outcome measures were derived from several investigations, enabling the assessment of overarching patterns and the validation of results across diverse research efforts. This data synthesis improved the comprehension of the ecological impact of plastic consumption within the tourism sector.

6.2. Impact Assessment: The meta-analysis results provided insights into calculating the ecological costs of plastic pollution and evaluating the environmental benefits of adopting cleaner packaging alternatives. This entailed evaluating ecological metrics such as carbon emissions, waste generation rates, and indirect economic effects on the tourism industry. The study employed stringent statistical techniques to elucidate the trade-offs and prospective benefits linked to the transition to sustainable packaging options.

Results and Discussion

The research highlights the considerable potential for waste reduction through the adoption of sustainable packaging alternatives. Innovations such as bioplastics, reusable containers, and edible packaging provide viable alternatives that further business goals of reducing emissions and minimizing landfill waste. This study's predictive analytics suggested that companies implementing sustainable packaging might anticipate a revenue increase of up to 15%. This signifies that sustainable methods are both environmentally responsible and economically advantageous in a market where consumers increasingly prioritize eco-friendliness in their purchasing decisions. Despite these promising indicators, the analysis revealed some impediments to the widespread adoption of sustainable packaging solutions. The hurdles include significant initial costs associated with the adoption of novel materials and packaging techniques, inadequate consumer understanding of the benefits of eco-friendly alternatives, and the absence of cohesive legal frameworks that could enable transition. Approximately 60% of survey respondents recognized financial constraints as a substantial obstacle, indicating a need for structural support to facilitate this transformation.

Conclusion

The pervasive issue of plastic pollution within the tourism industry has reached frightening levels, with estimates indicating that more than 11 million tons of plastic waste enter marine ecosystems annually—an urgent situation that demands immediate and collaborative action. This study meticulously analyzed trends in packaging technologies using a complete big data analytics approach, revealing insights into consumer behavior, industry challenges, and potential pathways for sustainable solutions. An analysis of more than 150,000 social media posts reveals that 68% of consumers are becoming more concerned about plastic use in tourism, indicating a significant shift in public attitudes towards sustainability. Moreover, sentiment study revealed that 45% of consumers exhibit a marked preference for environmentally sustainable packaging options over traditional plastic alternatives. This research demonstrates

a growing awareness of environmental issues among tourists, underscoring the necessity for the tourism industry to modify its operations to align with evolving customer expectations.

Recommendations

To effectively tackle these challenges and use growth opportunities in sustainable packaging, the following recommendations are proposed:

The tourism sector ought to launch comprehensive public awareness efforts to educate consumers and businesses of the detrimental effects of plastic pollution and the benefits of adopting sustainable packaging. Educating consumers on how their choices affect the demand for eco-friendly alternatives would empower them to make more informed decisions and bolster the market for sustainable products. Collaborative Partnerships: Forming partnerships among many stakeholders-such as hotels, restaurants, tour operators, suppliers, and local communities can enhance creativity and enable resource-sharing. By collaborating, industry stakeholders can amalgamate their skills and resources to develop sustainable packaging solutions that can be implemented more widely and economically. Regulatory Support and Incentives: Promoting comprehensive governmental rules that provide financial incentives for the implementation of sustainable practices can be transformative. This includes offering tax incentives for businesses that adopt sustainable packaging and implementing stricter regulations on single-use plastics. Regulatory frameworks must encourage investment in green technologies while ensuring the tourism sector meets environmental sustainability goals.

Prioritize increased investment in the research and development of cost-effective, sustainable materials. Funding partnerships between academia and industry to explore new biodegradable alternatives can produce innovative solutions that satisfy market requirements and environmental criteria. Implement a thorough monitoring and evaluation system to assess the effectiveness of sustainable packaging strategies over time. By implementing clear metrics and assessment tools, stakeholders may assess the environmental impacts of packaging choices and adjust strategy based on feedback and results. This data-driven approach will promote continuous improvement and accountability in sustainability efforts. Among them are:

Consumer Engagement Venues: Creating platforms for consumer input facilitates active participation of travelers in the transition to sustainable practices. Encouraging travelers to share their experiences and preferences on sustainable packaging can provide valuable insights for businesses and cultivate a community of environmentally conscious consumers. Showcasing Success Stories: Highlighting case studies of successful transitions to sustainable packaging within the tourism sector could serve as a persuasive motivation for other businesses. By demonstrating the advantageous ecological and economic outcomes of adopting sustainable practices, sector leaders can inspire their peers to embrace comparable initiatives.

The transition to sustainable packaging within the tourism industry is an essential solution to the pressing problem of plastic pollution. This research underscores the imperative for immediate action and collaboration among stakeholders to promote a more sustainable future in global tourism. Implementing these solutions mitigates environmental harm and positions the sector as a leader in corporate social responsibility, demonstrating that sustainable practices can promote economic growth while preserving the planet for future generations.

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Changing Travel Behaviors in Central Europe: The Role of Shared Accommodation in V4 Countries

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Abstract: Platform-based tourism services have profoundly transformed accommodation markets across Europe, bringing new patterns of consumer behavior and entrepreneurial activity. This has resulted in a significant transformation of the accommodation business. This study's primary purpose is to evaluate the current state of short-term shared accommodation in the Visegrad Four (V4), as well as its evolution, and to identify the patterns that have emerged over the course of time. The results indicate that the severity and duration of the decline varied among the four countries, despite the fact that all four countries experienced a substantial decline from 2020 to 2021. The Czech Republic and Hungary were the countries that were hit the hardest, while Poland and Slovakia had declines that were considerably less severe. Poland and Hungary experienced the most robust post-pandemic recovery, surpassing their pre-pandemic volume levels by 2022 to 2023. On the other hand, the Czech market recovered at a slower pace, and Slovakia, despite being the smallest in terms of scale, maintained consistent growth nonetheless. These results provide the tourism industry's policymakers and stakeholders with valuable insights, emphasizing the significance of adaptive strategies for platform-based accommodation. In addition, the findings enhance comprehension of consumer behavior changes and market resilience in the V4 region, underscoring the necessity of regional comparative methodologies in future research.

Introduction

The fast industrialization and urbanization have enabled the excessive resource usage. Effective resource usage has turned into a societal “hot issue”. A new business model, sharing economy business model is developing now to completely and effectively utilize. The sharing economy is a relatively recent phenomena that is being investigated to encourage environmentally responsible behaviors. Consumers are able to make better use of resources because of the synergy that exists between technology, information, and marketing. This synergy is considered as the promotion of a new culture in which consumers prioritize access above ownership. As a result, it is an example of a forward-thinking company strategy that has the potential to serve as a route towards green economic growth and increased energy efficiency. Platforms for collaborative consumption are now supporting operations in the corporate world. To be more specific, the sharing economy stimulates social and economic activity while simultaneously lowering the effect on the environment via the conservation of resources. The sharing economy has the potential to help fulfill sustainable development objectives and pillars in terms of social, economic, and environmental factors (Cui et al., 2022). However, the sharing economy does not prioritize environmental interests such as clean water, clean energy, and climate stability,

but creates synergy with economic and social interests (Dabija et al., 2023). Due to current global trends, there is much discourse on the sustainable development of EU areas (Vatamanescu et al., 2019). Environmental sustainability's major goal is the lowering of environmental effect, which is achieved by the avoidance of pollution and the efficient use of natural resources and materials (Odiachi et al., 2023).

An extensive amount of research has been conducted to investigate the effects that the sharing economy has had on conventional companies from the point of view of both consumers and enterprises. Shared accommodation is the practice of individuals (hosts) renting out excess occupied space they own to other individuals (guests) who are seeking short-term accommodation through an intermediary (online accommodation-sharing platform). Accommodation-sharing platforms are one of the most significant domains within the sharing economy and are gaining popularity among consumers in the tourism and travel markets (Lee, 2020; Zuo et al., 2022).

The sharing economy has lately garnered a significant amount of attention because it has the potential to disrupt a variety of businesses (Akbari et al., 2022). Sharing services and distributing low-cost commodities have resulted in the development of novel and unorthodox business models in industries that were previously considered to be traditional. The new phenomena of the sharing economy has not only resulted in the creation of new methods for people to make revenue from their surplus capacity of products or services, but it has also altered the nature of service and product accesses and redefined the notion of ownership and employment (Gonzalez-Padron, 2017; Schor, 2016). Those who advocate for the sharing economy highlight the beneficial effects it has on the environment, the economic advantages it offers (such as reduced expenses), and the social benefits it offers (such as more opportunities for social contact).

Motivation to use sharing economy services has been the subject of past research concentrating on either the user or provider. Most of the research, in particular, looked at how service users used sharing economy services (Hossain, 2021; Mont et al., 2021). This study provides more insights and addresses a research gap by examining not only providers and users but also the overall impact and trends of the sharing economy within the shared accommodation industry. This research is important because it provides insights into the use of short-term shared accommodation in the Visegrad Four (V4) countries, but also maps the development of shared accommodation, including during the COVID-19 pandemic. It also reflects the seasonal patterns of short-term shared accommodation utilization.

The paper is divided as follows: The introduction highlights the relevance of the subject, outlines the key requirements for the functioning of the sharing economy and emphasizes the importance of shared accommodation. The theoretical section presents an overview of the importance of sharing accommodation system, especially in connection with today's globalized world. This section also provides an overview of the theoretical foundations of the sharing economy, the fundamental principles that govern its operation, and emphasizes the significance of considering shared short-term accommodations as an alternative to conventional lodging providers. The main objective of the study, the compiled methodological steps, and analyzed data are described in the sections aim, methodology, and data. The investigation's findings are detailed in the results and discussion section. The discussion section compares the conducted study with other studies that dealt with the topic of sharing accommodation in V4 countries. The conclusion part describes a summary of crucial findings and future challenges and limitations that directly affect the study.

Theoretical part

Digital technologies drive the evolution of business models for firms via digitisation, digitalization, and digital transformation (Nagy et al., 2022). According to Belas (2023), small and medium-sized businesses are very important to the prosperity of economies all over the globe. Moreover, the organization is responsible for the configuration and coordination of the departments of manufacturing, logistics, information technology, marketing, investment, and customer support in order to shut material and energy loops for optimal efficiency. The performance and effectiveness are both important. A increasing awareness of the environmental effect of manufacturing is putting pressure on businesses in both developing and developed nations (Amin et al., 2024). This pressure is being exerted on businesses globally. It is possible for management to guarantee that the financial performance of the corporation continues to improve by focusing on a retrospective review of the current financial condition. This may assist management in gaining knowledge from previous errors (Gajdosikova et al., 2024).The global landscape has undergone substantial changes as a result of the proliferation of information technologies, technological advancements, online communities, and globalization. A contemporary marketplace that connects supply and demand through sharing has emerged within this context, known as the collaborative economy. Services, experiences, knowledge, and information are all included in this system, in addition to material products. The collaborative economy challenges conventional consumption patterns, prompting a reassessment of ownership paradigms, despite its definition (Nagy et al., 2024)

An alternative social and economic movement known as the sharing economy is characterized by the sharing of unused inactive resources with others in order to reduce waste and, in the end, to foster the development of shared interests within society. On the other hand, it represents an economy that is founded on collaborative consumption, in which products or assets are shared with others. This term denotes economic activities that are employed to optimize the utilization of idle resources by distributing commodities, including automobiles, apartments, literature, and toys, to others (Pouri and Hilty, 2021).

Although the online accommodation-sharing market has achieved remarkable success, it is currently experiencing challenges, particularly in the area of consumer engagement. Initially, the development of shared accommodation is significantly impeded by the issue of trust. In addition to confronting the same economic risks as the traditional hotel market, consumers who live with acquaintances or share space also face safety hazards (Jung et al., 2021). Additionally, perceived purchase risk can negatively influence online purchasing behavior (purchase intention). Guests' distrust of hostesses is also exacerbated by negative reports regarding shared accommodation and information asymmetries. In addition, it is becoming increasingly important for online accommodation-sharing platforms to enhance their performance and entice a greater number of room reservations, as they face competition from traditional hotels and a lack of traditional consumer acceptability (Kuhzady et al., 2022). Threats to the sharing economy arise from both internal and external environments. Among external variables belong the COVID-19 pandemic. As a result of production restrictions, the outcome of managing the majority of business entities and their added value was automatically compromised. Frequently, firms were driven to cut spending and personnel levels as a consequence of lack financial resources (Valaskova et al., 2023). Additionally, the market information is subject to significant uncertainty and changes rapidly in the context of regular COVID-19 prevention and control (Meyer et al., 2022). The COVID-19 epidemic has had a detrimental impact on suppliers (hosts) and accommodation-sharing platforms (Petruzzi and Marques, 2024). Consequently, hosts

should optimize the information they present on online platforms to attract guest bookings and increase revenue.

The sustainable operation of shared accommodation is contingent upon the significant motivation for landlords to utilize online accommodation-sharing platforms, which is to encourage consumers to reserve rooms through their online presence. In shared accommodation scenarios, consumers are only able to form initial judgments about a room based on visual impressions when they travel extended distances to the lodging location. Additionally, they can only gain a genuine experience of the accommodation service by staying in person for an extended period (Kreeger et al., 2025). The psychological distance that is created by the inability of consumers to see and touch the goods up close can weaken the psychological basis of cognition, emotion, and volition in traditional consumption patterns, and can affect consumers' purchase decisions to some extent, as suggested by the online shopping literature (Tussyadiah, 2016). Existing research indicates that in an environment characterized by high risk and uncertainty, a lack of trust will result in the failure of both parties' transactions (Han et al., 2024).

The scholarly community has been increasingly interested in the topic of consumer behavior in the context of accommodation markets in Central and Eastern Europe, particularly within the Visegrad Four (V4) countries. Skalova and Stavkova (2012) investigated the impact of economic conditions on household consumption behavior in the V4 region during the global financial crisis. They identified significant changes in consumer expenditure and preferences that indirectly influenced demand in tourism-related sectors. Petricek et al. (2020) conducted a more detailed analysis of accommodation services, examining consumer sensitivity and price elasticity in the Prague accommodation market. Their results suggested that pricing dynamics substantially influence consumer booking behavior in short-term rentals, emphasizing the importance of economic rationality in shared accommodation decisions. Piekut (2024) investigated the housing conditions of one-person households in Europe, including the V4, from a broader housing perspective. His findings indicate that attitudes toward alternative forms of accommodation, such as short-term rentals conducted through platforms such as Airbnb, can be influenced by economic constraints and unmet housing needs. Collectively, these studies confirm that the V4 region demonstrates unique behavioral patterns that are influenced by socio-economic conditions. Additionally, they offer a valuable comparative framework for examining the rise of platform-based accommodation services. The study by Pera et al. (2023) highlight that across Europe, post-COVID consumer behavior in the home-sharing sector has shifted toward greater sensitivity to hygiene, cancellation flexibility, and host reputation, reshaping the digital trust landscape. Similarly, recent literature on the evolution of sharing economy business models in Slovakia (Tokarcikova and Malichova, 2024) underscores how consumers increasingly weigh not only price but also sustainability and local impact, particularly in the wake of the pandemic. Collectively, these studies illustrate that while digital platforms such as Airbnb have become embedded in consumer routines, the factors influencing platform-based accommodation decisions in Central Europe remain deeply embedded in local economic, cultural, and regulatory contexts.

Aim, methodology, and data

Because digital platforms are increasingly acting as intermediaries in the provision of services in the tourism industry, the provision of accommodations has experienced a significant upheaval. A particularly dynamic and rapidly developing section of the collaborative economy is the peer-to-peer (P2P) short-term rental market. This market poses a challenge to the

conventional hospitality arrangements that have been in place for a long time and introduces new forms of contact between consumers and producers. This study investigates the dynamics of peer-to-peer (P2P) accommodation in the Visegrad Four (V4) countries—Slovakia, Czech Republic, Poland, and Hungary—from 2018 to 2023, with a specific focus on the effects of the COVID-19 pandemic. The V4 region is a pertinent and cohesive unit of analysis because of its shared institutional frameworks, comparable economic structures, EU membership, and similar trajectories in the development of platform-based services. However, the collaborative accommodation sector in this region of Central Europe continues to receive inadequate scholarly attention, rendering it an appealing subject for applied research in digital economies and tourism. The study's primary purpose is to evaluate the current state of short-term shared accommodation in the V4 region, as well as its evolution, and to identify the patterns that have emerged over the course of time.

The analysis is conducted using publicly available monthly data from Eurostat's "Short-stay accommodation offered via online collaborative economy platforms" section (Eurostat, 2024). The dataset is the outcome of a collaboration between Eurostat and prominent private platforms, including Airbnb and Booking.com, and it offers harmonized statistical estimates for each EU Member State. The total number of nights spent in short-term rental accommodation booked through online collaborative platforms is the indicator utilized.

The study examines the impact of the COVID-19 pandemic over a continuous six-year timeline, divided into three distinct phases: the pre-pandemic period (2018–2019), representing stable growth conditions; the pandemic period (2020–2021), characterized by extensive lockdowns, border closures, and significant fluctuations in tourism; and the post-pandemic period (2022–2023), during which tourism gradually resumed as travel restrictions were lifted. This temporal framework facilitates an analysis of the immediate shock, subsequent recovery, and potential structural changes within the collaborative accommodation sector over time.

To guarantee comparability and comprehensiveness of the analysis, the following methodological procedures were implemented. In order to structure the data, monthly observations for each nation were arranged in chronological order and grouped according to the COVID-19 time period. The methodological steps can be summarized as follows:

1. Data Cleaning: The dataset was examined in order to get rid of any possible discrepancies, make certain that it is comprehensive across all nations and time periods, and get period classifications to be consistent with one another.
2. Analysis of trends in the number of nights spent was performed in order to discover general patterns and seasonal variations.
3. Comparative Analysis: In order to investigate the unique effects that the pandemic has had on various countries within the V4 area, both cross-country and intra-country comparisons were carried out. A particular focus was placed on determining whether or not there were any disparities in the rate of recovery and the extent of the fall.
4. Visualization: In order to help explain essential trends and offer factual footing for interpretation, time series graphs and comparison plots were used.
5. Considering tourist rules, health-related limitations, and regional disparities in platform penetration and consumer behavior, the observed patterns were evaluated in the context of the aforementioned factors.

This method helps explain how the peer-to-peer accommodation market changed throughout a worldwide crisis. The study provides a solid empirical basis for measuring the resilience and susceptibility of the V4 collaborative accommodation market by combining consistent cross-

country data with a contextual interpretation of the pandemic's impact. The findings contribute to platform-based tourism research and provide policymakers, tourism authorities, and digital platform operators with practical advice on how to make accommodation more sustainable and adaptive.

