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TABLE OF CONTENT

FOREWORD.....	1

ACCOUNTING.....	3

ACCOUNTING – TRACK 1: Perspectives on Reporting Challenges.....	4

EXPLORING SUSTAINABLE PRACTICES: A CASE STUDY ON NON-FINANCIAL REPORTING IN THE SPANISH TOURISM SECTOR.....	5

Petra BARIŠIĆ
Dijana VUKOVIĆ
Alba CARDIL FORRADELLAS

CURRENT DEVELOPMENTS IN IFRS – A CRITICAL SPOTLIGHT ON SDG ALIGNMENT.....	17

Gunther MEEH-BUNSE
Katja LUER

ESG IN THE SPOTLIGHT: UNVEILING THE ROLE OF INTERNAL AUDITS IN THE MONTENEGRIN BANKING SECTOR.....	37

Sofija SEKULIĆ
Nikola DRAŠKOVIĆ
Jelena JOVOVIĆ

VALUATION OF LIFE INSURANCE CONTRACTS WITH SUPPLEMENT INSURANCE - AN APPROACH IN THE CONTEXT OF IFRS 17.....	48

Silvia ZELINOVÁ
Jana ŠPIRKOVÁ
Mária KAMENÁROVÁ

ECONOMICS.....	65

ECONOMICS – TRACK 1: Growth, Development, and Economic Resilience.....	67

THE ROLE OF INSTITUTIONS IN SUPPORTING ENTREPRENEURSHIP AND THE ECONOMIC GROWTH OF SELECTED EUROPEAN TRANSITION COUNTRIES 68

Esma FRLJAK
Lamija BIBER

IMPACT OF FILTERING METHODS ON CONVERGENCE DETECTION: A MONTE CARLO ANALYSIS USING THE PHILLIPS AND SUL MODEL..... 86

Goran MARKUŠIĆ

EFFECTS OF THE INVESTMENTS FINANCED BY EU FUNDS ON THE ECONOMIC ACTIVITY IN CROATIA..... 96

Davor MIKULIĆ

DEVELOPMENT OF THE BALTIC COUNTRIES' EXPORT NETWORK 110

Vaiva PETRYLĖ

REGIONAL CONVERGENCE OF INNOVATION ECOSYSTEMS: CASE OF CENTRAL AND EASTERN EUROPEAN COUNTRIES..... 123

Davor VLAJČIĆ

EXPLORING HEATFLATION: HOW CLIMATE CHANGE CONTRIBUTES TO INFLATIONARY PRESSURES 139

Berislav ŽMUK
Hrvoje JOŠIĆ

ECONOMICS – TRACK 2: Public Policy, Governance, And Sustainability 155

TAX COLLECTION EFFICIENCY IN CROATIA: A COMPARATIVE ANALYSIS 156

Fran GALETIĆ
Dora WALTER

SUSTAINABILITY AND ESG MATURITY OF LARGE EUROPEAN FINANCIAL INSTITUTIONS: A STATE-OF-THE-ART AND FUTURE RESEARCH DIRECTIONS 170

Ana IVANIŠEVIĆ HERNAUS

A STATISTICAL BREAKDOWN INTO THE EU-27 ENVIRONMENTAL TAXATION. PROFILING REGIONALITY SPECIFICITY IN A DECADE OVERVIEW..... 185

Andreea PERNICI
Stelian STANCU

CONSUMER ATTITUDES TOWARDS FOOD WASTE IN A SOCIODEMOGRAPHIC APPROACH 201

Petra PLATZ
Huszka PÉTER

ECONOMICS – TRACK 3: Human Capital Dynamics 211

LABOR PRODUCTIVITY AND WAGE ADJUSTMENTS IN CROATIA UNDER INFLATIONARY PRESSURES 212

Katarina BAČIĆ

THE ROLE OF ARTIFICIAL INTELLIGENCE IN BRIDGING THE NEGATIVE EFFECTS OF AN AGING WORKFORCE ON PRODUCTIVITY..... 229

Katja DEBELAK

Primož PEVCIN

GENERATION Z'S VIEWS OF SAVING, RETIREMENT, AND INSURANCE: A COMPARATIVE STUDY OF CROATIA AND SELECTED COUNTRIES 242

Marta HRENAR

Mira KRPAN

WORK ARRANGEMENTS AND FERTILITY INTENTIONS: THE ROLE OF JOB STABILITY AND FLEXIBILITY IN CROATIA..... 255

Marin STRMOTA

Krešimir IVANDA

Marta NIMAC

EDUCATION 266

EDUCATION – TRACK 1: Educational Innovation and Trends 267

PERCEIVED CONSUMER VALUES IN HIGHER EDUCATION: EXPLORING THE ALIGNMENT BETWEEN STUDENT EXPECTATIONS AND INSTRUCTOR PERSPECTIVES IN PRIVATE INSTITUTIONS IN CROATIA 268

Nina ANTIČIĆ

Isabell REPALUST

FROM OCCASIONAL TO DAILY USERS: HOW DOES THE FREQUENCY OF ChatGPT USAGE SHAPE STUDENT PERCEPTION? 284

Irena PANDŽA BAJŠ

OPEN GOVERNANCE AS A PART OF EDUCATIONAL PROGRAMMES: CASE STUDY OF SLOVAK REPUBLIC UNIVERSITIES AND NON-PROFIT ORGANISATIONS..... 293

Katarína VITÁLIŠOVÁ

Mária VAVRÚŠOVÁ

Anna VAŇOVÁ

Peter LACO

FINANCE..... 308

FINANCE – TRACK 1: Navigating Financial Markets and Monetary Flows 309

THE ROBUSTNESS OF THE UNCOVERED INTEREST PARITY (UIP) PARADOX FOR THE HUNGARIAN FORINT 310

Tamás ÁROKSZÁLLÁSI

Gábor Dávid KISS

DRIVERS OF DEPOSIT GROWTH IN NORTH MACEDONIA: AN EMPIRICAL STUDY 325

Milica MILOSHESKA GAVROVSKA

Trajko SLAVESKI

WHAT DOES IT HAVE TO DO WITH ME? – SOVEREIGN RISK AND HOUSEHOLD BORROWING COSTS..... 338

Marko PRIMORAC

Filip BADOVINAC

NETWORK ANALYSIS OF CROBEX: TWO SNAPSHOTS OF MARKET STRUCTURE 350

Silvija VLAH JERIĆ

Davor ZORIČIĆ

Jakov ČORAK

IT..... 364

IT – TRACK 1: Digital Transformation and Technological Innovations .. 365

ROBOTIC PROCESS AUTOMATION: A META-REVIEW AND FUTURE RESEARCH DIRECTIONS 366

Vesna BOSILJ VUKŠIĆ

Ljubica MILANOVIĆ

Dalia SUŠA VUGEC

Lucija IVANČIĆ

KNOWLEDGE, PERCEPTION AND USAGE OF NEW TECHNOLOGIES: RESEARCH ON TOURISM DEMAND IN CROATIA 379

Adriana JELUŠIĆ

Karmen MIKULIĆ

Stela PUŠELJIĆ

DIGITAL TRANSFORMATION AND SUSTAINABILITY IN THE CROATIAN HOTEL INDUSTRY: A COMPREHENSIVE ANALYSIS OF TOP-RATED HOTEL WEBSITES..... 393

Ivan PRANJIĆ
Božidar JAKOVIĆ
Ivan JAJIĆ

A QUANTITATIVE BIBLIOMETRIC LITERATURE REVIEW OF BUSINESS INTELLIGENCE IN CONSUMER-ORIENTED SECTOR..... 406

Ana-Marija STJEPIĆ

MANAGEMENT..... 417

MANAGEMENT – TRACK 1: Business Competencies in the Age of AI.. 419

REGLOBALIZATION: HOW EMERGING TECHNOLOGIES ARE SHAPING THE GLOBAL TRADE..... 420

Vladyslav BATO
Elena KAŠŤÁKOVÁ

AI AND THE FUTURE OF WORK: WAGE INEQUALITY, INDUSTRY TRANSFORMATION, AND RESKILLING BENEFITS 433

Karla Lea ČERKUĆ
Jasminka SAMARDZIJA

ARTIFICIAL INTELLIGENCE AND ORGANIZATIONAL EFFICIENCY: EXPLORING CORPORATE SOCIAL RESPONSIBILITY AS A MEDIATOR IN THE CONSULTING INDUSTRY 446

Soumaya DLIMI
Khawla BERAkkAB
Abir FAZROUN
Imane SIBAI

ARTIFICIAL INTELLIGENCE AND INDUSTRY 4.0 AN OVERVIEW OF THE CURRENT STATE OF RESEARCH AND FUTURE PERSPECTIVES IN BUSINESS AND MANAGEMENT: BIBLIOMETRIC LITERATURE REVIEW 463

Soumaya DLIMI
Zakaria OURICH
Abir FAZROUN
Khawla BERAkkAB
Fatiha LAHNINE
Mohamed LOULID

THE ROLE OF THE DIGITAL AGE AND ARTIFICIAL INTELLIGENCE IN SHAPING DIGITAL CORPORATE CULTURE 479

Natália MIŠÍKOVÁ
Nadežda JANKELOVÁ

MANAGEMENT – TRACK 2: Managing Innovation and Strategic Adaptation in the Digital Era..... 492

CHANGES IN CONSUMER HABITS AFTER THE COVID-19 PANDEMIC AND THEIR IMPACT ON SUPERMARKET BUSINESS MODELS..... 493

Juran GALETIĆ

NAVIGATING DIGITAL ENTREPRENEURSHIP: INSIGHTS FROM A BIBLIOMETRIC STUDY..... 507

Mircea Radu GEORGESCU
Anca Elena LUNGU

EMBRACING ORGANIZATIONAL AGILITY: TRANSFORMATIVE STRATEGIES FOR CREATING COMPETITIVE ADVANTAGE IN THE CORPORATE WORLD – LITERATURE OVERVIEW..... 518

Ina IVEKOVIĆ TAMHINA

LEARNING ORGANIZATIONS FOR VIABILITY IN THE HOSPITALITY INDUSTRY IN THE CONTEXT OF INSTITUTIONAL THEORY: A STUDY OF HOTELS IN ANTALYA, TÜRKİYE..... 529

Nataša RUPČIĆ
M. Bahadır KALIPÇI

AI DISCLOSURES AND BOARDS: ANALYZING THE ROLE OF FORMAL EDUCATION AND GENDER DIVERSITY 544

Darko TIPURIĆ
Elena PERIĆ

MANAGEMENT – TRACK 3: Sustainability and Emerging Business Models 559

THE ROLE OF INNOVATION IN THE CROATIAN METAL PROCESSING INDUSTRY: EXAMINING THE IMPACT OF INNOVATION TYPES AND FIRM PERFORMANCE 560

Tomislav BAKOVIĆ
Stjepan MIHALIĆ
Josip MIHALIĆ

SUSTAINABILITY MANAGEMENT REINFORCED BY THE SERVITIZATION - AN APPROACH TO EVALUATING SUSTAINABLE BUSINESS MODELS 573

Stephan KRESS
Christian SCHAEPERKOETTER

THE STRATEGIC INTEGRATION OF SUSTAINABILITY IN BUSINESS	588
Throstur Olaf SIGURJONSSON	
Svala GUDMUNDSDOTTIR	

EVALUATION FRAMEWORK FOR E-SCOOTER INTEGRATION INTO CITY INFRASTRUCTURE – THE FIRST RESULTS OF HUNGARY	602
Dorottya SZEMERE	
Vivien SURMAN	

MANAGEMENT – TRACK 4: Employees, Work, And Organizational Well-Being	616

NAVIGATING WORK-RELATED IDENTITY LOSS IN RETIREMENT: THE ROLE OF ORGANIZATIONAL CLIMATE AND SOCIAL LIFE	617
Ana BARTOL	
Barbara GRAH	
Darja PELJHAN	

DIGITAL COMPETENCE IN THE WORKPLACE: REVIEW OF ASSESSMENT SCALES	630
Andriana BAZIUK	
Róbert HANÁK	
Matej ČERNÝ	
Anita ROMANOVÁ	

EXPLORING THE LINK BETWEEN PURPOSE-DRIVEN LEADERSHIP AND EXTRA-ROLE BEHAVIOR: THE MEDIATING ROLES OF ENGAGEMENT AND JUSTICE	642
Nikolina DREVEN	
Ivan MALBAŠIĆ	
Lorena PIKL	

HR-RELATED ENABLERS OF HYBRID WORK REGIMES: CRANET DATA-BASED EVIDENCE	653
Soňa ĎURIŠOVÁ	
Jana BLŠTÁKOVÁ	

PLAY AS A TRANSFORMATIVE FORCE: HOW PLAYFUL LEADERSHIP FOSTERS IDENTITY, CREATIVITY, AND INNOVATION	667
Domagoj HRUŠKA	
Marek SZARUCKI	
Ivana MARIĆ	

INDIVIDUAL-LEVEL PARADOXES AND EMPLOYEE PERFORMANCE OUTCOMES: TESTING SUFFICIENCY AND NECESSITY CONDITIONS ACROSS CROATIAN ORGANIZATIONS..... 683

Sara MELKIĆ
Nikolina DRAGIČEVIĆ ROGGE
Matija MARIĆ

MAPPING THE RESEARCH LANDSCAPE OF WORKPLACE PHYSICAL ACTIVITY: A BIBLIOMETRIC REVIEW OF ITS IMPACT ON JOB PERFORMANCE AND EMPLOYEE WELLBEING..... 699

Tamara STANKOVIĆ
Alenka SLAVEC GOMEZEL

MARKETING..... 719

MARKETING – TRACK 1: Contemporary Marketing Strategies and Consumer Engagement..... 720

GENERATION Z CONSUMERS' PERCEPTION OF SHARING PERSONAL DATA FOR MARKETING PURPOSES..... 721

Luka BUNTIĆ
Mate DAMIĆ
Lovro MATIJEVIĆ

JUDGED BY ITS COVER: UNDERSTANDING THE FORMATION OF BOOK TESTIMONIAL NETWORKS..... 732

Jan DOMANSKI
Jonas REIF
Lea SCHAAB
Sebastian SCHÖTTELER
Heidi SCHUHBAUER

EFFECTS OF DIGITAL CHANNEL ACCEPTANCE ON INTERNAL COMMUNICATION CHANNEL SATISFACTION..... 745

Anja ŠPOLJARIĆ

CONFERENCE SPONSORS AND PARTNERS 757

FOREWORD

Dear researchers,

we are delighted to present this comprehensive collection of papers presented at the FEB Zagreb 16th International Odyssey Conference on Economics and Business held in Akademis Academia, Dubrovnik, Croatia and online from May 7th until May 10th, 2025. FEB Zagreb International Odyssey Conference on Economics and Business is an international conference organized annually by the Faculty of Economics & Business, University of Zagreb, Croatia. The aim of the Conference is to bring together researchers and practitioners to present their research and discuss recent challenges in the field of business and economics. Since the first conference in 2002, Odyssey conference provides an interdisciplinary forum for presentation and publication of original, most recent research and critical reviews dealing with topics directly or cross-disciplinary related to business and economics.

This year's conference hosted two distinguished and renowned keynote speakers:

- Professor Arnold B. Bakker, PhD, from Erasmus University Rotterdam, Netherlands
- Professor Nicolai J. Foss, PhD, from Copenhagen Business School, Denmark.