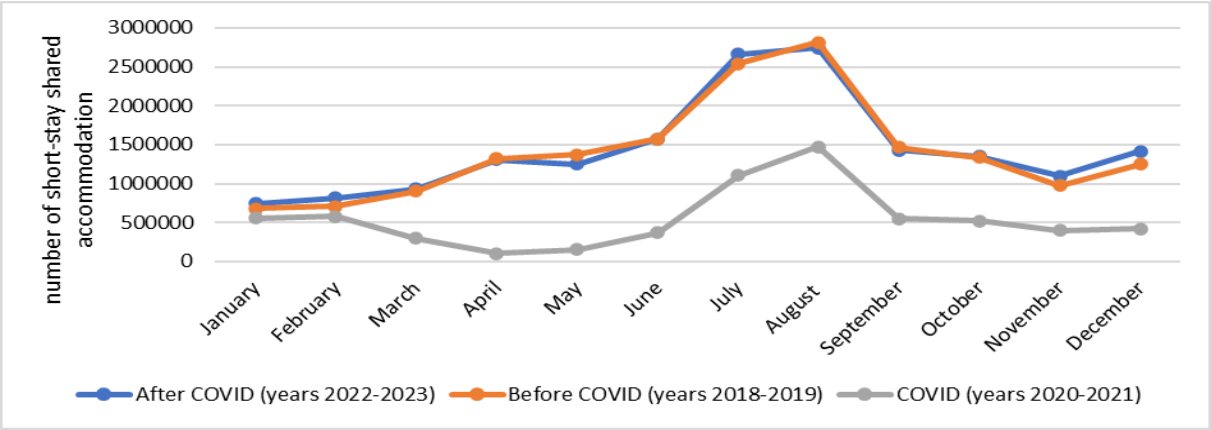
Results and discussion

In the tourism and hospitality sector, peer-to-peer accommodation has emerged as one of the most prominent and rapidly expanding segments of the collaborative economy. Traditional lodging models have been transformed by platforms like Airbnb and Booking.com, which have allowed individuals to provide short-term accommodations to a diverse range of travelers. This form of accommodation is still susceptible to external disturbances, as evidenced by the COVID-19 pandemic, despite its increasing popularity. The subsequent analysis concentrates on the trends in the Visegrad Four (V4) countries between 2018 and 2023 in order to comprehend the dynamics of shared accommodation in the context of such disruption. The demand for platform-based accommodation was the primary focus of the study, with a particular emphasis on the evolution of this demand before, during, and after the pandemic. The study also addressed the different recovery trajectories and national distinctions.

The results are presented by country and subsequently contrasted regionally to emphasize the similarities and differences in the sector's response to the crisis. In order to facilitate a more comprehensive comprehension of both short-term effects and emergent long-term patterns, the findings are interpreted in the context of existing research on the collaborative economy and tourism in Central Europe, whenever feasible.

Figure 1. The short-term shared accommodation sector in Hungary had significant variations between the years 2018 and 2023, as observed in Figure 1, which illustrates the trajectory in the country. A robust demand and consistent expansion were shown in the fact that the number of nights spent had surpassed 20 million prior to the pandemic. The impact of COVID-19, on the other hand, was dramatic and quick, resulting in a reduction to only 10 million nights for the period of 2020–2021. A time of lockdowns, travel restrictions, and uncertainty coincides with this fall in the population. The accommodation saw a significant recovery during the subsequent two years, going on to surpass the levels that existed prior to the pandemic by reaching approximately 23 million nights in 2022–2023. Particularly with regard to domestic tourism, such a rebound indicates a change in the behavior of travelers as well as a revived faith in platform-based accommodation services. The seasonal pattern in Hungary was consistent, with the highest activity occurring in July, August, and May, and the lowest levels of platform use occurring in January and March. This indicates a significant reliance on summer travelers and emphasizes the platform's vulnerability to seasonal fluctuations.

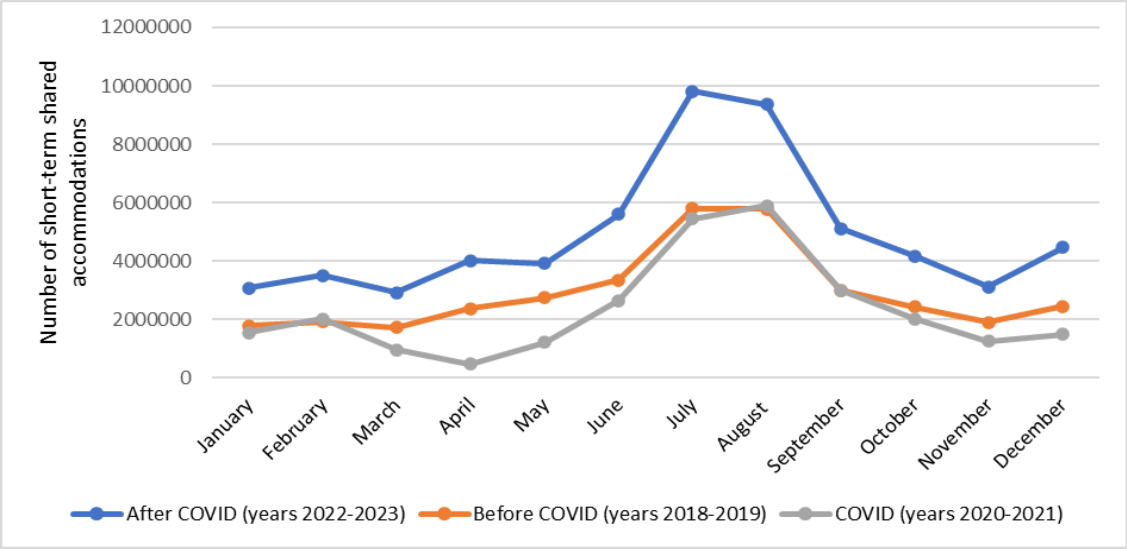
Figure 1: Number of short-term shared accommodations in Hungary



Source: Own processing according to Eurostat (2024)

Figure 2 shows that throughout the time period under consideration, the nation of Poland spent more nights than any other in the V4 zone. A more robust market, probably bolstered by robust internal demand, would explain the little drop, from approximately 70 million to around 56 million nights during the pandemic. This country had the greatest increase of the four after the pandemic, with statistics from 2022 and 2023 showing a dramatic spike to approximately 100 million nights. The broad tourism offers, vast population, and balanced mix of local and international travelers using collaborative platforms may be the reasons behind Poland's successful rebound. The demand distribution in Poland was more consistent throughout the year. Although July and August were the most active months, with August surpassing 10 million nights, other months, such as May and October, also exhibited significantly high usage. This suggests a more diverse and resilient demand framework, which is likely to be supported by a significant number of domestic passengers.

Figure 2: Number of short-term shared accommodations in Poland

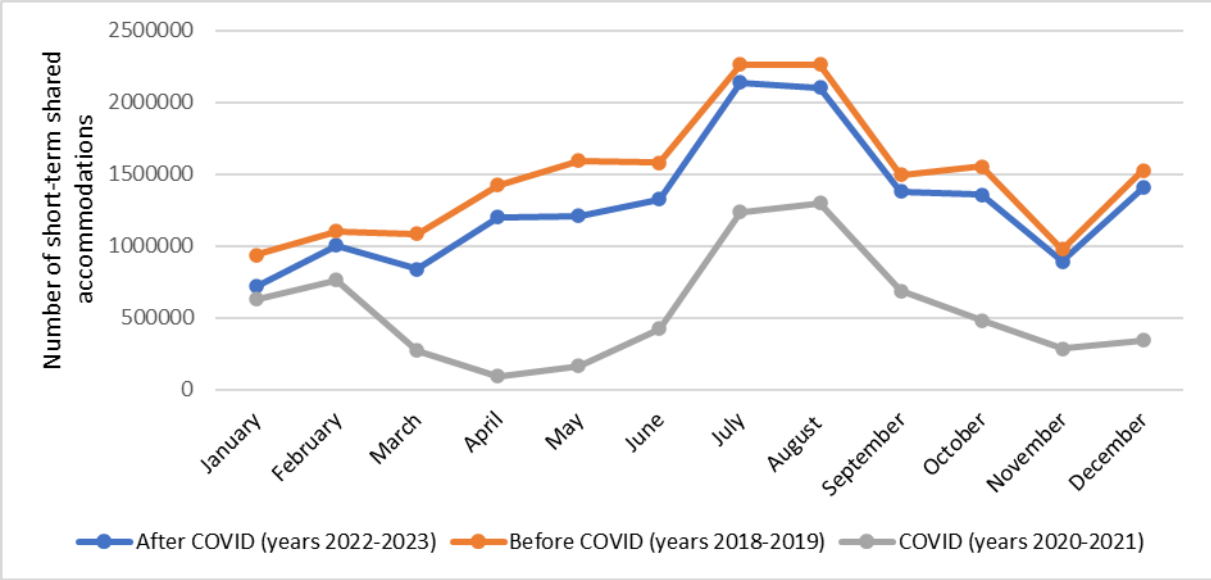


Source: Own processing according to Eurostat (2024)

The pandemic resulted in a significant decrease in activity in the Czech Republic (Figure 3). The utilization of shared accommodation decreased by over 50% from approximately 20

million nights in the pre-pandemic period to around 9 million nights in 2020–2021. The market has not yet returned to its previous levels, despite a partial recovery to about 18 million nights in 2022–2023. This delayed rebound may be indicative of Prague's substantial dependence on international tourism and the time necessary for these flows to recover. The pattern implies that platform-based accommodation is subject to increased volatility in markets dominated by foreign visitors, despite the fact that interest in it persists. The Czech Republic typically experiences the highest demand during the summer months, particularly in July and August, with a particularly significant increase in May. During these months, the average number of nights consistently exceeds 2 million, suggesting a significant summer-oriented travel trend. Conversely, January and March experience the least activity, suggesting the off-peak period in urban tourism.

Figure 3: Number of short-term shared accommodations in Czech Republic

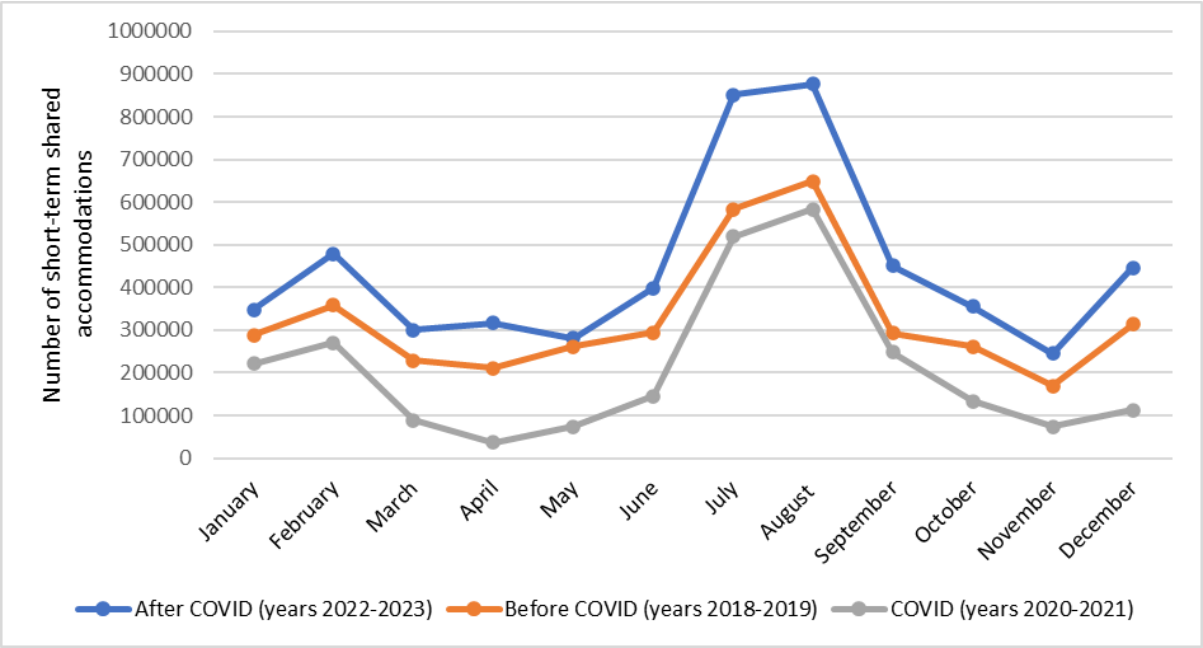


Source: Own processing according to Eurostat (2024)

As seen in Figure 4, Slovakia had the fewest nights spent in short-term shared lodging within the V4 group. Though smaller, the nation reflected the overall regional trend of decline during the epidemic and during recovery. Mobility limits caused the total to fall from 5.3 million nights in 2018 to approximately 3.3 million in 2020–21. Post-pandemic, there was a significant improvement; by 2022–2023, use had risen to around 6.7 million nights.

This upward trend suggests increasing domestic interest in cooperative accommodation platforms, especially in relation to regional travel and wellness tourism, segments that have been strong even during times of uncertainty. Although Slovakia's total volume is low in relation to its neighbors, the steady rise shows its long-term promise in this field.

Figure 4: Number of short-term shared accommodations in Slovakia

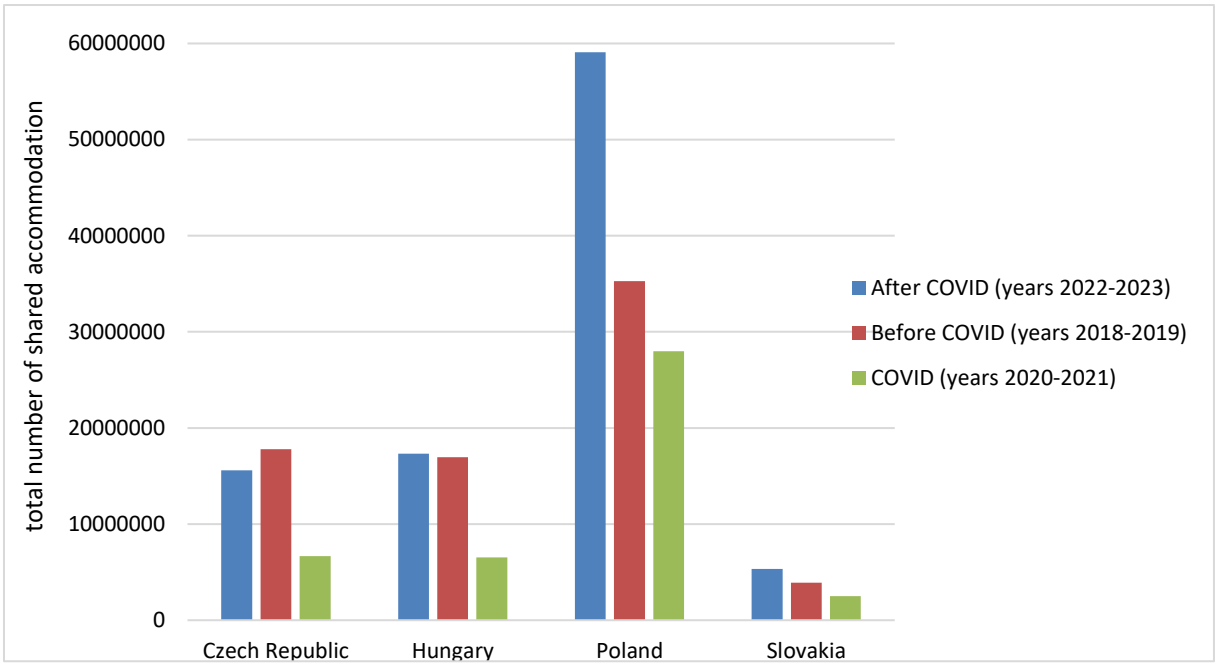


Source: Own processing according to Eurostat (2024)

The national-level results, when considered collectively, demonstrate both significant differences and shared tendencies in the manner in which each V4 country experienced and responded to the disruption caused by the COVID-19 pandemic. Although the number of nights spent in collaborative accommodation decreased significantly in all four countries from 2020 to 2021, the severity of the impact and the rate of recovery were inconsistent. These discrepancies are likely due to structural characteristics, including the scale of the market, the reliance on tourism, the proportion of domestic versus international visitors, and the influence of urban centers on demand. The data also indicate that platform-based accommodation exhibited long-term resilience, notably in countries with a higher level of domestic travel activity and a greater level of familiarity with digital booking tools. The necessity of a comparative perspective is underscored by the diversity of trajectories, which is addressed in the subsequent section.

A comparative overview of the total number of nights spent in short-term shared accommodation across the V4 countries between 2018 and 2023 is provided in Figure 5. The data plainly demonstrate the divergent recovery patterns that followed and the shared regional disruption caused by the COVID-19 pandemic. Poland consistently maintained the highest volume prior to the pandemic, with the Czech Republic, Hungary, and Slovakia following in that order. Despite the fact that the scope and pace of change varied significantly among the countries, this ranking remained constant throughout the observed period.

Figure 5: Total number of short-term shared accommodations in V4 region



Source: Own processing according to Eurostat (2024)

In the course of the pandemic (2020–2021), the number of nights spent decreased in all four countries, although the extent of the decrease differed. Poland and Slovakia experienced more moderate decreases, while the Czech Republic and Hungary experienced the sharpest relative declines—over 60% compared to pre-pandemic levels. These discrepancies are likely indicative of the varying reliance on international tourism, the structure of the accommodation supply, and the size of domestic demand.

In terms of recovery and overall development, Poland was the clear leader in the post-pandemic period (2022–2023). It not only regained but also substantially surpassed its pre-pandemic volume, with nearly 60 million nights recorded. Hungary also experienced a complete recovery, with levels that were marginally higher than the average of 2018–2019. Conversely, the Czech Republic experienced a delayed recovery, with the total number of nights spent remaining below the pre-crisis level. Slovakia, despite being the smallest market in absolute terms, has exhibited consistent growth and surpassed its pre-pandemic total, indicating a growing level of domestic engagement with collaborative platforms.

In general, the figure emphasizes the unequal impact of the pandemic on the V4 shared accommodation markets and emphasizes the significance of national context in determining recovery trajectories. The observed variation in outcomes was likely the result of differences in tourism infrastructure, digital platform penetration, and consumer behavior.

The findings of the research conducted by Dirgova et al. (2018) in Slovakia have demonstrated the existence of a broad variety of business models, some of which are well-known while others are relatively unknown. This substantiates the fact that there is a state of terminological uncertainty concerning the many types of shared consumption. In addition, the findings of our research have demonstrated that there is a possibility for the expansion and improvement of services. According to the findings of the research conducted by Garbarova and Vartiak (2020) in Slovakia, respondents had the highest expertise and knowledge about shared travel and accommodations. Simultaneously, respondents indicated that these two sectors

(accommodation and travel) were the most frequently considered for potential business activities. Currently, the sharing economy has been concentrating its efforts, in particular, on particular industries and particular economic areas. This has significant repercussions for economic "players" as well as for economic theory. In spite of the general popularity and success of well-established social media services and platforms, such as those that are frequently highlighted as prime examples, there is an urgent need to extend our understanding by digging into national or regional settings. Furthermore, in order to arrive at findings that are relevant, it is necessary to collect and analyze data that is both credible and complete. The discovery of new developing business models within the sharing economy and the utilization of the benefits that these models offer can be accomplished through this method.

Presently, the sharing economy is a topic that is constantly brought up in conversation. For a variety of reasons, including travel, lodging, and financial concerns, individuals are looking for options that will make their lives simpler. As a result of the continued expansion of the sharing economy, an increasing number of businesses that offer goods and services are becoming involved. The number of individuals who are developing an interest in this novel form is likewise growing. As a result of the increased motive to lend, the ownership structure shifts to co-ownership, the transaction costs are decreased, individuals acquire greater income, and they learn to live in a more environmentally responsible manner. The beneficial qualities of the shared economy should not only lead to its inclusion among full-fledged forms of economy, but they should also lead to its inclusion. Nonetheless, this will not be feasible until there are modifications made to the regulations that are in place at the state level. This will ensure that the shared economy does not become an adversary to established providers but rather operates as a viable alternative (Gogolova et al., 2022). In recent years, the significance of short-term rental platforms such as Airbnb. Initially, the sharing economy business model, which is based on modern technologies and digital platforms, presented new opportunities and challenges that primarily affected large cities. However, these challenges are now also evident in medium and small communities. Reliable data is needed to verify and quantify the impact of short-term rental services such as Airbnb. The study by Peterka et al. (2021) includes a quantification of Airbnb presence in V4 countries as well as an analysis. In 2019, guests in V4 nations spent 1.202 billion euros on local accommodations and services. In 2019, there were 104,400 Airbnb listings in Poland, Czechia, Hungary, and Slovakia. There were 50,100 ads in Poland, 26,200 in Czechia, 21,800 in Hungary, and 6,300 in Slovakia. This document provides a formula per 1000 inhabitants to adjust individual values for different population levels in V4 countries. In 2019, Czechia had the largest number of listings (2.46 per 1000 residents). Hungary has the second highest value, with 2.23 listings per 1 000 residents. Poland had 1,32 listings per 1,000 people, whereas Slovakia had 1,16 listings. Airbnb listings account for a varying percentage of total housing stock in V4 cities, ranging from 0.81% in Warsaw to 2.23% in Prague.