Esteemed professor Bakker delivered a compelling keynote speech under the title “*New Developments in JD-R Theory: AI-Enabled Job Crafting and Playful Work Design*”, while professor Foss delivered a lecture on the provocative topic “*Do We Need a Reset? – Rival Visions of the Future of Management Theory*”. Keynote speeches were succeeded by five parallel sessions, both in person and online, during two days featuring thematic tracks in business and economics topics. During these sessions, authors presented latest research findings and received constructive feedback from fellow participants.

The Proceedings of FEB Zagreb 16th International Odyssey Conference on Economics and Business contain 53 full papers that have passed rigorous double-blind peer review process by at least two international reviewers, experts in the area of the paper, and met all other publishing and editorial policies' requirements. We are especially proud that papers were written by authors coming from all around the globe.

Papers presented at the Conference, both in-person and online, reflect the current concerns in the field of business and economics, including sustainability issues, impacts of artificial intelligence and digitalization, economic growth, innovation, human resources, consumer dynamics and others, which are grouped into seven fields and subfields:

- Accounting (track: *Perspectives on Reporting Challenges*)
- Economics (three tracks: *Growth, Development, and Economic Resilience*; *Public Policy, Governance, and Sustainability*; *Human Capital Dynamics*)
- Education (track: *Educational Innovation and Trends*)
- Finance (track: *Navigating Financial Markets and Monetary Flows*)
- IT (track: *Digital Transformation and Technological Innovations*)

- Management (four tracks: *Business Competencies in the Age of AI; Managing Innovation and Strategic Adaptation in the Digital Era; Sustainability and Emerging Business Models; Employees, Work, and Organizational Well Being*)
- Marketing (track: *Contemporary Marketing Strategies and Consumer Engagement*)

In this Proceedings we proudly present conference papers and believe they will provide valuable insights and provoke further discussion among scholars and practitioners alike.

Editors



ACCOUNTING

TRACK 1: Perspectives on Reporting Challenges

PREFACE

ACCOUNTING – TRACK 1: PERSPECTIVES ON REPORTING CHALLENGES

Accounting is a crucial function within a company that provides relevant financial and non-financial information for decision-making purposes of various internal and external stakeholders. Auditing, both external and internal, on the other hand, provides independent assurance regarding the quality of these information, which increases the confidence of stakeholders in the quality of both financial and non-financial information for their decision-making purposes. Therefore, accounting is a central part of business and exploring topics related to accounting, as well as internal and external auditing, leads to achieving the defined aim and scope of the Odyssey conference. The track “Perspectives on Reporting Challenges” explores various important topics related to accounting and auditing in the contemporary digital era. This track delves into the evolving landscape of financial and non-financial reporting, examining the crucial roles of accountants and auditors.

Barišić, Vuković and Cardil Forradellas investigate non-financial reporting practices in the Spanish tourism sector, focusing on how companies integrate environmental, social, and governance (ESG) factors into their disclosures to demonstrate commitment to sustainable development. Meeh-Bunse and Luer evaluate whether current IFRS advancements adequately support SDG 17’s objectives by focusing on joint venture accounting as the common structure for fostering global partnerships. The paper specifically assesses whether existing regulations provide a sustainability driven true and fair view as per IASB standards and therefore are equipped with an SDG promotional character. Shortcomings are identified, especially in its role as data provider for legislator’s initiatives. In the second paper, Sekulić, Drašković and Jovović analyze the main responsibilities of the internal audit function in implementing ESG principles, according to international reporting standards and directives concerning sustainability reporting in the EU. This paper aims to be the basis for raising awareness among corporate leaders and internal auditors about the importance of ESG factors and their role in long-term sustainable business operations. The third paper by Zelinová, Špírková and Kamenárová proposes a model for valuating portfolio of term insurance contracts with supplement insurance that covers critical illness in terms of the IFRS 17. Collectively, these papers contribute by clarifying modern trends related to financial and non-financial or sustainability reporting challenges.

EXPLORING SUSTAINABLE PRACTICES: A CASE STUDY ON NON-FINANCIAL REPORTING IN THE SPANISH TOURISM SECTOR

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Abstract

This study investigates the role of non-financial reporting in the Spanish tourism sector, focusing on the integration of environmental, social, and governance (ESG) factors in corporate disclosures. Non-financial reporting has become a vital tool for tourism organizations, enabling them to demonstrate their commitment to sustainable development and corporate social responsibility (CSR). Through a case study approach this research analyze the non-financial reporting practices of key players in Spanish tourism sector, highlighting their diverse approaches and commitments to ESG principles, such as carbon reduction, resource efficiency, and social responsibility. The findings reveal a growing trend towards sustainability reporting yet also emphasize the need for standardized criteria to ensure consistent and comparable disclosures across the sector. This research underscores the importance of robust non-financial reporting in fostering sustainable tourism and enhancing corporate reputation in an increasingly environmentally and socially conscious market.

Keywords: non-financial reporting, Spanish tourism sector, sustainability report, ESG, corporate sustainability reporting directive (CSRD)

JEL classification: L83, Q56

Introduction

The tourism sector is a pivotal component of the Spanish economy, substantially contributing to the gross domestic product (GDP) and employment (Krivačić, 2016). Spain, renowned for its rich cultural heritage and diverse landscapes, ranks among the world's leading tourism destinations. According to the World Tourism Organization (UNWTO), the tourism sector accounts for approximately 12% of the national GDP (UNWTO, 2023). However, the rapid expansion of tourism has brought about numerous environmental and social challenges. These challenges include the overexploitation of natural resources,

environmental degradation, employment seasonality, and infrastructural pressures (Vuković, 2019).

In response to the growing global demand for sustainable business practices, non-financial reporting has become a vital mechanism for companies to demonstrate their commitment to environmental, social, and governance (ESG) aspects. Non-financial reporting, also known as sustainability reporting, refers to the disclosure of information regarding a company's ESG performance, which does not directly relate to its financial results (Global Reporting Initiative, 2020). This type of reporting allows organizations to showcase their contributions to sustainable development and corporate social responsibility (CSR), increasingly influenced by regulatory requirements, such as the EU Non-Financial Reporting Directive (2014/95/EU).

The concept of corporate social responsibility (CSR) is closely linked to non-financial reporting. CSR is defined as the voluntary integration of social and environmental concerns into a company's business operations and interactions with stakeholders (European Commission, 2014). CSR encompasses initiatives aimed at reducing negative externalities and enhancing the positive impact of business activities on society and the environment. In this context, sustainable development refers to development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (Brundtland, 1987). In the tourism sector, sustainability implies balancing economic, environmental, and social interests (Načinović Braje et al., 2020).

Furthermore, non-financial reporting serves as a transparency tool, enabling companies to communicate their ESG performance to stakeholders, including investors, employees, customers, and regulatory authorities. Transparency in non-financial reporting can enhance a company's reputation, build trust with stakeholders, and foster long-term business sustainability. In the Spanish tourism sector, companies are increasingly adopting non-financial reporting practices to comply with regulatory mandates and meet stakeholder expectations.

In addition to regulatory compliance, non-financial reporting can provide several business benefits. It can help companies identify and manage ESG risks, improve operational efficiency, and gain a competitive edge in the market. For instance, companies that proactively address environmental concerns, such as reducing carbon emissions and conserving water resources, may achieve cost savings and enhance their market reputation. Similarly, companies that invest in social initiatives, such as employee welfare programs and community development projects, can strengthen their relationships with stakeholders and enhance their long-term viability.

This study addresses a notable research gap in the current literature regarding the extent to which Spanish tourism companies adopt standardized non-financial reporting frameworks. While existing research has generally focused on ESG disclosures across various industries, there is limited insight into how these practices are applied specifically within the Spanish tourism sector under the evolving EU regulatory framework. By examining the sector through the lens of the new Corporate Sustainability Reporting Directive (CSRD), this study contributes to a better understanding of regulatory impact on sustainability reporting and the strategic integration of ESG principles in tourism.

The methodology adopted in this research is qualitative and based on secondary data analysis. Analyzed companies were selected using the following criteria: (1) direct and

indirect involvement in the Spanish tourism industry, (2) availability of sustainability or ESG reports published in 2023 or later, and (3) public accessibility of relevant. The sample includes both IBEX 35-listed companies and non-listed but tourism enterprises to ensure a comprehensive and diverse overview of the sector's sustainability reporting practices.

The concept of non-financial reporting

Non-financial reporting is grounded in the concepts of corporate social responsibility (CSR) and sustainable development. The EU defines CSR as the voluntary integration of social and environmental aspects into business operations and stakeholder relationships (European Commission, 2014). Sustainable development is development that fulfills current societal needs without limiting future generations' capacity to do the same (Pouresmaieli et al., 2024). The connection between CSR and non-financial reporting is becoming increasingly evident, as organizations use reporting as a tool for transparency and communication with investors and the public.

One of the key frameworks for non-financial reporting is the Global Reporting Initiative (GRI), which provides standards for disclosing information about a company's environmental, social, and governance impact (GRI, 2020). Besides the GRI standards, other significant frameworks include the Task Force on Climate-related Financial Disclosures (TCFD) and the United Nations Sustainable Development Goals (SDGs) (Vuković, 2019). The EU Non-Financial Reporting Directive (2014/95/EU) obliges large companies to disclose information on ESG factors, ensuring greater accountability, transparency, and performance (Cuomo et al., 2024) towards stakeholders.

Non-financial reporting is based on various theories that explain its purpose, benefits, and implications for business. One of the most commonly used theories in this context is the legitimacy theory, which posits that companies use non-financial reporting to ensure social acceptance and maintain their legitimacy in the eyes of stakeholders (Suchman, 1995; Peng et al., 2024). This theory emphasizes that organizations that operate in line with societal expectations are more likely to achieve long-term success. The application of legitimacy theory in the tourism sector highlights the need for transparency regarding the environmental and social impact of business operations, thereby increasing consumer and investor trust (Deegan, 2002).

Another relevant theory is stakeholder theory, which emphasizes the importance of corporate responsibility towards various stakeholders, including investors, employees, local communities, and regulators (Freeman, 1984; Awa et al., 2024). According to this theory, non-financial reporting is a tool that enables better management of stakeholder relationships, reduces conflicts, and helps build long-term business strategies based on sustainability (Donaldson & Preston, 1995). In the context of the Spanish tourism sector, the application of stakeholder theory can explain why companies are increasingly disclosing ESG data in their reports, to meet stakeholder demands and strengthen their market position.

Additionally, institutional theory explains how regulatory pressures, norms, and imitation influence the adoption of non-financial reporting in the tourism sector (DiMaggio & Powell, 1983). This theory suggests that companies in the tourism sector implement standardized reporting frameworks to conform to industry norms and reduce regulatory risk (Cerquetti et al., 2024). In Spain, where there is a strong regulatory framework for sustainability,

institutional pressures play a key role in shaping non-financial reporting practices (Krivačić, 2016).

Furthermore, signaling theory provides an explanation for why companies voluntarily disclose non-financial information. This theory suggests that organizations use non-financial reporting to signal their market advantages, reduce information asymmetry, and enhance their competitive edge (Spence, 1973). Studies have shown that companies adopting transparent and standardized non-financial reporting practices achieve better market performance, attract investments more easily, and manage operational risks more effectively (Krivačić, 2016). As well, non-financial reporting can improve organizational reputation, increase investor trust, and enhance long-term profitability (Nacinović Braje et al., 2020).

In the context of Spain, non-financial reporting in tourism plays a crucial role in achieving sustainability. Large hotel groups and travel agencies are increasingly publishing sustainability reports to comply with EU regulations and respond to market expectations. Transparency in ESG reporting allows for a better assessment of environmental and social risks, while providing investors with key information for decision-making (UNWTO, 2023). These practices not only enhance the reputation of tourism companies but also contribute to the long-term stability and competitiveness of the sector.

Non-financial reporting in the Spanish tourism sector

Tourism in Spain has important non-financial dimensions that include the social and cultural impact, the generation of employment, the preservation of cultural, historical and traditional heritage, the confluence and integration between the different cultures of foreign communities and/or the impact on the quality of life of locals (Mathieson & Wall, 1982). Other aspects found are environmental ones, related to the use of resources such as water and energy, waste management, emission of substances (Manniche et. al., 2017) or the effects caused in natural spaces. Among other issues related to tourism, it is found the impact on the real estate market, the demographic structure of specific areas or seasonal population movements. In addition, there is also impact on the level of security, tourist overcrowding and changes in leisure or cultural facilities.

The tourism sector generally has an important effect and, for this reason, the implementation of non-financial reports is of high interest given their importance in the environment in general. The effects that tourism generates on society must be the subject of special attention, since their management is the key factor for the subsistence and sustainability between this type of business and local communities. It is evident that tourism contributes significantly to the Spanish economy (12% of national GDP) (UNWTO, 2023), but it is advisable to closely control its presence and adequately manage its effects.

In a study aimed at the tourism sector in Spain (Camisón-Haba, 2020), it is shown that non-financial reports are the basis of the company's reputation among the different users of interest, and the perception that these users have about the company can affect its results. The non-financial report will only allow the company to be more transparent with the aim of improving its reputation, given the repercussions that this activity has in different areas: environmental, social, cultural, etc. Therefore, the tools linked to non-financial reporting have a relationship in the competitive advantage of companies. Man et. al. (2012) show that management system tools, such as the Balanced Scorecard and the non-financial report, can

alert managers to situations that are different from normality, centralize the information and offer a qualitative approach that can make up for the deficiencies of financial reports. For the tourism sector, the Scorecard is an applied tool in which not only economic-financial criteria are indicated, but also others such as the perception of the tourism company or the improvement of business actions.

There are also certain studies that relate corporate social responsibility (CSR) and performance. This relationship can be influenced by a country's tax system, this is, for example, the case of the Balearic Islands, in Spain, where the government demanded, an additional tax rate to finance environmental improvements. This had a negative effect on tourism within the islands, so the tax was rescinded (Holden, 2009). The research conducted by Moneva et al. (2019) showed that the higher the financial performance of Spanish tourism firms, the lower their commitment to corporate social responsibility issues. On the other hand, the research conducted by Goffi et al. (2022) showed that applying CSR principles, facilitating CSR values, and fostering local economic linkages have a positive and significant influence on performances of Spanish firms operating in the tourism and hospitality industry.

Study of Good Practices in Sustainability for the Tourism Sector prepared by Hotel Technology Institute studies sustainability initiatives implemented by hotels in Spain (ITH, 2023). Although the study highlights examples of good practices, it does not develop in the specific disclosure of ESG information or in the standard application of these practices throughout the tourism sector. Another report by CEOE addresses sustainability as a strategic objective for the tourism sector (CEOE, 2022). However, the report focuses more on the need to ensure the sustainability of Spain as a destination and the competitiveness of the tourism sector, without providing specific details on the disclosure of ESG information or implementation.

As noted, although there are studies related to sustainability in the Spanish tourism sector, there is a lack of research specifically focused on the disclosure of ESG information and its uniform application. This suggests that knowledge about how these practices is applied is limited in the tourism sector in Spain.

Case Study: Non-financial reporting in the Spanish tourism sector

In the case of Spain, in December 2022, a new Sustainability Directive was approved, which replaces Directive 2014/95/EU regarding the disclosure of non-financial information and data on sustainability.

Directive 2014/95/EU proposed an obligation for large companies and groups of companies to submit information on environmental, social, personnel-related issues, human rights and measures against corruption and bribery. Law 11/2018, expanding its scope and further regulates the content of the non-financial information statement, including the mandatory verification by an independent professional of verification services, transposed this directive. In 2021, the different directives were examined, and it was concluded that many companies did not present significant information on sustainability issues. Furthermore, the comparability and accessibility of this information is limited and the scope of application of the regulations is narrow.