The offer of accommodation via Airbnb platform in Prague is extensive, and compatible with the capacity of Prague hotels. The average occupancy rate in Prague is highly above the values of 14 largest European cities, and is even higher than in Amsterdam (39.42%), that indicates that Prague accommodation market is quite lucrative for Airbnb platform (Kljucnikov et al. 2018). The impact of short-term rental platforms is complex, reflecting the diverse subjects involved. Airbnb and other sharing economy platforms have a favorable impact on the economy, labor markets, living standards, and society as a whole. However, it's important to address the issues and concerns associated with regulatory and urban regions.

The findings from the study Kolesarova et al. (2024) highlight the importance of positive and negative reviews in influencing guest satisfaction and loyalty. A significant factor in the

reservation of accommodations is customer evaluations. The visitor is motivated to compose a review by either extreme satisfaction or absolute dissatisfaction. Consequently, it is imperative that the accommodation facility does not disregard their customers' evaluations of their services. The peer-to-peer (P2P) sector, particularly platforms such as Airbnb, was not immune to the disruptions caused by the COVID-19 pandemic, which affected all segments of the accommodation industry. The sector experienced a significant contraction in the Visegrad region (Czech Republic, Slovakia, Poland, and Hungary) as a result of travel restrictions, lockdowns, and changes in consumer behavior. Although the four countries exhibit varying levels of scholarly coverage regarding these impacts, the available evidence indicates that the shared accommodation market is characterized by regional patterns of vulnerability, adaptation, and structural transformation. Fialova and Vasenska (2020) conducted one of the few national studies that specifically concentrated on Airbnb during the pandemic in the Czech Republic. In comparison to the anticipated pre-pandemic levels, their quantitative analysis revealed a 28.2% decrease in occupancy rates in Prague's listings in 2020. The study emphasized that Airbnb hosts who were most reliant on inbound international tourism were disproportionately affected, while properties situated in suburban or rural areas exhibited relatively greater resilience as a result of the increased interest in lower-density destinations.

Our own analysis based on Eurostat data confirms a similar pattern: during the pandemic period (2020–2021), Czechia experienced a sharp decline in total nights spent in shared accommodation, with a drop of over 60% compared to the pre-pandemic years. This is consistent with the observed trend in Prague and reflects broader national-level contraction. Sebova et al. (2021) examined the leisure tourism sector in Slovakia, which accounts for a significant portion of domestic overnight stays, in order to gain insight into the broader accommodation market. The authors predicted visitor numbers for 2020–2021 and contrasted them to the actual figures using time series modeling. Their findings indicated a substantial deviation from the trend due to the pandemic, which was indicative of a more general decline in consumer confidence and mobility. The study's implications are transferable, particularly in regions where wellness tourism intersects with short-term rental offerings, despite the fact that it does not explicitly address P2P platforms.

According to our data, Slovakia also experienced a pandemic-related drop of more than 35%, which is in line with the general conclusions of Sebova et al. (2021) While not as steep as in Czechia or Hungary, the decline was nonetheless significant and visible across all months and years. The scope of scholarly literature that addresses shared accommodation during the pandemic in Poland is relatively limited. Nevertheless, Nemec et al. (2023) conducted comparative research to investigate the institutional responses to crisis management in the Czech Republic, Slovakia, and Poland. Although their research did not specifically address accommodation, it indicates that micro-entrepreneurs and informal providers—including numerous Airbnb hosts—frequently operated outside of formal aid mechanisms. This may have exacerbated the volatility of the P2P accommodation segment, particularly in cities with a high concentration of listings. Interestingly, the decline in Poland's shared accommodation market during the pandemic was much more moderate (approximately −20%), suggesting either stronger domestic demand or greater structural resilience. This aligns with the assumption that Poland's tourism sector may have been less dependent on international visitors.

Although databases did not identify a country-specific empirical study exclusively dedicated to shared accommodation under COVID-19 conditions in Hungary, regional analyses provide pertinent insights. In a study of Airbnb that was conducted across Europe, Hossain (2021) incorporated data from Budapest, where hosts exhibited a high rate of delisting or transitioning

to long-term rental models. According to his survival analysis, listings in urban centers that are highly touristic in Central and Eastern Europe, including Budapest, were among the most severely affected. Moreover, Sigala (2020) observed that flexible, decentralized platforms were the most severely affected during the initial shock, but they also had the potential for agile adaptation, as evidenced by the transition to domestic tourism and health-conscious travel in countries such as Hungary.

Our empirical results reinforce these conclusions, with Hungary showing a drop of over 60% during the pandemic years and an exceptionally strong post-pandemic rebound of more than 165%. This indicates not only initial vulnerability but also significant adaptive capacity in the later stages of recovery. Collectively, these results indicate that the COVID-19 pandemic exposed structural vulnerabilities that are common to shared accommodation markets, including spatial concentration in high-density urban zones, reliance on international travel, and a lack of formal policy integration, despite the fact that the depth of academic inquiry varies across the V4 countries. In the future, these insights underscore the significance of aligning platform-based accommodation with more resilient and sustainable tourism models, increasing risk preparedness, and diversifying host strategies.

Conclusions

The analysis provides a structured perspective on the shared accommodation industry in the Visegrad Four region, so broadening the academic conversation on platform-based tourism outside the contexts that are often addressed in Western Europe. The research sheds light on the dynamic relationship that exists between external shocks and the structural characteristics of the collaborative economy by bringing together advancements that occurred during different periods of the COVID-19. Specifically, the findings highlight the significance of institutional context in determining recovery trajectories and provide support for theoretical assumptions regarding the susceptibility of decentralized markets to global crises. The findings may help tourism agencies, local governments, and platform operators understand Central Europe's shared accommodation sector's recovery and potential. Understanding demand changes can help stakeholders plan for interruptions, alter tourism plans, and create targeted support. Understanding V4 nation distinctions can also help coordinate tourism and innovation policies, especially during crises or transitions. The examination of monthly data, alongside yearly trends, uncovers distinct seasonal patterns in short-term shared housing within the V4 nations. The seasonal dynamics are essential for understanding consumer behavior, platform use, and the robustness of local tourist markets year-round. In Czech Republic, the most significant demand was typically seen throughout the summer months, especially in July and August, with the sharp increase in May. In contrast, January and March saw the least activity, indicating the off-peak period in urban tourism. Hungary had a same seasonal pattern, with heightened activity in July, August, and May, whilst January and March recorded the lowest levels of platform use. This signifies a substantial dependence on summer tourists and underscores the platform's susceptibility to seasonal variations. The demand distribution in Poland was more uniform over the year. While July and August were the most active months, with August reaching over 1.6 million nights, other months including May and October also shown very high use. This indicates a more varied and robust demand framework, presumably bolstered by a substantial cohort of domestic passengers. Slovakia, albeit the smallest market, had a steady seasonal pattern. August had the largest number of nights, followed by July and February. February appeared as a modest high, maybe associated with domestic wellness and winter travel. The months of April, March, and November had the lowest performance, consistent with the overarching regional trend of less travel during transitional seasons.

Nevertheless, it is essential to emphasize the fact that the dataset has a number of restrictions. The data do not differentiate between domestic and international visitors, nor do they include information on the purpose of travel or the types of guests who are there. Furthermore, the numbers only cover accommodations that were booked through large online platforms. This means that alternative types of short-term stays, such as informal arrangements or bookings made through smaller providers, are not included in the statistics. The dataset continues to be one of the most credible and comparable sources for analyzing the growth of platform-based accommodation services across European countries.

Although the study is based on monthly data collected at the country level, it does not allow for analysis to be conducted at the level of individual cities or types of accommodations. However, it does provide an overview of trends in the category of shared accommodations. As a consequence of this, it was not possible to investigate geographical disparities, differences between urban and rural areas, or platform-specific dynamics (for example, Airbnb vs. Booking.com). In addition, because the study is descriptive in nature, it does not take into account the causative mechanisms that are responsible for the changes that have been seen. These factors include government initiatives, variations in passenger sentiment, and platform policy changes. These limitations point to potential avenues for subsequent research that could integrate qualitative and quantitative methods of investigation.

Future study should concentrate on capturing more precise spatial and behavioral features of the shared accommodation sector. This should be done by building on the constraints that have been discovered. Analyses conducted at the level of cities or tourist regions have the potential to demonstrate how demand and recovery trajectories vary within countries, particularly between capital cities and rural or peripheral areas. In addition, it would be beneficial to incorporate data that reflects the behavior of both hosts and guests, such as pricing strategies, cancellations of bookings, or preferences for particular types of accommodations. The responses of actors within the collaborative economy to crises like as the COVID-19 pandemic should be better understood because of these elements, which could provide greater understanding. The examination of the effects of policy should also be considered an important direction. By gaining an understanding of the ways in which national or local regulations influence the operation and resilience of platform-based accommodations, it may be possible to steer the future governance of the sector, particularly with regard to striking a balance between innovation, social fairness, and sustainability objectives.

Acknowledgements

This research was financially supported by the Slovak Research and Development Agency Grant VEGA 1/0494/24: Metamorphoses and causalities of indebtedness, liquidity and solvency of companies in the context of the global environment.

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Building Organizational Trust in Competitive Environments: Insights from Hungary and Slovakia

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Abstract. Organizational trust is a critical factor influencing employee engagement, job satisfaction, and overall organizational performance. This study aims to compare trust dynamics in Hungarian and Slovak organizations, focusing on the distinction between personal and impersonal trust, their impact on job satisfaction, organizational commitment, and competitiveness, and the role of technostress in shaping trust perceptions. The research investigates how cultural, managerial, and technological factors contribute to trust formation and its implications for leadership strategies. The study employs a quantitative research design using Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the relationships between trust dimensions and organizational outcomes. Data were collected from 2,300 respondents (1,572 in Hungary, 660 in Slovakia) across various industries. The study also incorporates PLS-MGA (multigroup analysis) to identify significant differences between the two countries. The findings reveal that Hungarian organizations rely more on personal trust, whereas Slovak organizations exhibit stronger impersonal trust. Technostress negatively affects organizational commitment, with a stronger impact in Hungary than in Slovakia. Furthermore, personal trust fosters collaboration and innovation in Hungary, while impersonal trust contributes to long-term stability in Slovakia. These insights highlight the need for context-specific trust-building strategies, particularly in the era of digital transformation.

Keywords: organizational trust, impersonal trust, interpersonal trust, leadership, commitment, satisfaction

Introduction

The Importance of Organizational Trust

Organizational trust is a fundamental component of workplace relationships, employee motivation, and business success. It influences job satisfaction, organizational commitment, and the overall effectiveness of leadership and decision-making. Trust plays a particularly significant role in dynamic and knowledge-intensive industries, where collaboration, innovation, and adaptability are key to competitiveness. Organizations with high levels of trust

experience greater cooperation, lower turnover rates, and stronger employee engagement, contributing to their long-term sustainability. Conversely, low levels of trust can lead to conflicts, disengagement, and resistance to change, ultimately affecting organizational performance.

Understanding the mechanisms of trust formation is essential for businesses seeking to enhance workplace relationships and maintain competitiveness in an evolving economic environment. While personal trust (built through direct relationships) has traditionally been a key factor in employee engagement, impersonal trust (rooted in institutional structures and formal processes) is becoming increasingly relevant, especially in large organizations and digitalized work environments. The growing reliance on AI-driven decision-making, automation, and remote workraises important questions about how employees perceive and build trust in modern workplaces.

Research Focus and Originality

This study explores organizational trust in Hungary and Slovakia, comparing how personal and impersonal trust influence employee satisfaction, commitment, and organizational performance. While previous research has examined trust formation in Western and Anglo-Saxon business environments, there is a gap in the literature regarding trust dynamics in Central European organizations. This study aims to fill this gap by providing empirical evidence on how trust functions in two neighboring countries with distinct historical, cultural, and managerial traditions.

A particularly innovative aspect of this research is its examination of technostress and its impact on organizational trust. As workplaces become more digitalized, employees must adapt to new technologies, AI-driven decision-making, and remote work environments. However, technological transformation can disrupt traditional trust-building mechanisms, leading to uncertainty and resistance. This study investigates how technostress influences organizational commitment and trust formation, particularly in the context of Hungary and Slovakia's evolving labor markets.

Structure of the Paper

The paper is structured as follows:

- Theoretical Background – This section reviews existing literature on organizational trust, leadership, and digital transformation, highlighting key theories and prior research findings.
- Aim, Methodology, and Data – The research objectives, data collection methods, and analytical approach (PLS-SEM and PLS-MGA) are explained in detail.
- Results and Discussion – The study's key empirical findings are presented, comparing Hungarian and Slovak organizations in terms of trust dynamics, leadership impact, and the effects of technostress.
- Conclusion – The final section summarizes the findings, discusses managerial implications, and outlines potential directions for future research.

By examining trust formation in Hungary and Slovakia, this study contributes to a deeper understanding of how cultural and organizational differences shape employee perceptions of trust. The findings provide practical insights for businesses, policymakers, and HR professionals, helping them develop trust-enhancing strategies that foster employee engagement, workplace stability, and long-term competitiveness.

Theoretical background

Organizational trust is a fundamental factor influencing the efficiency and performance of organizations. Various elements contribute to its formation, ranging from individual characteristics to organizational and cultural factors. Age, marital status, and workgroup cohesion positively influence organizational trust, whereas gender and ethnicity do not show significant differences in trust levels (Gilbert & Tang, 1998; Khaiat & Tichtich, 2024). Additionally, longer tenure is associated with higher trust levels (Khaiat & Tichtich, 2024).

At the organizational level, perceived organizational support, procedural justice, and effective communication are essential in strengthening trust, also affecting organizational citizenship behavior (Singh & Srivastava, 2016). Leadership plays a crucial role, as effective leaders act as facilitators and mediators of trust, which is closely linked to their competence, integrity, fairness, and openness (Li et al., 2012; Clark & Payne, 2006). Furthermore, cultural and social norms, such as collectivism and individualism, shape trust formation. In collectivist cultures, trust tends to be built within close social ties, while in individualistic cultures, it extends beyond direct relationships (Gordeyeva & Sharypova, 2022). The early stages of organizational relationships are particularly critical for trust development, as cognitive processes and initial interactions lay the foundation for high trust levels (McKnight et al., 1998).

Trust is a key determinant of organizational success, as it impacts collaboration, innovation, and financial performance. Hungarian organizations, particularly in the Information and Communication Technology (ICT) sector, rely on trust-building strategies to strengthen business relationships and enhance performance. Inter-organizational trust fosters innovation in Hungarian ICT firms, facilitating collaboration and financial performance. Innovation acts as a mediator between trust and financial success, emphasizing trust as a critical factor in adaptability and growth (Oláh et al., 2021).

Trust levels also vary based on organizational size: institutional trust is stronger in firms where formal institutions provide fair public services, while interpersonal trust remains similar across micro, small, and medium-sized enterprises. High trust in business partners is crucial for effective collaboration and long-term relationships (Oláh et al., 2021). In international business contexts, trust is a key factor in successful negotiations and partnerships. Hungarian negotiators face challenges in trust-building due to cultural differences, communication styles, and stereotypes, making culturally adaptive trust strategies essential (Szőke, 2020).

In the governance of Hungarian public interest foundation universities, trust plays a significant role in leadership. Board members' perception of trust influences their management approach, with higher trust levels leading to more empowerment and partnership-oriented leadership (Kováts et al., 2023). Trust-building is also critical in the context of AI development and technological advancements. In Hungary, cross-industrial collaborations depend on trust and shared responsibility to reduce social uncertainty and enhance the acceptance of AI technologies, supporting the development of reliable AI systems (Fehér & Veres, 2022).

In Slovakia, leadership significantly impacts organizational trust, particularly in small and medium-sized enterprises (SMEs). Effective leadership styles and communication

strategies are crucial in building trust and improving organizational performance. Assertive communication and a two-way flow of information play a key role in strengthening employee trust and commitment, enhancing motivation and job satisfaction. Conversely, hierarchical communication gaps and ineffective leadership can lead to dissatisfaction and inefficiency (Kuczman et al., 2024).

Inclusive leadership is positively associated with organizational trust, whereas autocratic leadership tends to have a negative impact. Higher trust levels contribute to job satisfaction and organizational commitment (Oh et al., 2023). Transformational leadership is particularly effective in fostering trust, openness to change, and employee engagement, which is crucial during organizational transitions (Hamza et al., 2022; Yue et al., 2019). Authentic and transparent leadership further enhances employee trust, creating a supportive and engaging organizational environment (Jiang & Luo, 2018).

Trust also acts as a mediating factor between leadership styles and organizational outcomes, such as performance and employee adaptability to change. Specifically, transformational and ethical leadership styles have proven to be highly effective in building trust (Legood et al., 2020; Hamza et al., 2022).

Organizational trust in Hungary and Slovakia is shaped by cultural values, organizational structures, leadership styles, and perceived institutional support. Hungarian firms operating within ethnic minority cultures, such as Slovak or Romanian organizations, tend to reflect their mother culture's trust-related values, which influence organizational trust and behavior (Bencsik et al., 2022). Hofstede's cultural dimensions also play a fundamental role in shaping trust levels in organizations (Bencsik et al., 2022).

Additionally, organizational structure and resource allocation affect trust levels: horizontal structures and equal distribution of resources foster greater trust and reliability (Pang et al., 2025). Transformational leadership enhances organizational trust, influencing employees' reactions to change and organizational commitment (Hamza et al., 2022). However, leadership and job characteristics play a crucial role in managing workplace alienation and commitment, with trust's impact in Hungary being less clear (Banai et al., 2004).

Perceived organizational support strengthens organizational citizenship behavior, mediated by employee engagement and affective commitment, which are essential for trust-building (Alshaabani et al., 2021). Impersonal trust, rather than interpersonal trust, has a significant effect on job satisfaction, organizational commitment, and competitiveness in both Hungarian and Slovak organizations (Michalec et al., 2024). Finally, trust in management and union member commitment are key determinants of union effectiveness, which in turn influences organizational trust in Hungary (Frege, 2002).

Aim, methodoly and data

The primary aim of this research is to compare organizational trust in Hungarian and Slovak organizations, focusing on the distinction between personal and impersonal trust and their impact on organizational commitment, job satisfaction, and competitiveness. The study investigates how trust operates within different organizational structures and leadership styles, examining the role of cultural, managerial, and technological factors in shaping trust levels. Additionally, the research explores the effects of technostress on organizational trust and employee engagement, highlighting how digital transformation influences trust dynamics in knowledge-intensive organizations.