Consequently, the objective of the new Sustainability Directive is to address these deficiencies by expanding the scope of application. It includes large companies and groups of large companies, regardless of their stock market listing; small and medium-sized enterprises, with the exception of micro-enterprises, that have issued securities on regulated secondary markets in the EU; insurance companies and credit institutions and subsidiaries or branches established in Spain with parent companies outside the European Union. The content and standards of the report are also regulated: Articles 19bis and 29bis of the CRSD, along with the ESRS prepared by the European Financial Report Advisory Group (EFRAG) and the verification conditions. On the other hand, an electronic report is proposed for greater accessibility. Digitization also makes it possible to consolidate data at the level of the European Union and the Member States, through an open, accessible and comparative format.

In this sense, large companies are those that for two consecutive years, at the closing date of each of them, meet at least two of the following three criteria (according to the new Delegated Directive (EU) 2023/2775 of the Commission, of October 17, 2023): that the total of the asset items exceeds 25,000,000 euros, that the net amount of the annual turnover exceeds 50,000,000 euros and that the average number of workers employed during the year is greater than 250.

The sustainability report should be included in the company's management report, providing the information necessary to understand the company's impact on sustainability issues (environmental, social, human rights and governance factors, including all information related to personnel and the fight against corruption and bribery) and how it affects the development, results and situation of the company. The content must include the company's business model and strategy in the face of risks related to sustainability and ensure compatibility with the transition towards a sustainable economy and the limitation of global warming to 1.5°C. It has to consider emissions reduction targets for 2030 and 2050. The roles of management bodies in sustainability issues should also be described, including their expertise in relation to these roles. The company should detail the exposure to activities related to coal, oil and gas, due diligence procedures and mention of main risks and dependencies. Likewise, a report should include specific indicators on the different sustainability issues and their impacts.

The European Sustainability Reporting Standards (NEIS) are prepared by a non-profit public interest association called EFRAG (European Financial Report Advisory Group). EFRAG prepares general, sectorial, specific NEIS for listed SMEs and voluntary NEIS for non-listed SMEs.

Regarding the deadlines for application of the Directive, it is estimated that it will be: For years starting in January 2024, large listed companies and the dominant entities of listed groups that exceed, in both cases, the average number of 500 employees during the year are required. For years starting in January 2025, large companies and dominant entities of large groups not included in the previous section. For years starting in January 2026, SMEs listed on a regulated market in the European Union, and for those that are not microenterprises, they may choose not to apply until January 1, 2028 (ICAC, 2025).

It is likely that over time the trend will be to replicate all these standards in small and medium-sized companies. Large organizations, which are within the main Spanish stock index called IBEX 35, are pioneers in presenting information on sustainability even before

the respective Directives are approved (Pacto Mundial de la ONU España, 2024). IBEX evaluates 61 indicators covering four thematic areas: measurement and reporting; strategy and governance; targets and reduction; and collaboration and innovation (ECOACT, 2019). As of today, it is not possible to analyse data from the companies that are affected by the new Directive, since it has effects for years starting in 2024, which will close during the current year 2025.

In Spain, 86% of IBEX 35 executives already have remuneration linked to sustainability performance, 86% carry out an equality plan and 97% of companies already issue an express statement supported by senior management on the importance of sustainability in their companies (Pacto Mundial de la ONU España, 2024). 71% of IBEX 35 companies have carbon emissions reduction objectives, while 86% have gender equality plans (ECOACT, 2019).

Within the IBEX 35 there are not just the companies from the tourism sector, but for the purpose of this research the focus will be only on tourism companies, and companies linked to tourism. Tourism in Spain has managed to have space among the most sustainable sectors of the IBEX 35, being a high energy consumption industry that tries to work with renewable energies and energy efficiency technologies. Although the representation of the hotel industry in the IBEX-35 disappears in 2024 with the Meliá Hotels International (2023), the tourism sector remains present through the airline holding company International Airlines Group, IAG (Iberia, British Airways, Vueling, LEVEL and Aer Lingus), the airport manager Aena and the airline technology provider Amadeus. In addition to this, Acciona and Ferrovial are two other companies that have important divisions dedicated to the development and management of tourism infrastructure (Table 1). Besides them, in Table 1 are also listed Spanish tourism companies that are not part of the IBEX 35 but are dedicated to sustainability and provide extensive non-financial reports, those are Meliá Hotels International, NH Hotel Group, Barceló Hotel Group, Globalia, and Hotusa Group. These companies demonstrate a commitment to sustainability and ESG principles through initiatives like waste management, circular economic strategies, employee well-being, resource conservation, CO2 reduction, and above all they are promoting sustainable practices within their respective industries.

Table 1: IBEX 35 Tourism Companies (and NON-IBEX 35) and Their Non-Financial Reporting Practices

Company	Sector	Non-Financial Reporting	ESG Commitments
Meliá Hotels International (2023) (OUT OF IBEX SINCE 2024)	Hospitality	Yes (Sustainability Reports)	CO2 reduction, energy efficiency (ECOACT, 2019)
IAG	Aviation	Yes (ESG Integrated Reporting)	Carbon neutrality by 2050, sustainable fuel (IAG, 2023)
Amadeus IT Group	Travel Technology	Yes (GRI Standards)	Digital sustainability, waste reduction (Amadeus, 2023)
Aena	Airport Management	Yes (Annual ESG Reports)	Renewable energy use, efficiency improvements (Aena, 2023)
Ferrovial (IBEX BUT NOT	Infrastructure (Tourism &	Yes (GRI, UN SDG Framework)	CO2 emissions reduction, ethical governance

Company	Sector	Non-Financial Reporting	ESG Commitments
DIRECT TOURISM)	Transport)		(Ferrovial, 2023)
Acciona (IBEX BUT NOT DIRECT TOURISM)	Sustainable Infrastructure	Yes (Integrated ESG Reports)	Renewable energy investments (Acciona, 2023)
NH Hotel Group (NON-IBEX)	Hospitality	Yes (Sustainability Reports)	Reduction of water and energy consumption (NH Hotel, 2023)
Barceló Hotel Group (NON-IBEX)	Hospitality	Yes (Sustainability Strategy)	Sustainable tourism practices (Barceló, 2023)
Globalia (NON-IBEX)	Travel & Tourism	Yes (CSR and Sustainability Reports)	Employee well-being, environmental impact reduction (Globalia, 2023)
Hotusa Group (NON-IBEX)	Hospitality	Yes (Annual Sustainability Plan)	Waste management, circular economy strategies (Hotusa, 2023)

Sources: Compiled from official sustainability and ESG reports from the respective companies, and verified data published by ECOACT (2019), IAG (2023), Amadeus (2023), Aena (2023), Ferrovial (2023), Acciona (2023), NH Hotel (2023), Barceló (2023), Globalia (2023), and Hotusa (2023)

From the provided data in Table 1, and analysed reports from ECOACT (2019), IAG (2023), Amadeus (2023), Aena (2023), Ferrovial (2023), Acciona (2023), NH Hotel (2023), Barceló (2023), Globalia (2023), and Hotusa (2023), it is obvious that companies that present information on sustainability do not do so in the same way or following the same standard criteria or regulation. One study found that 76% of the selected hotels used websites to disseminate sustainability information but the volume of sustainability discourse was different regarding size, ownership structures and website types (Fernández-Vallejo, 2023). Some of them present information about sustainability in the form of sustainability report, or sustainability plan, others include the information in their integrated reports, while third use GRI or UN SDG standards. This suggests a clear path forward in promoting greater consistency and understanding through the establishment of common, comparable, transparent, and accessible reporting frameworks that fits for all.

Discussion

When comparing the non-financial reporting practices of Spanish tourism companies to those in other European countries, key differences in maturity and approach become evident. For instance, German firms often align their disclosures with the German Sustainability Code and the EU taxonomy regulation, resulting in more structured and climate-specific ESG reporting (BMUV, 2023). In Sweden, sustainability reporting is deeply embedded within corporate governance, and firms frequently publish integrated reports that align with the Global Reporting Initiative (GRI) and Task Force on Climate-related Financial Disclosures (TCFD) recommendations (Swedish Corporate Governance Board, 2022). These countries also demonstrate strong stakeholder engagement practices and regulatory compliance, which contrast with the more transitional state of ESG reporting among Spanish tourism companies. The findings suggest that while Spanish companies are making progress, further alignment with European best practices is necessary to enhance comparability, transparency, and strategic ESG integration.

This study has explored the critical role of non-financial reporting in the Spanish tourism sector, emphasizing the growing integration of ESG principles within corporate disclosures. The analysis of key players, both within and outside the IBEX 35, reveals a clear trend towards increased sustainability reporting, reflecting a heightened awareness of environmental and social responsibilities. However, the diverse approaches observed highlight a pressing need for standardized reporting criteria to ensure comparability, consistency, and transparency.

The implementation of the new EU Sustainability Directive (CSRD) and the adoption of frameworks like GRI and the UN SDGs are driving significant changes in how Spanish tourism companies communicate their sustainability efforts. This research underscores the importance of robust non-financial reporting in not only meeting regulatory requirements but also in enhancing corporate reputation, fostering stakeholder trust, and promoting long-term sustainable development. Despite the progress demonstrated by leading companies, the lack of uniform reporting standards remains a challenge. The findings emphasize the necessity for collaborative efforts to establish common, comparable, transparent, and accessible reporting frameworks. Such standardization would enable a more accurate assessment of the sector's sustainability performance and facilitate informed decision-making by investors, consumers, and policymakers. Ultimately, this study reinforces that non-financial reporting is not merely a compliance exercise but a strategic tool that could drive positive change within the Spanish tourism sector. Sustainability reports are a key element in business strategies, as they help improve the reputation and level of trust that companies generate among their users of interest (ECOEMBES, 2024). For example, hotels operating in Spain are working to adapt to this new reality, shaped by the expectations and demands of travelers, institutions, and their value chain. In this commitment to sustainability, it is essential to consider management based on the principles of sustainable development with the implementation of initiatives that are framed as good sustainability practices. Society's growing commitment to the values of sustainable growth is generating an increase in demand for products and services aligned with sustainability (ITH, 2023). Environmental sustainability of the hotel sector is increasingly important to all industry stakeholders, including owners, investors and, increasingly, customers (Gomez-Guillen & Tapias-Baqu, 2024). By embracing transparency and accountability, tourism companies can contribute to a more sustainable and responsible future, ensuring the sector's continued success in an increasingly environmentally and socially conscious market.

Conclusion

A central contribution of this research is the clear identification of the lack of standardized reporting criteria across Spanish tourism companies. The paper states that companies present sustainability information in different ways, hindering comparability and consistency. This highlights a significant gap in current practices and underscores the need for the establishment of common, comparable, transparent, and accessible reporting frameworks.

Even this study provides valuable insights into non-financial reporting practices within the Spanish tourism sector, it is essential to acknowledge certain limitations. Firstly, the case study approach, while allowing for in-depth analysis of selected companies, may limit the generalizability of the findings to the entire Spanish tourism industry. The selection of key players, predominantly large companies and those within the IBEX 35, might not fully

represent the diversity of sustainability practices across all sizes and types of tourism enterprises, particularly SMEs, which constitute a significant portion of the sector. Secondly, the reliance on publicly available non-financial reports and related documents may restrict the depth of the analysis. Access to internal data and proprietary information would have provided a more comprehensive understanding of the companies' sustainability initiatives. Additionally, the variability in reporting standards and frameworks used by different companies poses a challenge to the comparability and consistency of the analysis.

Finally, the rapidly evolving regulatory landscape for non-financial reporting, particularly with the implementation of the new EU Sustainability Directive (CSRD), could potentially impact the relevance of the findings over time. Future research should consider these limitations and explore the evolving dynamics of sustainability reporting in the Spanish tourism sector.

Given the recent approval of the EU Corporate Sustainability Reporting Directive (CSRD), future research should examine the impact of this directive on the non-financial reporting practices of Spanish tourism companies. Studies could analyse how companies are adapting to the new reporting requirements, the challenges they face in implementing the European Sustainability Reporting Standards (ESRS), and the effectiveness of these standards in promoting transparency and comparability. Likewise, future studies should focus on the non-financial reporting practices of small and medium-sized enterprises (SMEs) in the Spanish tourism sector. A comparative analysis between large corporations and SMEs would provide insights into the challenges and opportunities faced by smaller businesses in adopting sustainable practices and reporting them.

This study provides several key managerial implications for tourism companies in Spain and beyond. Managers should prioritize the adoption of standardized reporting frameworks, such as those provided by GRI or the upcoming ESRS, to ensure consistency and comparability in their ESG disclosures. This will facilitate better benchmarking and demonstrate a genuine commitment to sustainability. As well, managers should prioritize investments in sustainable practices, such as renewable energy, resource efficiency, and employee well-being, to reduce their environmental footprint and enhance their social impact. These investments can lead to cost savings, improved brand reputation, and increased customer loyalty.

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CURRENT DEVELOPMENTS IN IFRS – A CRITICAL SPOTLIGHT ON SDG ALIGNMENT

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Abstract

Sustainable Development Goals (SDGs) as set in the United Nations 2030 Agenda require global efforts to address challenges like climate change, and poverty. The 17 SDGs have been adopted by the member states perceived as flagship and landmark for individual member states initiatives. Entities play a key role in achieving these SDGs through sustainable practices, innovation, and partnerships. To track, manage and evaluate such efforts preparers and stakeholders utilize corporate reporting as a central source of information. Reporting scheme initiatives originated in the recent past, such as the International Sustainability Standards Board (ISSB), promote sustainability by standardizing disclosures, e.g., on sustainability driven risks and opportunities. Although there are such still young prominent initiatives traditional financial reporting under IFRS is everything but eliminated in its role as data provider for sustainability assessment. This is on the one hand due to current further standard development towards an improved reporting on business realities. A spotlight therefore will be put on IFRS 7 and IFRS 9 up-to-the-minute adjustment as well as on the newly issued IFRS 18, in future replacing IAS 1. On the other hand, the EU legislator has selected IFRS reporting as data provider for some of its sustainable growth actions. Central to this is the EU Taxonomy that again feeds into The European Green Bond Standard (EU GBS). SDG 17 underscores the importance of partnerships to support all other SDGs. Partnerships are seen as starting point and enabler for achieving the other goals. This paper evaluates whether current IFRS advancements adequately support SDG 17's objectives by focusing on joint venture accounting as the common structure for fostering global partnerships. Joint ventures are accounted for and reported by equity method. It explores on a formal and applied basis how such ventures are presented in annual financial statements. It assesses whether existing regulations provide a sustainability driven true and fair view as per IASB standards and therefore are equipped with an SDG promotional character. Shortcomings in are identified, especially in its role as data provider for legislator's initiatives. The authors in consequence pledge for reintroducing proportionate consolidation into IFRS which was abolished in IFRS accounting even before SDG adoption.