This study employs a quantitative research design using Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the relationships between trust dimensions and organizational factors. The methodology includes:

- Survey Instrument: A structured questionnaire measuring personal and impersonal trust, job satisfaction, organizational commitment, perceived fairness, and leadership effectiveness. The instrument was adapted from validated trust scales used in previous research (Vanhala, 2011).
- Sample: The study collected data from 2,300 respondents (1,572 in Hungary, 660 in Slovakia) across organizations of various sizes, with a particular focus on knowledge-intensive industries.
- Data Analysis: The research applied PLS-SEM for structural equation modeling and PLS-MGA (multigroup analysis) to identify significant differences between the Hungarian and Slovak samples.

Result and discussion

The empirical findings highlight key differences in organizational trust between Hungary and Slovakia, particularly in the roles of personal and impersonal trust, their impact on job satisfaction and organizational commitment, and the influence of technostress. Table 1 presents the effect sizes (β), significance levels (p-values), and explanatory power (R^2) for the examined relationships.

Table 1: Trust Dynamics in Hungarian and Slovak Organizations

Trust Factors	Effect Size HU (β)	Effect Size SK (β)	Significance HU (p)	Significance SK (p)
Personal trust → Job satisfaction	0.361	0.293	<0.05	<0.05
Personal trust → Job satisfaction → Competitiveness	0.143	0.124	<0.05	<0.05
Personal trust → Org. commitment → Competitiveness		0.065		<0.05
Impersonal trust → Job satisfaction		0.49		<0.05
Impersonal trust → Job satisfaction → Competitiveness		0.173		<0.05
Impersonal trust → Org. commitment → Competitiveness		0.039		<0.05
Technostress → Org. commitment	-0.154	-0.099	<0.05	>0.05
Technostress → Job satisfaction		0.062		>0.05
Technostress → Job satisfaction → Competitiveness		0.024		>0.05
Technostress → Org. commitment → Competitiveness		0.017		>0.05

Source: self-edited table

The data reveals that personal trust has a stronger influence on job satisfaction and engagement in Hungary, while impersonal trust plays a more prominent role in Slovakia, particularly in organizations with established institutional structures. Additionally, technostress negatively affects organizational commitment, with a more significant impact observed in Hungary.

Trust Levels and Leadership Influence

Hungarian organizations rely more on personal trust, with employees placing greater emphasis on direct relationships with managers and colleagues.

Slovak organizations show stronger reliance on impersonal trust, particularly in workplaces with well-established institutional frameworks and procedural fairness.

Trust and Organizational Commitment

Personal trust had a stronger impact on job satisfaction and commitment in Hungary, whereas impersonal trust was a more significant predictor of organizational commitment in Slovakia.

Slovak respondents reported higher satisfaction with procedural fairness and institutional trust, while Hungarian respondents emphasized direct managerial trust as a key factor in engagement.

Impact of Technostress on Trust and Competitiveness

Technostress had a significantly negative effect on organizational commitment in Hungary, whereas its impact in Slovakia was weaker.

Slovak organizations, particularly those with structured AI-based decision-making processes, demonstrated greater acceptance of digital transformation, leading to higher impersonal trust.

Trust and Organizational Performance

Higher personal trust levels contributed more to collaboration and innovation in Hungarian firms, whereas impersonal trust played a stronger role in long-term stability and competitiveness in Slovak firms.

The model's explanatory power for competitiveness ($R^2 = 0.22$) suggests that trust is important but not the sole determinant of competitiveness.

The findings of this study highlight significant differences in organizational trust between Hungary and Slovakia, particularly in the role of personal and impersonal trust, their influence on job satisfaction and commitment, and the impact of technostress. These results align with previous research while also offering new insights into the mechanisms of trust formation in Central European organizations.

The study confirms previous findings that personal trust is more significant in Hungary, whereas impersonal trust plays a larger role in Slovakia. This aligns with Hofstede's cultural dimensions theory, which suggests that Hungary's relatively higher level of individualism fosters trust through interpersonal relationships, while Slovakia's structured institutional environment supports the development of impersonal trust. The results also complement Bencsik et al.'s (2022) argument that organizations reflecting minority cultures incorporate trust values from their motherland, as observed in Hungarian organizations operating within minority communities.

The findings reinforce the argument that leadership styles significantly influence trust-building (Li et al., 2012; Clark & Payne, 2006). The results indicate that transformational leadership is positively correlated with trust levels, supporting the claim that visionary leadership fosters openness to change and strengthens employee engagement (Hamza et al., 2022). However, the study also suggests that autocratic leadership negatively affects trust, consistent with Oh et al.'s (2023) findings. Hungarian organizations appear to benefit more from direct managerial engagement, while Slovak organizations rely on institutional frameworks and procedural justice to maintain trust.

The strong link between trust and organizational commitment observed in this study aligns with Singh & Srivastava's (2016) research, which emphasizes the role of perceived organizational support and procedural justice in shaping commitment. In Hungary, personal trust was a stronger predictor of commitment, whereas in Slovakia, institutional trust played a larger role. This supports the notion that trust-building strategies must align with cultural expectations (Gordeyeva & Sharypova, 2022).

The study found that technostress negatively affects organizational commitment, with a greater impact in Hungary than in Slovakia. This is consistent with previous research indicating that workplace digitalization can undermine trust when employees struggle with rapid technological adaptation (Fehér & Veres, 2022). The results also reflect findings by Pang et al. (2025), who suggest that impersonal trust structures help organizations adapt to digital transformation. Slovak employees, accustomed to structured governance, showed higher resilience to technological change, whereas Hungarian employees, who rely more on interpersonal interactions, experienced greater difficulty adapting.

Consistent with Oláh et al. (2021), the study found that trust plays a significant role in improving organizational performance and competitiveness. However, the explanatory power of the model ($R^2 = 0.22$) suggests that trust is not the sole determinant of competitiveness, supporting previous research that highlights the influence of market dynamics, leadership effectiveness, and external economic factors. Hungarian organizations, benefiting from high interpersonal trust, tend to focus on collaboration and innovation, whereas Slovak firms leverage institutional stability for long-term competitive advantages.

Implications and Future Research

The findings of this study offer meaningful insights for both researchers and practitioners seeking to understand and enhance organizational trust in varying cultural contexts. Organizations aiming to develop sustainable and effective workplace environments must consider the complex interplay between personal and impersonal trust, leadership practices, digital transformation, and industry-specific dynamics.

For Hungarian organizations, where personal trust is a key driver of job satisfaction and commitment, leadership strategies should emphasize direct communication, interpersonal relationships, and participatory decision-making. Managers must focus on cultivating trust through transparent interactions, active employee engagement, and fostering workplace collaboration. Given the negative impact of technostress on organizational commitment, Hungarian firms should develop structured technological adaptation programs to ensure employees feel supported in digital transformation efforts.

In contrast, Slovak organizations, which rely more on impersonal trust mechanisms, should prioritize clear institutional policies, procedural fairness, and structured decision-making frameworks. Establishing well-defined organizational structures, ethical leadership models, and AI-integrated management systems can further enhance trust and stability in Slovak workplaces.

Moreover, both Hungarian and Slovak firms must proactively address the challenges of digitalization and remote work. Providing digital literacy training, improving cybersecurity awareness, and fostering inclusive technological change can help reduce employees' concerns about automation and AI-driven decision-making. Organizations should aim to develop hybrid

trust-building strategies that balance personal and impersonal trust models, ensuring that employees feel both valued and secure in rapidly evolving workplaces.

Future Research Directions. While this study provides a robust comparative analysis of organizational trust in Hungary and Slovakia, further research is needed to explore additional factors influencing trust in different cultural and economic environments. Future studies could:

- Expand the research scope to include other Central and Eastern European (CEE) countries to examine broader regional trust trends.
- Incorporate qualitative research methods, such as in-depth interviews or case studies, to gain deeper insights into employee perceptions of trust.
- Investigate the long-term effects of digital transformation on organizational trust and employee engagement across different industries.
- Analyze generational differences in trust formation, considering how younger and older employees respond to different leadership styles and organizational structures.
- Explore industry-specific trust dynamics, particularly in high-tech, finance, and public sector organizations, where regulatory and operational frameworks significantly impact trust formation.

By addressing these research gaps, future studies can provide a more comprehensive understanding of trust mechanisms in diverse work environments. The ongoing evolution of digital workplaces and leadership models makes it imperative to continuously assess and refine trust-building strategies, ensuring that organizations remain adaptive, competitive, and resilient in an increasingly complex global landscape.

Conclusion

Organizational trust plays a crucial role in determining the effectiveness, stability, and overall success of organizations. This study has examined the differences in trust dynamics between Hungarian and Slovak organizations, with a particular focus on personal and impersonal trust, their impact on job satisfaction and organizational commitment, and the role of technostress in shaping trust perceptions. The findings indicate that trust formation is heavily influenced by cultural, structural, and managerial factors, underscoring the need for context-specific trust-building strategies in different organizational environments.

One of the key findings of this study is the difference in reliance on personal vs. impersonal trust in the two countries. Hungarian organizations tend to depend more on personal trust, meaning that direct relationships with managers and colleagues play a significant role in shaping employee engagement and commitment. In contrast, Slovak organizations exhibit a higher level of impersonal trust, particularly in workplaces where institutional frameworks and procedural fairness are well established. This suggests that cultural norms, historical experiences, and governance structures play a key role in shaping how trust is built and maintained within organizations.

Another significant finding is the relationship between trust and organizational commitment. In Hungary, personal trust strongly correlates with job satisfaction and engagement, emphasizing the importance of leader-employee relationships and direct managerial interactions in fostering trust. Meanwhile, in Slovakia, institutional trust serves as a stronger predictor of organizational commitment, suggesting that employees place greater trust in formal structures and fair processes rather than individual relationships. These findings highlight the need for different leadership approaches in trust-building—Hungarian organizations might

benefit from more personalized leadership styles, while Slovak organizations should focus on strengthening institutional reliability and procedural justice.

A particularly relevant aspect of this research is the impact of technostress on organizational trust. In the era of digital transformation, rapid technological advancements and automation are changing workplace dynamics. This study found that technostress negatively affects organizational commitment, with a stronger impact in Hungary than in Slovakia. One possible explanation for this difference is that Hungarian employees rely more on personal trust, and technology-driven organizational changes may disrupt existing trust-based relationships. In Slovakia, where impersonal trust is stronger, employees may be more accustomed to institutionalized decision-making processes, making them more adaptable to technological shifts. These results emphasize the importance of trust-based digital transformation strategies, ensuring that technological adoption does not undermine employee confidence and commitment.

Trust also plays a crucial role in organizational performance and competitiveness. The findings suggest that higher personal trust levels contribute to greater collaboration and innovation in Hungarian firms, whereas impersonal trust supports long-term stability and competitiveness in Slovak firms. This implies that Hungarian organizations may thrive in environments that encourage interpersonal cooperation and creativity, while Slovak organizations benefit from structured and well-regulated business processes. However, it is important to note that trust is not the sole determinant of competitiveness, as the model's explanatory power ($R^2 = 0.22$) suggests that other factors, such as market dynamics, leadership strategies, and regulatory environments, also play significant roles.

From a practical perspective, these findings offer valuable implications for organizations seeking to improve trust levels. Hungarian firms should focus on strengthening interpersonal trust through effective communication, leadership transparency, and employee involvement in decision-making processes. Conversely, Slovak firms should reinforce institutional trust by ensuring fair and consistent policies, transparent governance, and reliable procedural justice. Additionally, given the increasing impact of digitalization and AI-driven decision-making, companies in both countries should develop trust-oriented technological strategies to mitigate the negative effects of technostress and foster employee confidence in digital transformation processes.

Furthermore, this study highlights the importance of leadership styles in trust formation. Transformational and ethical leadership styles have proven effective in fostering trust, as they encourage openness, integrity, and fairness in managerial decision-making. While inclusive leadership has a positive effect on trust, autocratic leadership has a detrimental impact, suggesting that organizations should prioritize participatory leadership styles to strengthen employee engagement and organizational commitment.

Despite the valuable insights gained, this study has certain limitations that should be acknowledged. First, while the quantitative approach provides robust statistical evidence, a qualitative exploration could have provided deeper insights into employee perceptions and trust formation processes. Future research could incorporate interviews or case studies to capture contextual nuances in trust development. Additionally, the study primarily focused on knowledge-intensive industries, meaning that the findings may not be fully generalizable to other sectors, such as manufacturing or service industries. Expanding the scope of research to

different economic sectors would provide a broader understanding of trust dynamics across industries.

In conclusion, this study contributes to the growing body of research on organizational trust by highlighting the differences in trust formation and its impact on job satisfaction, commitment, and competitiveness in Hungary and Slovakia. The results emphasize that trust is a multidimensional concept shaped by cultural, structural, and technological factors, requiring tailored strategies for its effective development. By understanding these differences, organizations can adopt trust-enhancing approaches that align with their unique cultural and managerial contexts, ultimately fostering greater stability, engagement, and long-term success.

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The impact of Industry 4.0 on global value chains, employment, and lean manufacturing

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Abstract. Increasingly, Industry 4.0 has been acknowledged as a transformative force in the global economic landscape, affecting supply chain management, employment structures, and production systems. The integration of digital solutions, automation, and smart technologies has not only transformed traditional production models but has also reshaped global value chains and employment dynamics. The implications of Industry 4.0 for the Slovak manufacturing sector, employment trends, and lean manufacturing techniques are the primary focus of this study, which synthesises the findings from multiple perspectives. The structural transformation of industrial enterprises, workforce adaptation, and production efficiency have all been examined in relation to the application of Industry 4.0 tools. Special consideration has been given to the obstacles that businesses encounter when attempting to integrate these technologies while maintaining workforce readiness. The results underscore the importance of a balanced approach, in which automation and digitalisation are implemented as complementary rather than substitutive measures. The analysis emphasises that Industry 4.0's success is contingent upon the strategic reskilling of the workforce and the preservation of lean production principles, despite the fact that it enables efficiency gains.

Keywords: Industry 4.0; digitalisation; automation; workforce adaptation; lean manufacturing

Introduction

Technological advancements have fundamentally altered manufacturing processes and economic structures throughout the history of industrial production. The emergence of Industry 4.0 is a continuation of this trajectory, introducing a comprehensive digital transformation that integrates cyber-physical systems, the Internet of Things (IoT), artificial intelligence (AI), and automation into traditional production frameworks. The consequences of these developments are not limited to technological innovation; they also have a global impact on competitive market dynamics, supply chains, and employment. The transition to Industry 4.0 has been viewed as both an opportunity and a challenge in the Slovak Republic, a nation with a robust industrial base. Due to Slovakia's dependence on export-driven industries, particularly the automotive sector, the implementation of smart manufacturing solutions has become indispensable for the preservation of its competitiveness in global value chains. Nevertheless, this transition requires substantial structural modifications, such as the development of adaptive business models that are in accordance with the changing demands of the market, employee retraining, and investment in digital infrastructure. The employment implications of the integration of Industry 4.0 principles have also been a source of concern. The potential displacement of workers remains a subject of ongoing debate, despite the fact that automation has been instrumental in enhancing production efficiency. Technological advancements have not exclusively resulted in job losses, as previous industrial revolutions have illustrated, but they also create new employment opportunities in emerging sectors. Nevertheless, the rapidity

of automation in Industry 4.0 requires proactive measures to guarantee that the skillsets of the workforce are in accordance with the changing industry requirements. An additional factor to consider is the correlation between lean manufacturing principles and Industry 4.0. Lean manufacturing was initially developed as a systematic approach to maximising efficiency and minimising waste. It has since been widely adopted across a variety of industries. The implementation of Industry 4.0 technologies has been perceived as a method of improving lean production strategies by enabling real-time data monitoring, predictive maintenance, and supply chain optimisation. Nevertheless, the successful integration of these technologies necessitates rigorous implementation to prevent the disruption of the fundamental principles of lean manufacturing, including continuous process improvement and just-in-time production. The objective of this investigation is to consolidate critical insights regarding the influence of Industry 4.0 on the Slovak manufacturing sector, including global value chains, employment, and lean manufacturing. The research aims to offer a comprehensive comprehension of the challenges and opportunities brought about by the ongoing digital transformation in industrial production by analysing the interplay between these dimensions.

Literature review

The concept of Industry 4.0 has been defined by the integration of digital technologies, artificial intelligence, and cyber-physical systems into production processes, which has fundamentally altered traditional manufacturing models (Zhong et al., 2021). The complexity of global value chains has been the driving force behind this transformation, which has necessitated increased efficiency, flexibility, and data-driven decision-making (Balaz & Zabojnik, 2020). The opportunities and challenges associated with the adoption of Industry 4.0 have been extensively studied in the context of lean manufacturing, employment, and supply chain optimisation (Clayton & Kral, 2021). Smart production techniques and automated systems are among the primary benefits of Industry 4.0, which is its capacity to improve the efficiency of global value chains (Kolberg & Zühlke, 2015). These technologies enable companies to enhance overall supply chain performance, reduce waste, and optimise production scheduling by enabling real-time data collection and predictive analytics (Hopkins & Siekelova, 2021). In the automotive sector of Slovakia, the widespread implementation of these technologies has been observed, as firms have incorporated Industry 4.0 tools to sustain their competitiveness in global markets (Minarik et al., 2022). Nevertheless, there are apprehensions about the potential effects of automation on the labour market. Industry 4.0 has resulted in the displacement of low-skilled workers, despite the fact that it has contributed to increased productivity and job creation in specific sectors (Fana et al., 2020). The demand for labour has been altered by the introduction of smart factories and autonomous systems, necessitating the reskilling of employees to meet the demands of digitalised production environments (Gallacher & Hossain, 2020). Research indicates that the transition to Industry 4.0 necessitates proactive workforce policies to guarantee that employees possess the requisite digital competencies (De Stefano et al., 2021). Academic inquiry has also focused on the relationship between Industry 4.0 and lean manufacturing. Toyota was the first to develop lean production systems, which prioritise process efficiency, waste reduction, and continuous improvement (Liker, 2008). Johnson and Nica (2021) have suggested that the integration of Industry 4.0 tools can improve lean methodologies by facilitating more precise data analysis, predictive maintenance, and supply chain automation. Nevertheless, scholars have issued a warning that the current production efficiencies may be disrupted if automation is over-used without proper integration into lean principles (Rüttimann & Stöckli, 2016). Implementing Industry 4.0 within lean manufacturing systems presents a significant challenge in terms of upholding the fundamental principles of waste minimisation and just-in-time production. According to research, digitalisation improves

efficiency; however, it must be integrated with lean practices to guarantee a sustainable production model (Vinerean et al., 2022). The convergence of lean production and Industry 4.0 is rooted in the utilisation of digital tools to enhance existing workflows, rather than to substitute human oversight and process control (Said et al., 2021). In general, the literature suggests that Industry 4.0 has the potential to significantly improve global value chains, employment structures, and lean manufacturing. Nevertheless, its execution necessitates a meticulous assessment of workforce adaptation, strategic investment in digital infrastructure, and adherence to lean production principles. Additional research is required to investigate the long-term implications of Industry 4.0 adoption across various industrial sectors and its potential impact on future employment trends.

Methodology

The Slovak Republic's economic policy is focused on the improvement of living standards, the reinforcement of competitiveness in the global market, and the attainment of sustainable economic development. In this framework, a variety of strategies and measures are gradually incorporated into the fields of education, innovation, research, and regional development, as well as in macroeconomic stability and business support. The business environment is being enhanced by the reduction of bureaucracy, the reinforcement of the rule of law, the enhancement of legislation, and the support for small and medium-sized enterprises. Furthermore, the importance of enhancing the conditions for foreign investments and export support is underscored. Regional development initiatives are focused on the effective utilisation of European and structural funds, the reduction of regional disparities, and the stimulation of growth in underdeveloped regions. Economic policy measures in the European Union are designed to oppose excessive European regulation and bureaucracy while simultaneously supporting initiatives that facilitate market liberalisation. Providing that the fundamental principles of the common European market are not violated, there is a strong advocacy for the preservation of sovereignty in economic and social policies. At the same time, the promotion of responsible economic policies within EU member states is actively pursued, and European policies and instruments that guarantee long-term fiscal sustainability are bolstered (OECD, 2020). Competitive advantages resulting from the availability of a qualified labour force, the inflow of foreign direct investments, and low wages were initially assumed to be the cause of the rapid economic growth observed in the Slovak Republic. Nevertheless, this model has been found to be ineffective in ensuring the long-term expansion of the economy (adaptations to global trends and efforts).

Table 1. Slovak export in 2023.

Slovakia export (2023 in mil. €)		
Food and live animals	4 142.40	3.83 %
Beverages and tobacco	268.00	0.25 %
Raw materials	1849.00	1.71 %
Mineral fuels	3 783.40	3.49 %
Animal and vegetable oils	153.10	0.14 %
Chemicals and related products	4 300.10	3.97 %
Market products sorted by material	15 938.50	14.72 %
Machines and transport equipment	68 384.80	63.16 %
Various industrial products	9 220.60	8.52 %
Commodities and transactions	225.60	0.21 %

Source: Author’s compilation according to SUSR (2023).

Table 1 indicates that the engineering industry is the primary source of Slovak exports in 2023. Machinery and transport equipment comprised 63.16% (€68,384.80 million) of the total exports, making it the most significant export category. This is succeeded by market products sorted by material, which accounted for 14.72% (€15,938.50 million), and various industrial products, which accounted for 8.52% (€9,220.60 million). The engineering sector's critical role in Slovakia's economy is further underscored by the fact that the sum of the remaining export categories is 13.6% (€13,721.60 million). In a rapidly changing industrial landscape, the integration of innovative tools, the implementation of cutting-edge technological processes, and the continued advancement of innovation are considered essential for maintaining competitiveness and increasing added value.

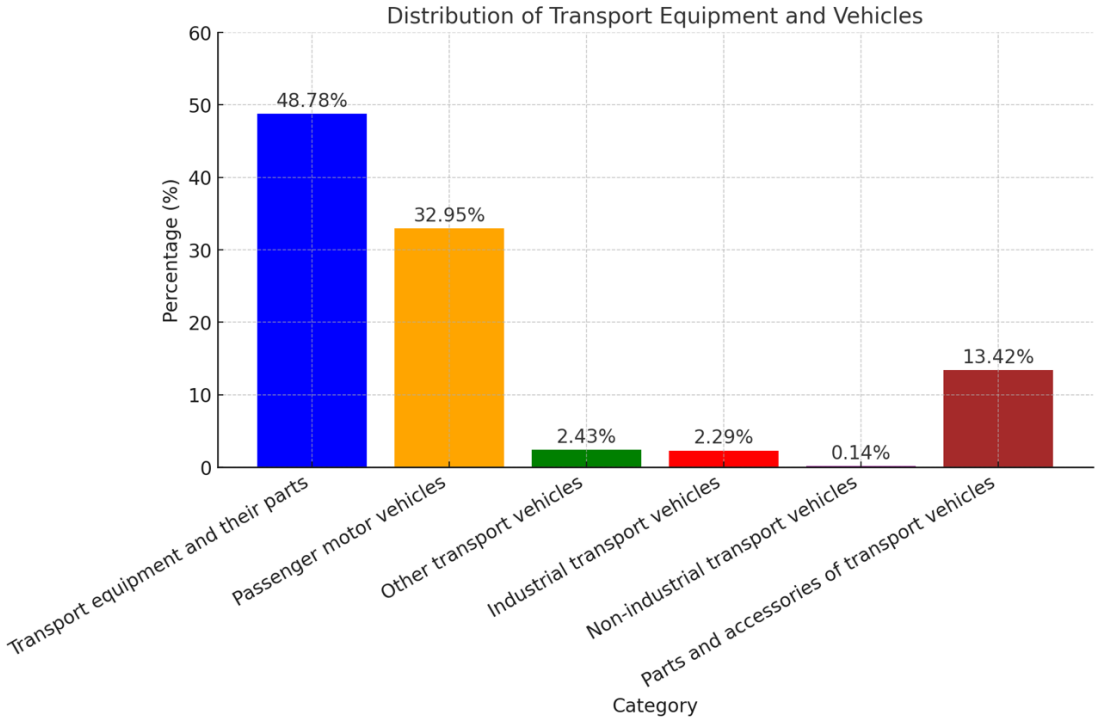

Figure 1. % share of automotive industry items.

Source: Author’s compilation.

Figure 1 illustrates that the automotive industry is a critical component of the Slovak engineering sector. The primary components of this sector are transport equipment and their parts (48.78% or €45,398.60 million), passenger motor vehicles (32.95% or €30,666.60 million), and parts and accessories for transport vehicles (13.40% or €12,469.90 million). The majority of these segments are under the control of multinational corporations, with Volkswagen Slovakia, a.s., Kia Slovakia, a.s., and Stellantis, a.s. contributing significantly. Slovakia has effectively integrated into international supply chains by leveraging strategic coordination at a global level, managerial expertise, modern production technologies, and foreign investments. As a result, global market dynamics frequently determine investment decisions, production strategies, and market positioning. Slovakia's engineering industry is committed to adhering to production processes that are in accordance with the needs of end

consumers as a component of the global value chain. The industry's performance is contingent upon the availability of skilled labour and material resources at competitive prices, while simultaneously upholding high quality standards. However, obstacles to long-term sustainable economic growth are posed by factors such as a decreasing supply of unskilled labour, a decrease in wage-based competitive advantages, and reliance on foreign investments. The acceleration of the development of exported added value and the reduction of dependence on foreign investments have been identified as potential solutions through the implementation of the fourth industrial revolution in small and medium-sized enterprises. In response to these obstacles, economic policy initiatives that are designed to cultivate an innovative economic model are being implemented gradually. The transition to an economy that is innovation-driven is being facilitated by the promotion of technological advancements, the enhancement of service and product value, and policy adjustments (Ministry of Economy of the Slovak Republic, 2019). The fourth industrial revolution offers a plethora of opportunities at every stage of its implementation. Nevertheless, in order to fully leverage these opportunities, it is necessary to make adjustments across a variety of domains, such as the educational system, labour market structures, and business environment quality standards. Slovakia's economic development strategy prioritises adaptability to these transformations.

Results

The findings of a structured interview conducted in the specified sector are examined in this section, with a particular emphasis on Industry 4.0.

Business owners' comprehension of Industry 4.0 instruments

The business owner's vision has a substantial impact on the strategic direction and prioritisation of investments in new technologies. Ultimately, the organization's competitiveness is enhanced by the effective guidance of management decisions, which is ensured by an adequate comprehension of emerging technologies. The integration of new technologies has been demonstrated to improve the quality of work, operational efficiency, and flexibility of production processes. Consequently, it is imperative to acknowledge the potential and influence of these technologies. The business owner has been found to have a sufficient level of understanding of the Industrial Internet of Things (IIoT) and Industry 4.0 tools. Furthermore, a comprehensive comprehension of technological advancements in a variety of manufacturing sectors has been demonstrated, with a particular emphasis on automation, data collection and analysis, predictive maintenance, production process optimisation, and real-time data evaluation.

Line managers' comprehension of Industry 4.0 instruments

In order to guarantee the organization's efficient daily operations, it is imperative that line managers possess a comprehensive comprehension of Industry 4.0 tools. Line managers are accountable for the successful implementation of new technologies and work methodologies and play a critical role in employee supervision. Additionally, their role is essential in the management of organisational change and the facilitation of communication between departments. As a result, their involvement in the integration of Industry 4.0 instruments into routine operations is essential. Nevertheless, their current level of understanding of Industry 4.0 and IIoT technologies has been determined to be insufficient. Consequently, it will be imperative to implement the requisite measures to improve their proficiency in this area.

Employees' comprehension of Industry 4.0 instruments

It is imperative that employees obtain adequate training and knowledge in order to effectively implement Industry 4.0 tools. Increased awareness of these tools has been identified as a necessary condition for their optimal utilisation and for maximising their potential to enhance production efficiency. Employees who are proficient in Industry 4.0 technologies are more adept at adapting to new tools and workflows, which in turn reduces the time necessary for retraining and minimises production downtime. It has been determined that the current level of awareness among employees within the organisation is insufficient. Similar trends have been observed among small and medium-sized enterprises (SMEs) in the engineering sector of the Slovak Republic, where the adoption and utilisation of Industry 4.0 tools remain underdeveloped. This issue is not exclusive to the studied enterprise.

Employees' Proficiency in Information, Communication, and Data Analysis Systems

IIoT is fundamentally dependent on the integration of information and communication technology (ICT) systems and data analysis. Advanced analytical systems, such as big data solutions, are necessary to convert the vast amount of data produced by IIoT into actionable insights. The implementation of these systems has allowed businesses to analyse data that would have been challenging to interpret in the past, thereby enabling real-time monitoring of production processes and predictive maintenance. ICT systems are essential in facilitating managerial decision-making by facilitating the access to pertinent and current information, thereby expediting the flow of information and facilitating the implementation of timely decisions. The strategic importance of the integration of IIoT with ICT and data analysis systems for sustainable business growth in the digital era has been acknowledged.

Equipment Employed by the Organisation

Modern equipment has been recognised as a critical component of engineering enterprises. The integration of machinery with IIoT enables the collection and analysis of real-time data, as well as the support of informed decision-making, within digital networks. In addition, the implementation of these technologies facilitates predictive maintenance and the mitigation of unforeseen operational disruptions. The implementation of new equipment has also been observed to improve the quality of production and the flexibility of work. It has been determined that the organization's machinery is relatively contemporary and satisfies the criteria for IIoT implementation.

Selecting Between RFID Sensors and Advanced Integrated Devices

The capacity of machines to improve production monitoring, predictive maintenance, and process optimisation has been acknowledged as a result of their integration with IIoT technology, which is designed to collect, analyse, and share real-time data. RFID (Radio Frequency Identification), BLE (Bluetooth Low Energy), NFC (Near Field Communication), and Zigbee are among the technologies that enhance the efficiency of device communication, short-distance data collection, and location tracking. The company has determined that the acquisition of additional machines with built-in sensors is unnecessary in light of the current state of its machinery. Rather, the preferred approach is to acquire IIoT equipment to complement the recently acquired production machinery.

The integration of IIoT into current company systems

IIoT has the capacity to integrate with a variety of technologies in order to optimise their functionality. Its implementation is particularly advantageous for automated warehouses, as it

improves inventory monitoring and management. Additionally, automated parking systems that integrate IIoT contribute to streamlined parking management, enhanced monitoring, and increased efficiency. The optimal solution for improving production efficiency, machine health monitoring, and predictive maintenance is the integration of advanced CNC technologies with IIoT. At present, the organisation implements sophisticated CNC bending, machining, and welding technologies, in addition to automated storage and file management systems.

Digitalisation in Primary and Secondary Production Processes

Transformational changes in value delivery are the result of the integration of digital technologies into all facets of an engineering company's operations, which is known as digitalisation. The digitalisation of primary and secondary production processes improves quality, reduces operational costs, and increases efficiency. Utilising digital tools facilitates the collection and analysis of data, the real-time monitoring of equipment conditions, and the formulation of well-informed decisions. The organization's primary production activities consist of the development of hardware and software, CNC machining, welding, bending, and the production of plastic parts. Equipment maintenance, logistics, warehousing, human resource management, and information systems are all considered secondary processes. Strategies for the Development of Intelligent Industry in Slovakia:

Measure 1: Terminology Standardisation

The strategic objective entails the alignment of stakeholders' comprehension of critical concepts. A dictionary will be created to standardise and clarify terminology, thereby guaranteeing that it is accessible to all Slovak citizens.

Measure 2: Harmonisation of Concepts and Nomenclature

A thorough comprehension of the principles of intelligent industry and their practical application will be achieved. In order to incorporate these components into the educational system, an ontology will be developed to establish relationships, technologies, system approaches, and technical standards.

Measure 3: Establishment of Slovak Technical Standards for Intelligent Industry

Through technical committees such as CEN, CENELEC, ETSI, ISO, and IEC, Slovakian experts will participate in the development of European and international standards. On the UNMS SR website, a catalogue of pertinent Slovak and international technical standards will be composed and updated on a regular basis. In order to encourage the participation of experts in standardisation activities, a national technical commission will be established.

Measure 4: Legislative Framework for Intelligent Industry

An examination of EU policies concerning the digital single market will be conducted, with an emphasis on strategic priorities, binding directives, and market regulations. In order to ensure that national regulations are consistent with EU digital market policies, the Slovak Republic will develop coordinated legislative positions in conjunction with pertinent departments. Slovakia's objective is to facilitate sustainable innovation and economic growth by fostering a robust and intelligent industrial environment that is consistent with international standards. This will be achieved through the implementation of these measures.

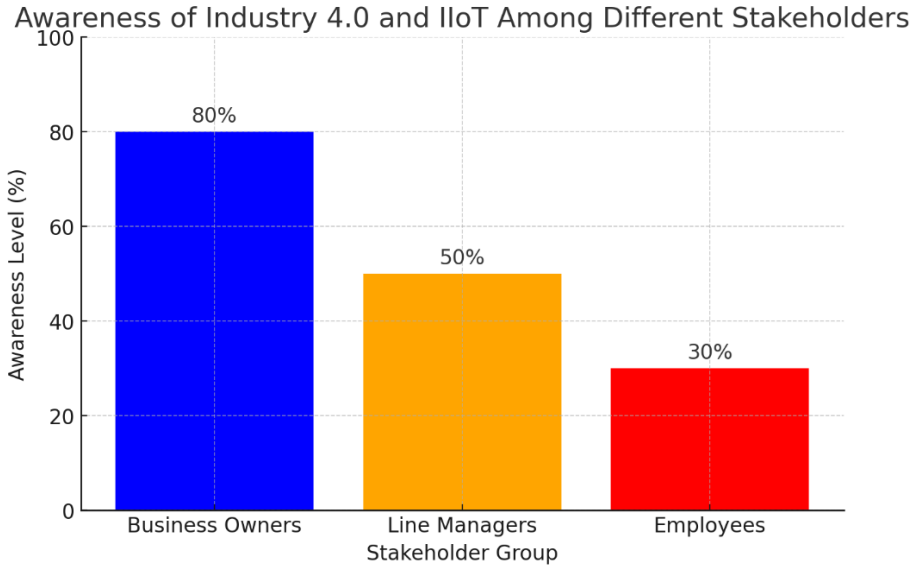

Figure 2. % share of automotive industry items.

Source: Author's compilation.

The figure 2 illustrates the degree of awareness of Industry 4.0 and IIoT among various stakeholder groups within a company. Business owners are the most knowledgeable (80%), as they are responsible for making decisions regarding investments in new technologies. Further training is required to guarantee the successful implementation of technological solutions, as line managers demonstrate a moderate level of awareness (50%). The successful implementation of new tools and processes within the organisation may be influenced by the fact that employees possess the lowest level of knowledge (30%). The findings underscore the importance of managers and employees receiving targeted education and training to optimise the utilisation of Industry 4.0 technologies.

Discussion

The objective of Industry 4.0 is to provide competitive products by utilising a sustainable, nimble, and loss-free value stream. Flexibility, robustness, and resource optimisation can be achieved by integrating people, machines, objects, and systems, which is consistent with the Bosch Production System (BPS) vision of a "value stream without losses" (Zhong et al., 2021; Lawrence et al., 2021). Industry 4.0 is therefore acknowledged as a collection of digitisation tools that facilitate lean manufacturing by facilitating waste-free, sustainable, and agile value flows. Frequent production schedule modifications and inaccurate material tracking frequently undermine the pull principle (Vuong and Mansori, 2021). According to Lawrence et al. (2021), conventional lean systems depend on the Kanban system to regulate material supply, with its optimisation contingent upon variables such as process stability, batch size, and refill time. Real-time adjustments are necessary as a result of these intricacies. Johnson and Nica (2021) have proposed the implementation of the E-Kanban system, which utilises sensor-equipped material boxes to enhance efficiency. Lean production is facilitated by Industry 4.0 technologies, which reduce repetitive tasks and increase process transparency (Zhong et al., 2021). Nevertheless, obstacles persist, including the misinterpretation of data, the inability to comprehend complex tools, and the implementation of autonomous system interventions (Vuong and Mansori, 2021). Industry 4.0 adoption should be implemented in processes that are well-defined and stable in order to mitigate risks and adhere to lean principles. Employees must

possess a high level of proficiency in data analysis, and the results should be presented in a manner that is easily comprehensible. Furthermore, autonomous systems should not modify production paths without human authorisation (Lawrence et al., 2021). It is imperative to maintain stability by concurrently operating both traditional and new systems. Direct observation through the Genchi Genbutsu method is still required, as sensors are unable to capture all pertinent factors (Johnson and Nica, 2021). Although the Slovak labour market has experienced substantial changes, its future trajectory remains uncertain (Vuong and Mansori, 2021). Continuous learning and adaptation to technological advancements are essential, despite the anticipated extinction of certain professions. Industrial revolutions should be viewed with foresight rather than apprehension, as they offer opportunities for both economic and societal development. Industry 4.0 technologies enable the creation of new job opportunities and informed decision-making, despite the fact that human involvement in production remains essential (Zhong et al., 2021; Johnson and Nica, 2021).

Conclusions

Industry 4.0 has emerged as a transformative force, reshaping global supply chains, employment structures, and production systems through digitalisation, automation, and smart technologies. This investigation has investigated the implications of these developments for the Slovak manufacturing sector, with a particular emphasis on the efficiency of production, workforce adaptation, and lean manufacturing principles. The results emphasise that the integration of Industry 4.0 tools provides substantial efficiency gains; however, a balanced approach is required to guarantee that automation complements human labour rather than replacing it. An important conclusion from the analysis is that the successful implementation of Industry 4.0 is contingent upon the strategic reskilling of the workforce, the preservation of lean production principles, and the readiness of the technology. Automation has the potential to eliminate specific job roles, but it also generates new opportunities that necessitate advanced digital competencies. It is imperative to guarantee that employees have the necessary technological literacy and training in order to optimise the advantages of digital transformation and reduce socio-economic disruptions. Additionally, this investigation emphasises the significance of transparency in production processes that are facilitated by Industry 4.0 technologies. The efficiency of decision-making is improved through the integration of real-time data monitoring, predictive maintenance, and supply chain optimisation. Nevertheless, barriers such as employee unfamiliarity with digital tools, the complexity of autonomous systems, and data misinterpretation must be resolved to guarantee the seamless adoption of these tools. In order to maintain efficiency and promote sustainable industrial transformation, it will be essential to implement Industry 4.0 solutions in a structured and gradual manner, in accordance with existing lean methodologies.

In summary, Industry 4.0 necessitates ongoing adaptation from businesses and policymakers, as it represents a fundamental shift in industrial production. Although the transition presents obstacles, particularly in the area of workforce adaptation, the long-term advantages for economic sustainability, competitiveness, and productivity outweigh the risks. The long-term consequences of Industry 4.0 adoption across various industrial sectors and its implications for the evolution of employment structures should be the primary focus of future research.