Keywords: Accounting Standards, Sustainable Development Goals, equity method, EU Taxonomy, accounting projects

JEL classification: M41, M48, G38, Q01, F65

Introduction

In a globalized world, sustainability goals are becoming increasingly important. The United Nations 2030 Agenda, adopted in September 2015, defines 17 Sustainable Development Goals (SDGs) that integrate social, environmental and economic aspects. These goals serve as a universal roadmap for tackling global challenges such as poverty, hunger, inequality and climate change (United Nations, 2023). The implementation of the SDGs requires close international cooperation (Hák et al., 2016, p. 571), as global problems cannot be solved by national efforts alone. Supranationals such as the United Nations and the European Union as well as (multinational) entities play a crucial role in this by coordinating, consolidating and thus accelerating sustainable development (Federal Government Germany, 2025). Despite the progress made, the global community and the industrialized countries in particular struggle to achieve the sustainability goals by 2030. At the Hamburg Sustainability Conference in October 2024, Germany's Federal Chancellor, Olaf Scholz, emphasized the responsibility of developed countries to promote global prosperity without resorting to environmentally harmful technologies. He emphasized the need to develop sustainable technologies in order to make global growth environmentally friendly (Federal Government Germany, 2024). Entities that develop and use technology can have a profound impact on achieving the SDGs, provided they make strategic choices aligned with sustainable development priorities. These entities can leverage their influence through sustainable production processes, environmentally conscious supply chains, and the development of innovative products and services that directly address environmental and social challenges – ultimately determining whether technology becomes a catalyst or hindrance to sustainable development. Such technological innovations in green technologies, digital inclusion and sustainable production are crucial for the SDGs and require cooperation between companies, governments and NGOs. The importance of partnerships is underpinned by the existence of a separate SDG promoting this special purpose. Entities can enter into partnerships with others to pool their resources and promote the SDGs at a global level. One important way of manifesting these partnerships formally is to establish a joint venture. As (accounting) rules drive (business) behaviour the following explications accentuate joint venture accounting. General focus is on the question whether the current IFRS regulation enables a true and fair view in financial reporting in the sense of promoting SDGs. The core research question is “do the current Joint Venture consolidation rules under IFRS empower, contribute and advocate for SDG 17”?

SDG 17

Embedded in other SDGs, SDG 17 (“Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development”) was set by the UN in 2015 and adopted by all Member States as a central component of the 2030 Agenda (United Nations, 2016-2023). “The 2030 Agenda for Sustainable Development” (United Nations, 2015) is defined as a “promise to secure the rights and well-being of everyone on a healthy, thriving planet” when being adopted (United Nations, 2025).

Figure 1: UN SDGs



Source: United Nations (2016-2023)

The 2030 Agenda claims that "sustainability" is to be understood holistically with no priority order of goals. Sustainable Development Goals are therefore addressed to everyone: politicians, civil society, business, science and each and every individual (United Nations, 2015, No. 52, p. 12). Achieving the SDGs is gaining massively in importance: Sovereigns are now also forming partnerships in this regard. Canada, for example, has joined the Horizon Europe program in July 2024, which is why Canadian researchers and organizations have the opportunity to participate in the program on equal terms with European Union researchers and organizations (European Commission, 2024a). The Horizon Europe Programme is a European Union research and innovation program with the mission to tackle climate change and to achieve the SDGs (European Commission, 2025). Corporational behavior also confirms the continuing importance of tackling climate change (KPMG, 2024a, p. 6). Tackling climate change is currently on the agenda of many entities, reinforced by regulatory requirements. In this context, the entities are driven by changed customer preferences and/or new requirements of investors and lenders (KPMG, 2024a, p. 24 et seq.).

Not all 17 SDGs are equally important and/or covered by the individual preparer. A survey by the German Chamber of Industry and Commerce shows that corporates attach quite different importance when it comes to the contribution to achieving the 17 goals (IHK, 2017, p.2).

Remarkable is the importance attached to partnerships. They ensure or boost the other 16 SDGs regardless of the preparers' attributes. SDG 17 states that global partnerships are needed to achieve 2030 Agenda goals and targets. Against this background SDG 17 can be seen as orientation and essence of pursuing sustainable ethos. In line with perceiving SDG

17 even as the inevitable starting point (German Federal Association for Sustainability, 2024), many non-financial reports refer to SDG 17 (e.g. Merck, 2023). These partnerships include e.g. the areas of finance, technology, capacity-building or trade (IHK, 2017, p. 2). Using the example of accounting for joint ventures (*the* corporate structure for corporate partnerships), the equity method plays a key role (Meeh-Bunse & Luer, 2024). This allows to examine whether financial reports are especially more consistent and transparent regarding sustainability efforts. If yes, this is accordance with the concept of a "fairly" view set by the IFRS in IAS 1.15. "Fairly" within the EU is better known as "true and fair view" (e.g. IFRS Foundation, 2016, No. 75) and a prerequisite of IFRS standard adoption into EU law. IFRS 18 most likely replacing IAS 1 in the EU from financial year 2027 onwards will obviously bring no change to this superordinate concept (EFRAG, 2024). On April 9, 2024, the International Accounting Standards Board (IASB) published this new standard IFRS 18 "Presentation and Disclosure in Financial Statements", which replaces the previous IAS 1 "Presentation of Financial Statements" (PricewaterhouseCoopers. 2024).

IFRS – ongoing sustainably driven reviews

Financial statements prepared according to IFRS standards provide information about assets, liabilities, equity, income and expenses in a faithful (CF 2.12) way to show a true and fair view (prerequisite for endorsement, European Parliament, 2002, No. 9) on financial positions and performance of the entity. Therefore, users get hold to useful information on economic facts in a relevant, reliable and undistorted manner that supports users making economic decisions (CF. 2.19). As accounting can be regarded as a "living language" (Stolowy et al., 2020, p. 7), from time to time the need will arise to adjust standards. This raises the question of the extent to which a connection between the International Financial Reporting Standards (IFRS) and the Sustainable Development Goals (SDGs) is given. According to IAS 1.14, environmental reports and related disclosures do not fall within the scope of IFRS. In formal terms, therefore there is initially no direct link. However, this missing link has been de facto replaced: The 2014 published Non-Financial Reporting Directive (NFRD) was the first comprehensive EU framework for non-financial reporting before the SDGs were fully integrated into EU policies. It required so called PIEs - public interest entities - to disclosure on environmental, social and governance issues that align with the SDGs. The 2017 guidelines recommended the SDGs as a frame of reference, without a binding requirement (European Commission, 2019, C209/2). The Corporate Sustainability Reporting Directive (CSRD), which was proposed in 2021 as the successor to the NFRD and adopted in 2022 for step-by-step implementation from financial year 2024 onwards, significantly expands the EU sustainability reporting requirements for companies (Čufar et al., 2023, p. 481 et seqq.). It explicitly refers to the SDGs as an important framework for sustainability reporting (European Parliament, 2022, No. 44). A strong connection between the SDGs and the EU regulation has become evident. The audit and reporting priorities of the European Securities and Markets Authority (ESMA) have also increasingly focused on environmental aspects in recent years. Particularly noteworthy is the emphasis on climate-related issues, which were addressed as key topics in the 2021 (European Securities and Markets Authorities, 2021, p. 4 et seq.) and 2022 (European Securities and Markets Authorities, 2022, p. 3 et seq.) audit guidelines: ESMA requires companies to transparently present the financial and operational impact of climate change on their business activities. In particular, this includes reporting on potential risks related to climate change adaptation and the integration of these risks into financial reporting. In 2023 and 2024, ESMA intensified its focus on the consistent combination of financial and non-

financial information to ensure a comprehensive presentation of climate and environmental aspects (European Securities and Markets Authorities, 2023, p. 2 or European Securities and Markets Authorities, 2024). Hence, SDG-related sustainability aspects are a focus of ESMA's audit for the fourth year in a row. The authors are of the opinion that – at least out of a EU's perspective - accounting standards beneficially should be in line with the SDGs if the relevant content is audited correspondently. Obviously, such connectivity is already practically mandatory on EU level. In this context, the regulatory framework should be designed to enable effective implementation of the SDGs in corporate reporting. In addition, the International Accounting Standards Board (IASB) explicitly emphasizes the need to create a clear link between financial reports and sustainability-related financial disclosures (IFRS Foundation, 2024i). This “connectivity” ensures integrated reporting that presents both the financial and non-financial aspects of a company in a coherent and transparent manner. Against this background we take a closer look whether the current developments in IFRS are in alignment with the SDGs. Due to SDG 17's key role promotion of partnerships will be in focus. For this purpose, joint venture accounting is closer analyzed than other review initiatives.