Acknowledgements

This research was financially supported by the Slovak Research and Development Agency Grant VEGA 1/0494/24: Metamorphoses and causalities of indebtedness, liquidity and solvency of companies in the context of the global environment.

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Analyzing the Gender Pay Gap: A Review

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Abstract: Gender inequality related to work is one of the issues that has been raised and debated often. Pay gap affects women from diverse backgrounds, for different groups and at different levels of educational achievement, although earnings and the gap vary depending on a woman's individual situation. This paper aims to investigate the issues related to gender pay gap for the satisfaction of employees and to define, develop and propose the future agenda for research, based on the research gaps identified. This study conducts a systematic literature review of 82 peer reviewed journal articles published in 39 journals over a span of 25 years from 2000 to 2024. This review also investigates the content of research to describe the major themes or research focus area of gender pay gap. A bibliometric analysis is applied to identify the trends related to gender pay gap, country wise study, year wise study and citation measures of identified papers. The objective of the paper is to review research on gender pay gap, to identify the issues related to the area which needs to be addressed and to study the impact of gender pay gap on employee satisfaction. It further explains and accurately investigates innovative ways to level the playing field for women while at the same time not penalizing men across sectors. The contributing roles, as well as the challenges, have helped us to develop an employee-centric conceptual model for further study. The uniqueness of the study, as well as its contribution, is towards extending the existing domain of knowledge using a rational thematic approach for the literature review and to provide scope for further study.

Introduction

The gender pay gap continues to be a critical issue of concern, not only for policymakers at the national and international levels but also for strategists and human resource professionals within organizations. Despite decades of advocacy and reform efforts aimed at promoting workplace equity, persistent disparities in compensation between men and women remain entrenched across many sectors of the global economy. Over the past three decades, there have been substantial theoretical advancements in the fields of compensation management, labor economics, and human resource practices. Numerous innovative frameworks and techniques—ranging from performance-based pay structures to equitable benefits administration—have been successfully adopted in industrial and organizational contexts. However, comparatively less attention has been devoted to the nuanced and systemic factors underpinning gender-based pay disparities.

Compensation has emerged as a central determinant of employee motivation, satisfaction, and retention. Research consistently shows that inadequate pay is among the leading causes of

voluntary employee turnover, particularly in medium and large enterprises. Recent data from PayScale (2024) reveals that over 25% of employees cite "seeking higher pay elsewhere" as the primary reason for leaving their jobs. Furthermore, approximately 15% of organizations report lacking a formal compensation structure, underscoring the extent to which unregulated or inconsistent pay practices may contribute to employee dissatisfaction and attrition. Employers themselves often acknowledge compensation as one of the most significant obstacles to effective talent retention.

Within this context, wage discrimination—often defined as the scenario in which women receive lower remuneration than men for equivalent roles, responsibilities, and qualifications—remains a pressing concern (Ehrenberg & Smith, 2003). While legal frameworks in many countries prohibit overt discriminatory practices, gender-based pay gaps continue to persist in both explicit and implicit forms. These disparities are particularly pronounced when analyzed across specific industries. For example, PayScale (2015) reported that in the Wholesale and Retail Trade sector, women earned approximately 8.72% less than their male counterparts. In contrast, the Arts, Entertainment, and Recreation industry demonstrated a staggering 58.42% gender pay gap, highlighting the heterogeneous nature of the issue across different economic sectors.

These findings underscore the vital role of compensation systems not only in promoting organizational efficiency and competitiveness but also in advancing principles of fairness and equity in the workplace. The existence of gender pay disparities-even in highly developed economies—reflects broader structural and cultural dynamics that merit comprehensive investigation. Addressing these issues is not merely a matter of compliance or corporate social responsibility; rather, it is fundamental to fostering inclusive, sustainable, and high-performing work environments.

The primary objective of this paper is to conduct a comprehensive review of existing literature on the gender pay gap, with a particular focus on the theoretical evolution of the concept and its implications at both the individual and organizational levels. By exploring the multidimensional nature of wage disparities-including their economic, sociological, and institutional underpinnings-this study seeks to contribute to a deeper understanding of the gender pay gap and to identify actionable pathways for mitigating its effects in contemporary workplaces.

Theoretical part

The gender pay gap, which refers to the consistent disparity in average earnings between men and women, has been examined through multiple theoretical lenses across economic and social sciences. These theories offer varying explanations, ranging from individual-level choices to broader structural and institutional dynamics. Economists' efforts to understand the gender pay gap have traditionally rested on two pillars: the human capital explanation (Mincer & Polachek, 1974) and models of labor market discrimination. The Human Capital Model offers a theoretical framework for understanding wage differentials by attributing variations in earnings to differences in individual characteristics such as education, work experience, skills, and training (Becker, 1964; Mincer, 1974). Within this model, individuals are viewed as rational agents who invest in their own human capital to maximize lifetime earnings. Wage disparities, therefore, are seen as the outcome of differing levels and types of investment in human capital.

In the context of the gender pay gap, the Human Capital Model has frequently been used to explain differences in average earnings between men and women. According to this framework,

women may earn less on average due to lower accumulated human capital, often resulting from career interruptions, part-time employment, or occupational choices influenced by family responsibilities and societal norms (Blau & Kahn, 2017). These factors can lead to differences in experience, tenure, or field of study, which in turn affect productivity and earnings. However, empirical studies have shown that even after accounting for such factors, a significant portion of the gender pay gap remains unexplained.

To account for this residual gap, theories of labour market discrimination have been developed. Labour market discrimination refers to the unequal treatment of individuals in employment decisions such as hiring, promotion, compensation, and job assignments—based on characteristics unrelated to productivity, such as gender, race, or ethnicity. In the context of the gender pay gap, discrimination occurs when women receive lower wages or fewer opportunities than men with comparable levels of education, experience, and performance. Economic theories distinguish between two main types of discrimination: taste-based and statistical discrimination. Taste-based discrimination, first introduced by Becker (1957), arises when employers, coworkers, or customers hold prejudiced preferences against women in the workplace, resulting in discriminatory wage offers or exclusion from certain roles. In contrast, statistical discrimination occurs when employers use gender as a proxy for expected productivity or job commitment—assuming, for example, that women are more likely to interrupt their careers for family reasons—thereby offering them lower pay or limiting their advancement opportunities (Phelps, 1972; Arrow, 1973).

Both forms of discrimination can result in unequal pay or reduced access to high-paying roles and promotions. Beyond individual and employer behavior, institutional and structural theories emphasize how workplace norms, occupational segregation, and gendered organizational cultures perpetuate inequality (Reskin & Padavic, 2002). For instance, women are often overrepresented in lower-paying sectors (horizontal segregation) and underrepresented in leadership roles (vertical segregation), contributing to persistent wage differentials (Anker, 1998).

Additionally, feminist and sociological perspectives argue that systemic undervaluation of work typically performed by women, such as caregiving or administrative support, reinforces the pay gap (England, 1992). These approaches highlight the influence of social norms, gender roles, and power relations in shaping labor market outcomes (Acker, 1990; Ridgeway, 2011). More recently, intersectional frameworks have expanded the analysis of the gender pay gap by considering how multiple identities—such as race, class, and ethnicity-interact with gender to produce unique patterns of inequality (Crenshaw, 1991; Browne & Misra, 2003).

Empirical research consistently shows that a substantial portion of the gender pay gap cannot be explained by human capital variables alone (such as education, experience, or occupational choice). This unexplained residual gap is widely interpreted as evidence of discriminatory practices in the labor market (Blau & Kahn, 2017). Moreover, gender segregation into lower-paying industries and roles, gender norms around caregiving, and unequal access to leadership positions further perpetuate wage disparities. Labour market discrimination is often subtle and systemic rather than overt, and it may be reinforced by organizational practices, implicit bias, and institutional structures. As such, addressing the gender pay gap requires not only policies that promote equal pay for equal work but also structural reforms aimed at challenging stereotypes, improving workplace flexibility, and supporting women's career progression.

Together, these theoretical approaches demonstrate that the gender pay gap is not solely a consequence of individual choices, but rather a multifaceted issue rooted in complex social, economic, and institutional structures.

Aim, methodology, and data

This section discusses systematic literature review methodology, as proposed by Tranfield, Denyer, and Smart (2003), for the study using databases viz; ABI/Inform, Emerald, JSTOR and Web of Science. A search for published journal articles has been conducted and the domain and boundaries of research were duly established. The systematic literature review process creates transparency and assists in developing the research questions

Glass, McGaw, and Smith (1981) present that such research tools help utilize findings from past studies to understand trends and predict cumulative findings on the position of a subject matter of interest. Systematic search process helps to locate studies which address a particular research question, as well as a systematic presentation and findings of the results.

To build a comprehensive database specific inclusion criteria have been used. Articles that primarily focused on social sciences, human resource management, personnel management, organizational behavior, and economics have been included. Preference was given to research papers, conceptual paper, literature review, case study while selecting the paper, over a time span of 25 years (2000-2024). Articles were further identified from scholarly and peer reviewed journals indexed with SSCI, SCOPUS and ABDC list of journals. Thus, a detailed study for relevancy and elimination of duplicity have been done to check the overall reliability and validity of the review

A search for published journal articles has been conducted and the domain and boundaries of research were duly established. Articles were searched with keywords viz ‘pay gap’, ‘wage discrimination’, ‘salary differences’, ‘pay equity’, employee satisfaction ‘pay and employee satisfaction’ and ‘pay gap and employee satisfaction’ The search process helped to identify 205 articles, of which 82 were considered to be relevant following application of the inclusion and exclusion criteria as shown in Table 1 below.

Table 1: Review of Selected Papers

S. No.	Author(s), year	Theme of Study	Journal	ABDC Ranking of Journal	Journal Indexing (Scopus and SSCI)
1.	Dex, Sutherland, and Joshi (2000)	Calculating the effects on gender wage ratios of introducing the statutory minimum wage in the UK.	National Institute Economic Review	B	SSCI
2.	Gough (2001)	Identifying the factors affecting women’s earnings during their working years and affect their earnings in retirement	Critical Social Policy	-	SCOPUS, SSCI
3.	Blau and Kahn (2003)	Understanding the gender pay gap using micro data for 22 countries over the 1985–94 period	Journal of Labor Economics	A*	SCOPUS, SSCI
4.	Grajek (2003)	Examining the gender pay gap in Poland over 1987-1996	Economics of Planning	B	-

5.	Huffman (2004)	To examine the racial wage inequality in the local labor market.	Social Science Research	-	SCOPUS, SSCI
6.	Linstead, Brewis, and Linstead (2005)	To review the existing contributions to gender and change management	Journal of Organizational Change Management	B	SCOPUS, SSCI
7.	Morgan and Arthur (2005)	Addressing a methodological issue in estimating pay penalties to women professionals	Sociological Methods & Research	A	SCOPUS, SSCI
8.	Solberg (2005)	Females are being crowded in low paying occupations is the main cause of gender pay gap, estimating this hypothesis by identifying structural wage equation for seven occupations.	Contemporary Economic Policy	B	SCOPUS, SSCI
9.	Kara (2006)	To estimate the occupational gender wage discrimination in Turkey	Journal of Economic Studies	B	SCOPUS
10.	Grybaite (2006)	To focus on theoretical approaches like human capital model, labor market discrimination and theory of occupational segregation to answer the question why women are paid less than men.	Journal of business economics and management	B	SCOPUS, SSCI
11.	Chevalier (2007)	The role of education, occupation, career expectations and aspirations among UK graduates to analyze gender pay gap	Oxford Bulletin of Economics and Statistics	A	SCOPUS, SSCI
12.	Arulampalam, Booth, and Bryan (2007)	Analyze gender pay gaps by sector across the wage distribution in eleven countries.	ILR Review	A*	SCOPUS, SSCI
13.	Srinivas (2007)	Examining the social attitudes towards women's roles and gender pay gap in USA	International Journal of Social Economics	B	SCOPUS
14.	Olivetti and Petrongolo (2008)	To understand whether wage structure has an important effect on the gender pay gap across a broad variety of countries	Journal of Labor Economics	A*	SCOPUS, SSCI
15.	Barnet-Verzat and Wolff (2008)	Estimating the effect of glass ceiling on gender wage gap	International Journal of Manpower	A	SCOPUS, SSCI
16.	Jamali, Sidani, and Kobeissi (2008)	To identify the gender pay gap and to highlight the fair and equitable compensation practices to eliminate inequity.	Gender in Management: An International Journal	C	SCOPUS
17.	Broyles (2009)	To determine the relative effects of human capital, labor market structure, and employer discrimination on the gender pay gap of chemists	International Journal of Sociology and Social Policy	B	-

18.	EvElinE and ToDD (2009)	To answer the question whether gender main streaming offers the way for closing gender pay gap.	Gender, Work and Organization	A	SCOPUS, SSCI
19.	Miller (2009)	Analysis of the gender pay gap by sector of employment using 2000 US Census data	Journal of Labor Research	B	SCOPUS, SSCI
20.	Mcdevitt, Irwin, and Inwood (2009)	By using 1870 census data classical hypothesis have been rejected that the gender pay gap as a reflection of a gender productivity gap.	Economic Journal	B	--
21.	Manning and Saidi (2010).	The use of performance pay in the workplace and compare the gender gap not only in incidence of performance pay but also in earnings and work effort	ILR Review	A*	SCOPUS, SSCI
22.	Pena-Boquete, Stefanis, and Fernandez-Grela (2010)	To analyze the gender wage distribution in Spain and Italy	International Journal of Manpower	A	SCOPUS, SSCI
23.	Crothers et al. (2010)	To identify the salary differences and promotion negotiation practices of male and female.	Gender in Management: An International Journal	C	SCOPUS
24.	Hampel-Milagrosa (2010)	Addressing the combined qualitative and quantitative approach as a way to address gender issues in doing business.	The European Journal of Development Research	B	SSCI
25.	Grove, Hussey, and Jetter (2011)	Pay gap explained by incorporating non-cognitive skills and preferences regarding family, career and jobs.	Journal of Human Resources	A*	SCOPUS, SSCI
26.	Smith, Smith, and Verne (2011)	Analyze the gender pay gap among CEOs, VPs and potential top executives.	International Journal of Manpower	A	SCOPUS, SSCI
27.	Khoreva (2011)	Examining the factors which affects the gender pay gap perception	Equality, Diversity and Inclusion: An International Journal	B	SCOPUS
28.	Hedija and Musil (2011)	To find out the factors which affects the gender pay gap and also to identify whether women are paid less than men or not.	Review of Economic Perspectives	-	SCOPUS
29.	Livanos and Pouliakas (2012)	To investigate the extent to which differences in the subject of degree studied by male and female university graduates contributes to the gender pay gap	Journal of Economic Studies	B	SCOPUS
30.	Ñopo, Daza, and Ramos (2012)	To analyze gender disparities in labor earnings for a comprehensive set of 64 countries.	International Journal of Manpower	A	SCOPUS, SSCI
31.	Bolitzer and Godtland (2012)	To examine the factors and gender pay gap changes in the Federal	The American Review of	B	SCOPUS, SSCI

		Workforce over the period 1988-2007	Public Administration		
32.	Drolet and Mumford (2012)	Understanding the gender pay gap in the context of individual characteristics and workplace effects.	British Journal of Industrial Relations	A*	SCOPUS, SSCI
33.	Doucet, Smith, and Durand (2012)	To analyze the impact of two factors on pay gap: the increased used by universities of market supplements and the implementation of the Canada research chairs program.	Relations Industrielles/Industrial Relations	A*	SCOPUS, SSCI
34.	Reese and Warner (2012)	Utilize a panel set of EEO-4 data to investigate the pay of women relative to men for 1999-2005.	Review of Public Personnel Administration	C	SCOPUS, SSCI
35.	Hirsch, König, and Möller (2013)	Exploring the regional differences in the gender pay gap theoretically and empirically	Scottish Journal of Political Economy	A	SCOPUS, SSCI
36.	Chiang and Ohtake (2014)	Examining the gender wage gap by performance-pay group across the whole earnings distribution in Japan	Journal of the Japanese and International Economies	A	SSCI
37.	Kilgour (2014)	Controlling the effect of hours worked, the gap between male and female earnings are less, it differs according to different states	Compensation & Benefits Review	-	SCOPUS
38.	Xiu and Gunderson (2014)	Examining the male-female pay gap and its determinants throughout the pay distribution.	International Journal of Manpower	A	SCOPUS, SSCI
39.	Couppié, Dupray and Moullet (2014)	To measure the gender pay gap at the beginning of the working life depending on the gender composition of occupations	International Journal of Manpower	A	SCOPUS, SSCI
40.	Mishra and Smyth (2014)	Collection of cross sectional data and examining the relationship between subjective wellbeing and male and female earnings	International Journal of Manpower	A	SCOPUS, SSCI
41.	Mandel and Semyonov (2014)	To analyze the trends in gender earnings gap using data from the IPUMS-USA	Demography	A	SCOPUS, SSCI
42.	McGee, McGee and Pan (2015)	Examining the receipt of different types of performance pay and women are slightly less likely than men to receive competitive compensation	Economics Letters	A	SSCI
43.	Grund (2015)	to examine possible differences in gender pay gaps for compensation components (fixed salaries, bonuses and other payments)	Labour Economics	A	SCOPUS,SSCI
44.	Janssen, Tuor Sartore and Backes-Gellner (2016)	Analyze the relationship between discriminatory social attitudes toward gender equality and firms' pay-setting behavior.	ILR Review	A*	SCOPUS, SSCI
45.	Duraisamy and Duraisamy (2016)	Using national level representative (1983-2012) examining gender	Applied Economics	A	SCOPUS, SSCI

		wage gap in India across different segments of the labor market			
46.	Leuze and Strauß (2016)	To identify the effect of devaluation of 'female-typical' work tasks and working-time arrangements on gender pay gap	Work, employment and society	A	SCOPUS, SSCI
47.	Craigie and Dasgupta (2017)	Exploring the role of the gender pay gap in explaining the downward trend in son preference in India using data from the 2005–2006 National Family and Health Survey (NFHS) and the 2004 Integrated Public Use Microdata Series-International (IPUMS International)	Oxford Development Studies	B	-
48.	Windebank and Martinez-Perez (2018)	This article explores how dual-earner mixed-sex couples divide household chores and their reliance on paid domestic services.	Service Industries Journal	B	SCOPUS, SSCI
49.	Yanadori, Gould and Kulik (2018)	This study investigates the salary disparity between male and female executives in major Australian corporations.	International Journal of Human Resource Management	A	SCOPUS, SSCI
50.	Conley and Page (2018)	This article analyzes the implementation of the gender equality duty and the Single Status Agreement in five English local authorities from 2008 to 2010.	Work, Employment and Society	A	SCOPUS, SSCI
51.	Dahanayake, et. al. (2018)	The purpose of this paper is to argue that diversity management (DM) interventions, grounded in principles of justice and fairness, serve as a powerful force driving sustainable outcomes.	Equality, Diversity and Inclusion: An International Journal	B	SCOPUS
52.	Jewell, Razzu and Singleton (2019)	This study presents new insights into the UK gender pay gap by utilizing a representative, longitudinal, and linked employer-employee dataset from 2002 to 2016.	British Journal of Industrial Relations	A*	SCOPUS, SSCI
53.	Healy and Ahamed (2019)	This study compares the gender pay gap across pre-recession, during-recession, and post-recession periods using Labour Force Survey data.	British Journal of Industrial Relations	A*	SCOPUS, SSCI

54.	Stanberry (2019)	This article explores new approaches to tackle a long-standing employment compensation issue—the gender pay gap.	Compensation & Benefits Review	-	SCOPUS
55.	Brown (2019)	The author profiles the action plans published by U.K. employers aimed at closing gender pay gaps, with a particular focus on higher education institutions.	Compensation & Benefits Review	-	SCOPUS
56.	Fan and Sturman (2019)	This study investigates the gender wage difference among new graduates with the same level of education, using the most recent data from the National Longitudinal Survey of Youth.	Compensation & Benefits Review	-	SCOPUS
57.	Agrawal (2020)	This paper aims to explore the relationship between two key aspects of gender segregation: education and occupation.	International Journal of Manpower	A	SCOPUS, SSCI
58.	Groysberg, Healy and Lin (2020)	The authors examine the factors influencing differences in pay changes between male and female executives who transition to new employers.	ILR Review	A*	SCOPUS, SSCI
59.	Matteazzi and Scherer (2020)	This study examines how a partner's contribution to household chores impacts individual wages.	Work, Employment and Society	A	SCOPUS, SSCI
60.	Gash and Plagnol (2020)	This article explores the relationship between the partner pay gap (the income difference between married, co-resident partners) and life satisfaction.	Work, Employment and Society	A	SCOPUS, SSCI
61.	Patterson, Varadarajan and Salim (2020)	The purpose of this paper is to perform a meta-analysis of existing research on gender discrimination and the gender gap among women in Science, Technology, Engineering, and Mathematics (STEM) in the UAE.	Gender in Management: An International Journal	C	SCOPUS
62.	Ikävalko and Kohvakka (2020)	This paper aims to explore the moderating effect of employees' work orientation and gender on their perceptions of pay.	Gender in Management: An International Journal	C	SCOPUS
63.	Coron (2020)	This work explores social representations of gender equality in the workplace.	Equality, Diversity and Inclusion: An International Journal	B	SCOPUS

64.	Rink, Walle and Klasen (2021)	This paper empirically explores how culture contributes to the commonly observed gender differences in financial literacy.	The Quarterly Review of Economics and Finance	-	SCOPUS
65.	Gaweł and Mroczek-Dąbrowska (2021)	This paper aims to examine how industry specificity affects the gender pay gap and its connection to female entrepreneurship.	International Journal of Manpower	A	SCOPUS, SSCI
66.	Patterson and Benuyenah (2021)	This study aims to provide a deeper understanding of employment trends in the labor market following the two Korean financial crises.	International Journal of Manpower	A	SCOPUS, SSCI
67.	Rudakov, et. al. (2022)	This research aims to assess the extent of the early career gender wage gap in Russia.	International Journal of Manpower	A	SCOPUS, SSCI
68.	Li, Dostie and Duplain (2022)	The authors analyze how firms' hiring and pay-setting policies influence the gender earnings gap in Canada.	ILR Review	A*	SCOPUS, SSCI
69.	Li, Daspit and Marler (2022)	This article resolves previous inconsistencies by adopting a more nuanced approach, examining the impact of both explained and unexplained executive pay dispersion on a firm's short- and long-term performance.	The International Journal of Human Resource Management	A	SCOPUS, SSCI
70.	Hek and Lippe (2022)	This mixed-method study utilizes survey data from the Netherlands to assess whether female employees earn higher wages when working under a female manager.	Work, Employment and Society	A	SCOPUS, SSCI
71.	Orji and Nwosu (2023)	This study examined the gender wage gap in Nigeria by analyzing data from two waves of household surveys.	International Journal of Manpower	A	SCOPUS, SSCI
72.	Ghignoni and Pastore (2023)	The authors present a comprehensive and up-to-date analysis of the gender wage gap in Egypt, tracing its evolution over the past 20 years.	International Journal of Manpower	A	SCOPUS, SSCI

73.	Destefanis, Mazzotta and Paris (2023)	This article examines the applicability of Goldin's hypothesis to Italy, suggesting that the unexplained gender pay gap is largely driven by firms' incentives to disproportionately reward individuals who work long and irregular hours.	Work, Employment and Society	A	SCOPUS, SSCI
74.	Gamage et. al. (2023)	This study explores the effect of a pay transparency intervention on reducing the gender pay gap within the UK university sector.	British Journal of Industrial Relations	A*	SCOPUS, SSCI
75.	Abdulla (2023)	This article presents an augmented Roy model in which workers self-select into occupations, while being subject to labor market barriers specific to their socio-linguistic group.	Scottish Journal of Political Economy	A	SCOPUS, SSCI
76.	Kräft, Kaimann and Frick (2023)	This study seeks to identify and explain a potential gender pay gap within the creative industry.	Gender in Management: An International Journal	C	SCOPUS
77.	Tarkovska, Gabaldon and Ratiu (2023)	This study aims to explore how a growing presence of women on boards helps reduce gender pay disparity among nonexecutive directors (NEDs).	Gender in Management: An International Journal	C	SCOPUS
78.	Basbug and Fernandez (2024)	This study analyzes gender differences in reservation wages and applied-for occupational categories using a weekly survey of unemployed workers.	ILR Review	A*	SCOPUS, SSCI
79.	Han and Hermansen (2024)	This study examines wage disparities among immigrant generations based on educational qualifications, occupational and workplace segregation, or unequal compensation for identical work.	ILR Review	A*	SCOPUS, SSCI
80.	Miller, Petrie and Segal (2024)	The authors investigate how competition influences the creation of high-paying and high-status jobs through two field experiments.	ILR Review	A*	SCOPUS, SSCI
81.	Dressel, et. al. (2024)	This article examines the impact of gender differences in detailed work activities on the gender wage gap among full-time, year-round, college-graduate workers.	Work, Employment and Society	A	SCOPUS, SSCI

82.	Sandner and Yükselen (2024)	This study analyzes the gender wage gap in the first job and its evolution during the early years of careers following graduation.	Scottish Journal of Political Economy	A	SCOPUS, SSCI

Source: Authors Own Compilation

The identified articles were further analyzed with respect to the publication year, country wise study, and citation measures. It is done to understand the trends and issues in the literature relevant to the identified area. Articles collected from the year 2000 to 2024, shows an exponential growth in terms of number of studies dealing with gender pay gap specifically in the year 2020-2024. The analysis by journal aims to identify the journals most involved in the conversation of literature. The journals in which the identified articles are published indexed in SCOPUS and SSCI and ABDC listed. ABDC ranked journals achieve a transparent, efficient and effective review process to minimize irrelevant information and duplicity of articles. Several publications have been done in A* and A category journals. SCOPUS and SSCI are the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings.

In total, 39 journals contained the selected publications and the key publication outlets are *Journal of the Japanese and International Economies, Gender in Management: An International Journal, International Journal of Manpower, British Journal of Industrial Relations, Gender, Work and Organization, Industrial Relations, ILR Review, Journal of Labor Research, International Journal of Human Resource Management and Journal of Human Resources.* Approximately 19.5% of the articles were published in A* journals; 40% were published in A; 22% were published in B; 8.5% were published in C category journals and the remaining 10% were not listed in ABDC but indexed in SCOPUS or SSCI. The spread of authors revealed that they came from 16 countries.

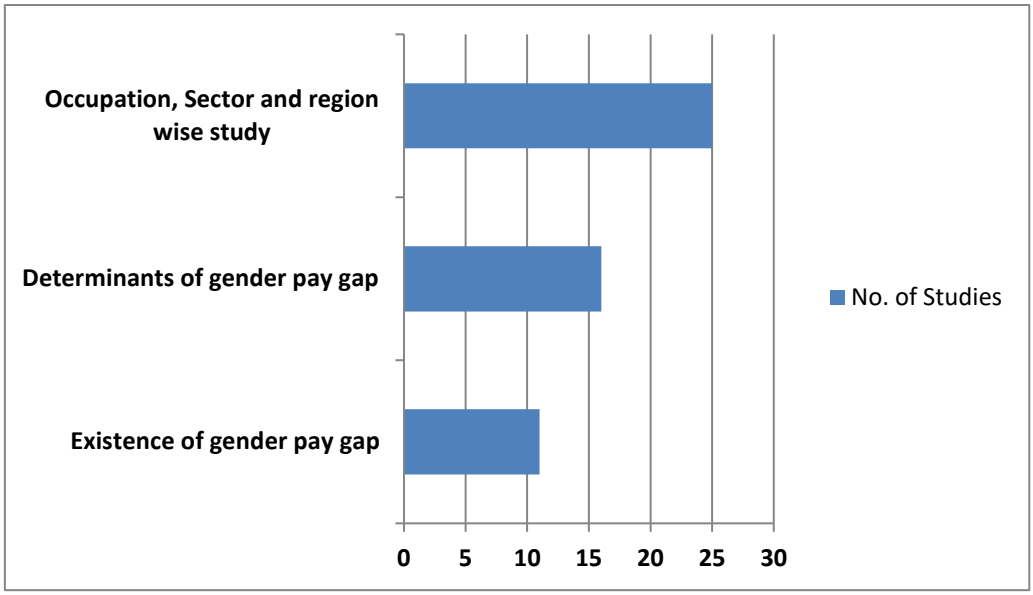
The selected research article were further categorized based on the country studied, however it is important to note that very less number of studies have been conducted in the context of developing countries. Undoubtedly, studies are still being more intensely conducted in developed economies as compared to those in emerging economies and the highest numbers of articles are published in the context of USA followed by UK and Germany.

Effort has been undertaken in conducting the citation analysis of top ten papers, helps to study the impact and assumed quality of an article. The work of Arulampalam and Bryan (2007) has received the highest number of citation with 1430 citations followed by Blau and Kahn (2003) achieving the second position with 1216 and the third position is occupied by Olivetti and Petrongolo (2008) with 659 citations.

Results and discussion

The identified articles were further analyzed for their content and to identify the themes/focus area of research, duly presented in Figure 1: Recurring themes of gender pay gap in the context of its effect on individuals and organization. It includes a list of themes associated with the gender pay gap in the workforce and includes studies directly or indirectly, related to gender as a significant predictor of the pay gap.

Figure 1: Recurring themes of gender pay gap in the context of its effect on individuals and organization



Occupation, sector and region wise study: Various studies are identified in the related area, based on occupational discrimination, sector and region (Leuze & Strauß, 2016; Couppié, Dupray, & Moullet, 2014; Hirsch, König, & Möller, 2013). According to Blau and Kahn (1992), in eight industrialized countries the female/male earnings ratios were between 0.62 and 0.77. The US female/male ratio was 0.69. In Latin American and Caribbean countries, the earnings ratios ranged from 0.55 to 0.99, mostly between 0.6 to 0.8 (Terrell, 1992). Looking at wage ratios of male female, it has been identified that there are several factors affects the wage ratios and productivity in different countries viz; education, experience, ability, labor market, occupation, and other individual differences.

A larger portion of the gender earnings gap can be attributed to firm-level characteristics than individual characteristics and female managers tend to have fewer firm-level characteristics that are associated with higher pay, and when they do, they tend to receive a smaller pay premium for those characteristics (Xiu, 2013).

Existence of gender pay gap: Wage structure has an important effect on the gender pay gap across a broad variety of countries (Blau & Kahn, 2003). Significant gender differences in compensation were noted across all levels, among CEOs, women were compensated 27 percent less than their male counterparts and among executives, women were compensated 29 percent less than male counterparts (Orser & Leck, 2010) but Grajek (2003) have identified that to satisfy excess demand for labor females were needed as the educational attainment of females was an average higher than males in the year 1988/89 and women have gained various advantages like maternity benefit with an allowance and the principle of equal pay for equal work, international standards participation rates of women have been increased by these policies and attitudes.

There are significant pay gaps between men and women throughout the world including the UK, Australia and the USA despite Equal pay legislation in numerous western countries (Women & Work Commission, 2009). However, the main reason of gender earnings gap which have been found in many countries is lower female net supply and wage structure (Blau & Kahn, 2003).

Determinants of gender pay gap: There are many facets of gender inequality, and in the current scenario, it is defined as "professional inequality" identified as discrimination in terms of employment, remuneration, promotion at work and even occupation that acts as a barrier for women's advancement at the workplace. One of the studies using a conceptual framework found that individual factors as pay expectations, gender role orientation, perceived pay fairness, gender, age, marital status and education facilitate the perceived gender pay gap (Khoreva, 2011). The identified factors are presented in a tabulated form below:

Table 2: Literature review on factors leading to gender pay gap

S. No.	Factors	Reference	Findings
1.	Educational Choice	Chevalier (2007)	Differences in subject choices may increase gender pay gap as subjects most popular with women are associated with lower grades, higher risk of unemployment and lower average pay
2.	Occupational Choice	Chevalier (2007); Kara (2006); Solberg (2005)	Women generally prefers to work in a female-dominated and in a limited number of occupations associated with lower wages
3.	Career Gap	Chevalier (2007)	Gender differences in career expectations have been found in many studies and 28% of women strongly agree that they expect to take a career break for family reasons but only 2% of male graduates do.
4.	Negotiation Skills	Crothers et al. (2010); Kara (2006)	Salary equity in the workplace remains a challenge for women as women's lack of confidence in their negotiation skills perpetuate the disparity in compensation packages between men and women
5.	Personality Trait Effects	Chevalier (2007)	Leadership, motivation, self-esteem, aggression, beauty and cleanliness are among the traits positively correlated with wages and therefore associated with gender pay gap
6.	Social Attitude	Srinivas (2007); Janssen, Tuor Sartore, and Backes-Gellner (2016)	Significant and negative correlations have been found with an increase in pay among women who became more traditional, whereas no significant correlation was observed among those who became less traditional in their social attitudes.

Source: Authors Own Compilation

The gender pay gap is lowest for women who are never married; these women earned 26.53% less than men. Married and divorced women face a greater gender wage gap where women earned 35% and 28.53% less than men (Varkkey & Korde, 2013).

Albrecht et al. (2003) found a sharp acceleration of the gap in the upper tail of the wage distribution and interpreted it as the result of a "glass ceiling" which prevents women from reaching high wages. Glass ceiling is a metaphor for the hard-to-see informal barriers that keep women from getting promotions, pay raises and further opportunities. Indeed, women are characterized by more discontinuous careers and they are not so career oriented, choose jobs which require less labor because they generally believe that they will spend fewer years in any company in comparison to men so firms would offer them lower wages since they take the risk of facing their poor productivity (Jellal et al., 2007).

Conclusion

Gender Pay Gap has emerged as an important area of research not only from the perspective of management but its social aspects have far reaching implications. Gender Pay Gap is manifested not only at the organizational level but also sector wise differentiation exists. This can be

attributed to the different job profile, the required competencies for it including Job demands. However considering the importance of diversity management and need for multi-skilled teams, gender balance becomes an important issue. An important contribution of the study has been identification of the themes or research focus area in the identified area of research i.e gender pay gap as well its determinants. The main factors identified are both person and personality centric as well as organization-centric. These are identified as educational choices, occupational choices, career gap, negotiation skills, personality trait effects and social attitude. However it needs to be empirically validated. Such an intervention would further help the industry and the society at large to provide policies and programs to support the growth and well being of the fairer sex.

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Exploring the Role of Behavioral Intention and Trust in Technology Adoption: A Meta-UTAUT Model Approach

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Abstract: This paper discusses the adoption of the meta UTAUT model incorporating trust. The model consists of PE, EE, SI, FC, and trust as independent variables, attitude as a mediating variable, while BI and UB are the dependent variables. A sample size of 279 users drawn from urban and rural settings was done. The suggested model was experimented through structural equation modelling (SEM). The outcome of this study indicates that BI is positively affecting the UB and becoming the strongest predictor of it. Importantly, trust is also affecting in a favorable way BI and UB. FC and EE play vital roles in building the attitude of the user. EE, PE, and BI-even SI-found not so strong in predicting BI. BI as the strong predictor came in the finding so it can contribute in predicting the behavior of the user. The study focused more on the role of trust and user experience. Limitations include the study's context-specific nature and reliance on self-reported data.

***Keywords**:* Behavioral Intention, Usage Behavior, Trust, UTAUT, Technology Adoption, Facilitating Conditions, Effort Expectancy, Social Influence

Introduction

Mobile payment systems have emerged as a solution to replace cash transactions in the digital financial landscape. They have successfully transformed how users conduct financial transactions across geographies. However, challenges persist at various levels in emerging economies, such as India.

The widespread influence of mobile device-based payment systems has surpassed all other innovations in human history, making them an integral part of contemporary society in the 21st century (Thakur & Srivastava, 2014). These developments have transformed the otherwise static processes of money transfer into digital versions accessible through mobile devices (Thakur & Srivastava, 2014). The technological advancements and a digitalized economy have propelled exponential growth in the mobile payments domain in India. This trend has been pivotal to the economic development process and facilitated financial inclusion, which has heretofore been unobtained for the poor strata of Indian society (Demombynes, 2012).

The paper looks forward to the rapid expansion and potential growth of the mobile payment wallet in the upcoming years. It is estimated that the compound annual growth rate (CAGR) of

mobile payment wallets will reach 23.9% between 2023 and 2027 (Livemint, 17 May 2023). The adoption of such technologies, like mobile payment systems, is influenced by various factors (Alalwan et al., 2016a). The literature has looked at mobile phone usage from many different angles. For example, there is work on tracking travel patterns (Medeiros et al., 2022), studying digital financial services (Jadil et al., 2021), and examining mobile commerce (Marinković et al., 2020). There is also considerable scholarly work on mobile learning and healthcare domains (Alghazi et al., 2021; Loh et al., 2021; Arfi et al., 2021).

India, with its extensive population and the increasing penetration of smartphones, becomes an excellent test bed for investigating mobile payment adoption. The rapidly increasing mobile payment in developing countries makes this study relevant (Arjun et al., 2021). With the introduction of mobile payments, it has now become easy to buy goods and services online by using Amazon or Flipkart websites, which helps in making a digital shopping process more efficient and satisfying (M and Roy, 2017; Rastogi et al., 2021).

Much of the previous work on mobile payments in developing economies was focused on the technological, economic, and social factors influencing user behavior. The role of trust and behavioral intention in mobile payment systems is a gap in the literature that has not been explored much in emerging economies like India. Although trust is the most important element of technology adoption, its applicability in the model, like UTAUT, is relatively less in mobile payments. The proposed model intends to bridge this gap by further developing the META-UTAUT (Dwivedi et al., 2019) model by integrating trust, providing further insight into factors that are driving behavioral intention towards mobile payment adoption in a developing country such as India (Al-Saedi & Al-Emran, 2021). This research contributes to filling that gap in the literature and advancing our understanding of digital financial inclusion in emerging markets.

This study addresses these knowledge deficiencies through three main objectives:

1.To provide a detailed analysis of the technological adoption models currently in use and identify the underlying factors influencing Indian consumers' behavior toward digital payment ecosystems., 2. To study how trust impacts the growth of electronic payment practices (Rahman et al., 2022). 3. To validate the conceptual model designed for this study by gathering information from a relevant subset of Indian mobile payment users.

The results of this research are relevant for stakeholders in the mobile payments system, including the providers of payment systems, marketers, and policy makers.

Theoretical part

The first to articulate the UTAUT framework was Venkatesh et al. in 2003 to provide an adequate and more detailed model of explaining the technology adoption and usage process. The META-UTAUT model developed by Dwivedi et al. (2019) has also gained momentum on account of the complex and evolving characteristics of technology acceptance in emerging technological environments. The META-UTAUT model upgrades the classical UTAUT model by bringing forth additional constructs, with emphasis placed on relevant applications in respective domains. In this study, we adapt and further extend the META-UTAUT model, and include Trust as another factor and then investigate its implications toward behavioral intention and usage behavior, all within mobile payment systems.

Performance expectancy (PE)

PE is explained as a consumer expects that while doing any job, the use of technology can increase the performance in a better way (Venkatesh et al., 2003). On the basis of the abovementioned statement, PE is an important variable to predict new technology. In the past, some studies have confirmed the advantageous impact of PE in encouraging people to continue using digital automation such as the World Wide Web (Zhou, 2011a). Researchers Marinkovi´c et al. (2020) and Chong (2013) have found that PE is a strong indicator of customer happiness with digital payment use.

Effort expectancy (EE)

EE reflects how a technology is so easy to use and how it affects the intention to use that particular technology (Venkatesh et al., 2003). EE has a forthcoming beneficial influence on users' intention to continue using mobile applications (Kang, 2014; Fang and Fang, 2016). With the use of a UTAUT-based model, Marinkovi´c et al.,2020 confirmed that EE had a considerable impact on satisfaction with regard to the continuation of digital payment usage

Social influence (SI)

SI states to the amount to which users of a certain tech are encouraged by others (such as family members, neighbours, & coworkers) to use that technology (Venkatesh et al., 2003). Users' intents to keep utilizing digital applications are significantly influenced by SI, which is a significant variable in UTAUT (Lai and Shi, 2015).

Facilitating conditions (FC)

In order to use technology effectively, an individual must have a supportive environment in place, which includes both technological and organizational support (Venkatesh et al., 2003). Originally, UTAUT believed that facilitating conditions predicted actual use behaviour. Possibilities to use new technologies expand when perceived resources, expertise, and cooperation are available. Facilitating conditions lower possible obstacles to technology adoption (Blok et al., 2020).

Trust

Trust in this study is a major determinant of both behavioral intentions and usage patterns. In mobile payment systems, the concept of trust is very important since users often have to provide sensitive financial information to both primary and tertiary systems. Prior research suggests that trust can improve technological behaviour intentions (Sarkar et al., 2020). Zhou (2013) said that even though mobile phones aren't always safe and there are risks that come from that, trust is a big part of how people use them and how likely they are to use them. When it comes to mobile payments, customers are expected to disclose their sensitive financial information to both 1st & 3rd payment systems (Wang et al., 2019a). This requires increased trust to establish behavioural intention.

Attitude (ATT)

The attitude (ATT) towards the usage behaviour of online tax return reporting systems The extent to which a person feels favourably or unfavourably about a product or service is an example of their attitude (Ajzen, 1991). A strong association between attitude and behaviour has been found in online retail, information systems (Dwivedi & Weerakkody, 2007; Ismagilova et al., 2020), tourism (Tolkes, 2020), and services (Rahman et al., 2019). Attitude is a significant predictor of behavioral intention across various contexts, including mobile

banking and e-wallet usage. In mobile banking, attitude directly influenced behavioral intentions, highlighting its importance in user acceptance (Handayani, W. P. P. ,2023). A positive or negative attitude can influence one's decision making and ultimately their actions. As a result, having a positive attitude about a mobile payment system can have a beneficial influence on a user intention to act in a certain way.

Behavioural intentions to use mobile payment systems

The META UTAUT model relies heavily on the concept of BI, which quantifies an individual's propensity and motivation to carry out a given behaviour. It is hypothesised by researchers that intention may be able to convey the variety of individual motivations that drive a behaviour. As a result, the likelihood that a person will carry out the action that is the focus of their intentions is directly proportional to the strength of those intentions (Ajzen, 1991). A number of research, such as the one conducted by Sivathanu (2019), have shown that there is a substantial association between BI and the actual use of electronic payments.

H1: ATT and BI are positively related.

H2: The Impact of BI on UB is positive.

H3: EE positively affects ATT.

H4: EE has a favorable impact on BI

H5: FC has a positive impact on ATT

H6: FC is positively related to BI.

H7: PE is positively related to ATT

H8: PE is positively related to BI.

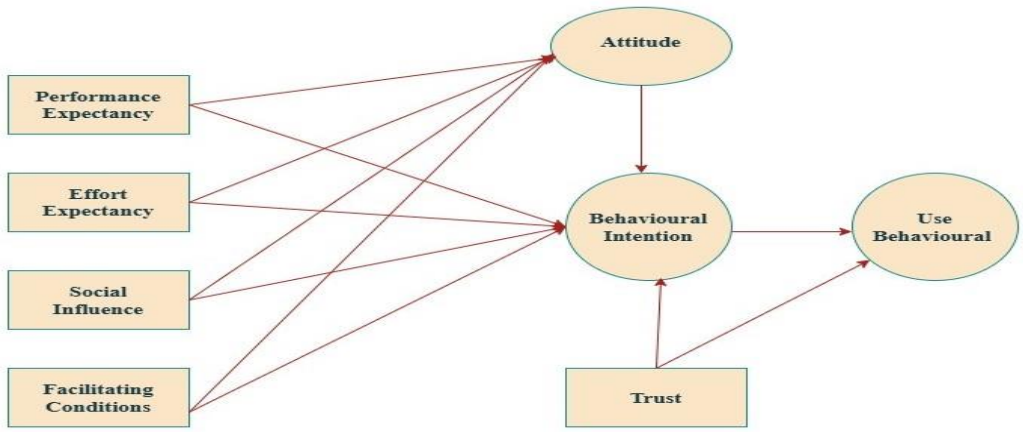
H9: SI positively impacts ATT.

H10: SI will positively influence BI.

H11: Trust shall have a positive impact on BI.

H12: UB will be influenced positively.

Figure 1: Proposed Research Model



Source: own research

Aim, methodology, and data

The methodology of this work is purely based on the enumerative tools and techniques to cross check the intention to use MPS among users of Uttar Pradesh. This research design allows to collect the empirical data, and the statistical tools explore the associations between the independent, mediating, and outcome variables.

Research Model

In 2019 The research model for this study is based on the meta-UTAUT model, which was originally proposed by Dwivedi et al. (2019). The model includes PE, EE, SI, FC, and trust as the independent variables, attitude as the mediating variable, and BI and UB as the outcome variables. The research aims to assess the effect of these variables on individuals' intents to use m-payment services.

Sampling

This research dataset was gathered through interviews conducted in several districts across the state of Uttar Pradesh, India. The sample size comprised 279 individuals, as selected through a purposive sampling technique. A purposive sampling technique was used to collect the sample to ensure diversity in terms of age, gender, occupation, and educational qualifications of the participants in order to enhance generalizability.

Table 1: Demographic characteristic of respondents

Demographic Characteristic	**Category**	**Percentage (%)**	**Number of Respondents**
Age Distribution	18-25 years	20%	56
	26-35 years	25%	70
	36-45 years	30%	84
	46-60 years	15%	42
	60+ years	10%	28
Gender Distribution	Male	55%	153
	Female	45%	126
Occupation	Salaried Employee	30%	84
	Business Owner/Entrepreneur	20%	56
	Self-employed/Freelancer	15%	42
	Student	20%	56
	Homemaker	15%	41

Educational Background	No formal education	5%	14
	Primary education	10%	28
	Secondary education	30%	84
	Graduate	40%	112
	Postgraduate	15%	41
Income Distribution (Monthly)	Less than ₹20,000	25%	70
	₹20,000 - ₹40,000	30%	84
	₹40,000 - ₹60,000	20%	56
	More than ₹60,000	25%	69
Payment Adoption	Adopted Digital Payments	80%	223
	Did Not Adopt Digital Payments	20%	56

Source: own research

This study's respondents totaled 279, with a balanced distribution across important demographics. The sample's age range is wide, with the bulk lying between 26 and 45 years. Gender representation is slightly biased towards males. Respondents are predominantly salaried employees, business owners, and students, with a sizable proportion having completed graduate studies. Most responders earn between ₹20,000 and ₹60,000 per month. Notably, 80% of participants have adopted digital payments, largely using UPI and mobile wallets, citing convenience as the primary reason for their decision.

Data Collection Instrument

A systematic questionnaire was created based on the meta-UTAUT model, with information from relevant literature. The questionnaires contained items for both independent, mediating and outcome variables, which each used a Likert scale range from 1 to 5. This scale has a range or standardization on each point. The items in the questionnaire were, therefore, tested for clarity and reliability and validity by taking a small pilot sample using pretesting. Henseler, Ringle and Sinkovics, 2009; F. Hair Jr. et al. (2014) and Henseler, Ringle, and Sarstedt (2014) recommended that construct reliability and validity could be measured through calculation of several metrics like Cronbach's alpha, composite reliability, Rho_A, AVE, and HTMT. Other than this, both Cronbach's alpha and composite reliability were above the threshold of 0.7, thus construct reliability was established (Table 2) (Hair et al., 2017, 2019).

Furthermore, all calculated AVE values were higher than 0.5, showing convergent validity, whereas the offered HTMT values were below the limit of the acceptable value and hence guaranteed discriminant validity, and this is represented in table 3 as well (Henseler et al. 2014; Sarstedt et al., 2020).

Table 2: Reliability & Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ATT	0.904	0.906	0.929	0.723
BI	0.855	0.856	0.912	0.776
EE	0.891	0.892	0.925	0.755
FC	0.887	0.888	0.922	0.747
PER	0.877	0.881	0.924	0.802
SI	0.858	0.859	0.914	0.779
TRUST	0.827	0.831	0.896	0.743
UB	0.849	0.853	0.908	0.767

Source- Author calculated values through SmartPLS 4

Table.3 Discriminant validity

	ATT	BI	EE	FC	PER	SI	TRUST	UB
ATT	**0.85**							
BI	0.691	**0.881**						
EE	0.651	0.68	**0.869**					
FC	0.651	0.705	0.643	**0.864**				
PER	0.667	0.71	0.729	0.672	**0.896**			
SI	0.67	0.71	0.727	0.701	0.798	**0.883**		
TRUST	0.656	0.736	0.639	0.637	0.683	0.677	**0.862**	
UB	0.728	0.771	0.752	0.707	0.788	0.777	0.721	**0.876**

Source- Author calculated values through SmartPLS 4

Data Collection Procedure

The data collection procedure involved administering the questionnaire to the selected respondents through face-to-face interviews. Trained interviewers conducted the interviews and explained the purpose of the study to the participants. The confidentiality and anonymity of the respondents were ensured, and their informed consent was obtained prior to data collection. The interviews were conducted from March to May 2024.

Results

The analysis revealed that attitude has a favorable impact on the BI with (β=0.158, $p<0.05$) and behavioral intention has a positive impact on use behavior with (β =0.524, $p<0.05$) respectively leading to the acceptance of the formulated hypotheses. Similarly, effort expectancy also positively affects attitude with ($\beta = 0.213$, $p < 0.05$). However, effort expectancy failed to affect behavioral intention. The other key variable of the model facilitating condition (FC) has a positive effect on both attitude and behavioral intention with ($\beta = 0.257$, $p < 0.05$) and ($\beta = 0.204$, $p < 0.05$) leading to the acceptance of the formulated hypotheses. Similarly, the other two constructs of the examination PE and SI have a positive impact on the attitude but both of them failed to impact BI with ($\beta = 0.114$, $p > 0.05$) and ($\beta = 0.094$, $p > 0.05$). The other key variable under study trust reflected a positive impact on both BI and usage behavior thereby

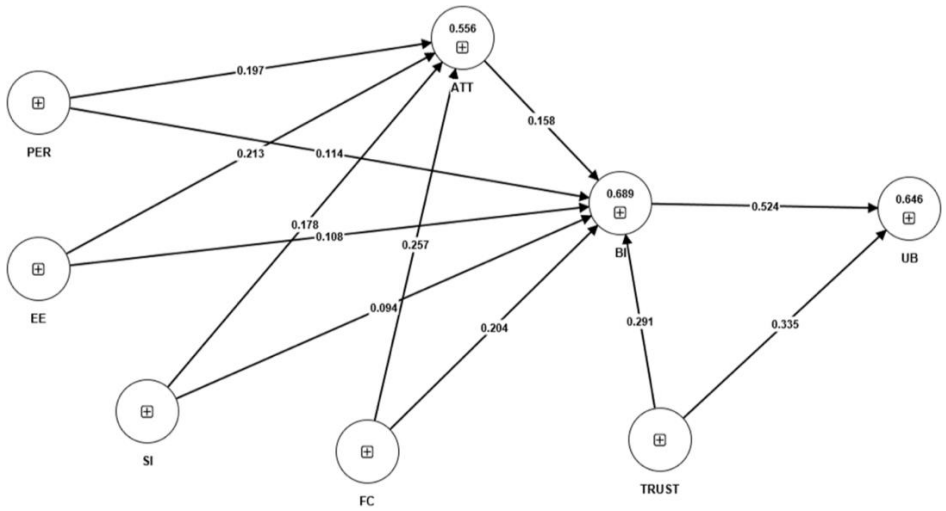
again establishing the relevance of trust as a key predictor affecting intentions to use m-payment in an emerging economy (see Table 4 and Fig.2).

Table 4: Path–coeficcient

	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
ATT -> BI	0.158	0.057	2.794	0.005
BI -> UB	0.524	0.072	7.243	0
EE -> ATT	0.213	0.08	2.672	0.008
EE -> BI	0.108	0.066	1.638	0.102
FC -> ATT	0.257	0.062	4.117	0
FC -> BI	0.204	0.055	3.677	0
PER -> ATT	0.197	0.089	2.214	0.027
PER -> BI	0.114	0.067	1.699	0.089
SI -> ATT	0.178	0.081	2.209	0.027
SI -> BI	0.094	0.07	1.34	0.18
TRUST -> BI	0.291	0.068	4.274	0
TRUST -> UB	0.335	0.071	4.726	0

Source- Author calculated values through SmartPLS 4

Figure 2: Author generated model



Discussion & Conclusion

This research's results draw important understandings in regarding the relations between the distinct factors influencing user behavior as well as intentions. One of the hypotheses receiving very strong support is H2, that states the variable BI indeed influences UB positively, meaning BI positively has influences on UB. This was such a very high t-score of 7.243 and with a p of 0, where UB is really dependent on it for real usage to become possible. It shows that once people have the intention to do something, they are highly likely to do it.

Others include H11 and H12, which seek to support the participation of TRUST toward BI and UB, respectively.

The strong positive association found between TRUST and BI (t-statistic 4.274, p-value 0) as well as between TRUST and UB (t-statistic 4.726, p-value 0) highlights the significant factor of trust in enhancing intention to use and actual usage of a service or good. This result is supported by previous researches in which trust was cited to be one of the main issues that affect behavioral outcomes based on various scenarios. The research further ascertains the existence of a significant relationship between FC and both ATT and BI, as explained by hypotheses H5 and H6. This would mean that when the individual recognizes the availability of resources and support, he or she would be likely to have positive attitudes and a stronger intention to engage in the behavior.

We find another critical result that the positive influence of EE on ATT (H3), and it suggests that if a user finds a system easy to use, they have better attitudes toward it.

However, all hypotheses were not supported. For example, H4 and H8 which asserted that EE would have positive effects on BI while PE will have positive effects on BI were not supported. Thus, it may be the case that ease of use and performance expectations have no bearing on the intention to use in this case. It is also true that SI had no influence on BI (H10) because social pressure was not seen as a salient driver of behavioral intention in this context.

In summary, the results indicate that a significant role in predicting an actual usage behavior is portrayed by Behavioral Intention, yet Trust and Facilitating Conditions also played a significant part. The failure to support several hypotheses does suggest that context dependence in the interrelation may exist, which means simply that more research needs to be conducted to study all these interactions across different environments.

This section begins by providing a concise summary of the obtained results. Subsequently, it establishes a connection between these findings and prior research, followed by an exploration of both theoretical and practical implications stemming from the results.The data from 279 participants in the questionnaire survey were utilized to assess a model rooted in the meta-UTAUT framework (Dwivedi et al., 2019).

The outcomes of this research paper provide noteworthy insights into relationships between various factors influencing user behavior and intentions. The most strongly supported hypothesis is H2, which proposes that BI has a positive effect on Usage Behavior (UB). This finding, with a very high t-statistic of 7.243 and a p-value of 0, underscores the critical role of BI in driving actual usage behavior. It suggests that when individuals intend to perform a behavior, they are highly likely to follow through with that intention.

Theoretical implications

It makes the existing literature richer because it illustrates the critical function of Behavioral Intention (BI) as the best predictor of actual usage behavior (UB), which means that the credibility of the models that rely on intention as a major precursor to behavior is strengthened. The strong influence of Trust on both BI and UB strengthens the theoretical understanding of trust as an essential component in technology acceptance and usage models. Furthermore, the findings show that FC significantly affect ATT and BI, thus supporting the notion that external support and available resources are essential in shaping user perceptions and intentions.

Surprisingly, the work presents a challenge to some well-established theories arguing that EE and PE do not have direct effects on BI in this context, even pointing to a hint that their influence may be much more context-dependent than previously thought.

Besides the weak effect of Social Influence on BI, its common applicability as a predictor in technology adoption models in contention arise, which even suggests that social factors may not always have something to do with shaping user intentions. Such insights allow revisions of existing models and guide future researches to explore such relationships in diverse contexts.

Practical implication

Practically, it will be significant that the users' Behavioral Intentions will be enhanced since it turns out to be the best predictor of the actual usage behavior. This can perhaps be done through focused marketing efforts and user education programs. Practical outcomes indicate that organizations should focus more on the development of user's Behavioral Intentions because it is the strongest usage predictor of actual usage behavior. Strategic marketing, educational efforts made to the users, as well as individualized experience aligned with user needs could be used for this reason. Trust building is very important because it has also been found to influence not only BI but also actual usage behavior. This objective will involve assurances of transparency, data protection, and reliable services. Improving FC, that is, availability of all necessary resources and support for the use of a new technology, will enhance the positive attitude and intention towards its adoption. Another factor is the user experience because user-friendliness yields more positive perceptions and adoption rates. Lastly, because SI had little influence on BI, there could be fewer social pressure drivers and more intrinsic motivators to fuel user engagement. Building trust about the innovation is also relevant since it highly influences BI; however, it mainly determines usage behavior. Here, transparency, data security, and reliance on the service will be saviors. The conditions of facilitation, like resource provision and support, would enhance attitudes and intentions. The simpler the user experience is, the more positive attitudes and higher adoption rates are likely to be. Finally, since SI has little effect on BI, organizations might not focus too much on social pressure but instead rely on the intrinsic factors to motivate their users to engage.

Limitations

The current study provides important insights; however, it is not without its limitations. The findings of the research are limited to a certain context and may not generalize across various industries or demographics of users. The low sample size and particular attributes of the demographic could limit the generalizability of the findings. The final limitation is that it relied on self-reported data that could be prone to bias in terms of social desirability or the accuracy of response. Third, some of the relations, like EE and SI, were very weak and indicated that there may be more unmeasured variables affecting BI in different contexts. Finally, the cross-sectional research design only captures a point-in-time view, making it difficult to assess the change in user behavior or attitude over time. Longitudinal studies would better provide deeper insights into the development of these relationships.

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Proceedings of

10th International Scientific Conference

Economics, Management, Finance and Social Attributes of Economic System (EMFSA 2025)

July, 4-7, 2025

Published by: BCSS. L.L.C, Považská Bystrica, Slovakia

This publication has not been linguistically corrected.

The authors are responsible for substantive, professional level and linguistic accuracy of abstracts and papers.

ISBN: 978-80-973642-7-4