IFRS 18 enhances the presentation of financial statements by introducing three new income and expense categories - operational, investing, and financing (IFRS 18.47). Key new subtotals, “operating profit or loss” and “profit or loss before financing and income taxes” (IFRS 18.69–18.72, IFRS 18.86), aim to improve comparability (KPMG, 2024b, p. 7 et seqq.). Additionally, the structured classification of financial performance can positively impact sustainability reporting by facilitating a clearer identification of sustainability-related financial sources. If entities voluntarily disclose sustainability-relevant sub-positions, these categories can enhance the presentation of sustainability-related content: Particularly investments (“investing category”) can provide a starting point in analyzing to what extent a reporting entity is channeling capital into sustainable projects or green technologies. In addition, the clear delineation of financing activities (“financing category”) can allow a better assessment of whether sustainable financing instruments, such as green bonds or ESG-linked loans, are drawn upon. Overall, IFRS 18 therefore supports more precise reporting on an entity's financial sustainability and facilitates for users to efficiently interpret sustainability-related financial information.

Core reporting standards with initially less sustainability-specific focus are also undergoing revision. On December 18, 2024, the IASB amended IFRS 9 and IFRS 7 to standardize the accounting of nature-dependent electricity contracts, particularly Power Purchase Agreements (PPAs) (IFRS Foundation, 2024a; EFRAG, 2025). If a PPA (long-term contracts between an energy producer and an energy consumer for the delivery of electricity: Deutsches Rechnungslegungs Standards Committee e.V., 2025) qualifies as a financial instrument, entities must disclose its impact on financial performance and cash flows. The IFRS 7 amendments introduce new disclosure requirements to enhance transparency regarding PPA-related risks and effects (IFRS Foundation, 2025a). Further sustainability-related adjustment projects are in the pipeline. In September 2024 the IFRS Interpretations Committee (IFRIC) dealt with initiating a project on pollutant pricing mechanisms (IFRS Foundation, 2024b), better known as emission certificates. These mechanisms aim to reduce the emission of greenhouse gases and other pollutants by creating economic incentives. There are two main types of mechanisms:

- Cap-and-trade systems: Here, an upper limit is set for total emissions. entities receive or buy emission rights that they can trade. The accounting of certificates received or

acquired and the treatment of obligations in the event of exceeding the allocated emission rights deserve consideration (IFRS Foundation, 2024c).

- Emissions/Carbon taxes: Entities pay a tax based on the amount of pollutants emitted. The constantly changing (local) legal frameworks and unresolved issues make long-term planning more difficult. Entities must react with flexibility to new regulations and adapt their accounting practices accordingly (Federal Ministry for Economic Affairs and Climate Action Germany, 2024, p. 9 et seqq.). In particular, the question of whether the tax should be recognized as an (operating) expense in the income statement or as a provision in accordance with IAS 37 is at stake.

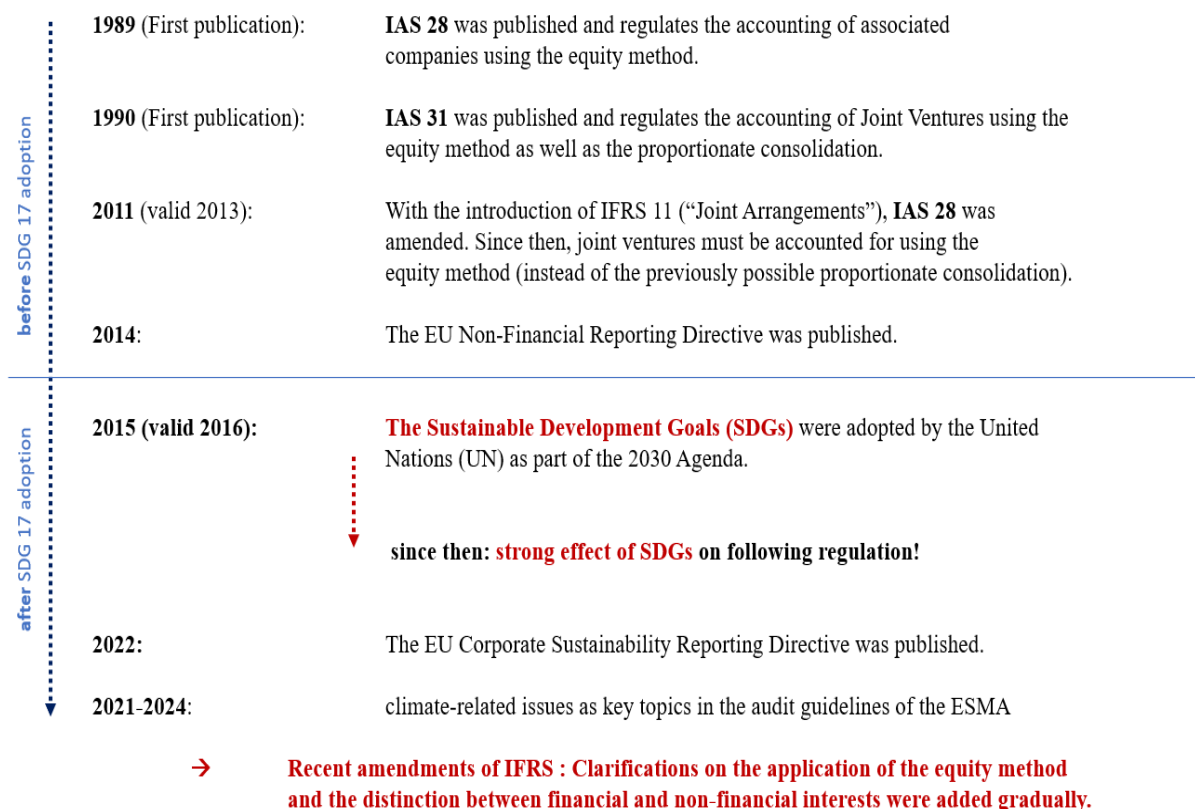
There is currently no respective explicit IFRS accounting guidance for the two mechanisms. This leads to inconsistent accounting practices and complicates comparability between reporting entities and/or between periods (PricewaterhouseCoopers, 2021, p. 6 et seqq. as well as Subramaniam et al., 2023, p. 1 et seqq.).

The IFRIC discussed the prevalence and financial impact of such mechanisms on financial statements and possible differences in accounting practices. The Committee decided not to pursue the issue further as it believed that existing IFRS standards provide sufficient guidance for accounting for such mechanisms. However, it was emphasized that reporting entities should carefully analyse the specific circumstances and conditions of their pollution pricing mechanisms to ensure appropriate application of the standards. These discussions will serve as a basis for the IASB to decide whether a separate project on accounting for Pollutant Pricing Mechanisms should be prioritized (IFRS Foundation, 2024b). This confirms the general willingness of IASB to include environmental driven aspects into IFRS. This is complementary to the focus placed in sustainability reporting frameworks that have been recently set up such as IFRS S and ESRS. Hence, a consideration of sustainable aspects in traditional financial reporting can be observed. As SDG commitment on stand-alone entity level has been assessed as with limited impact, current IFRS reviews on accounting for business combinations with influence on SDG 17 achievement need special attention.

Mandatory application of the equity method: A contradiction to SDGs!?

Particularly for the accounting of investments in associates and joint ventures, the equity method (or at-equity method) is applied in financial reporting. The focus on the equity method has increased in recent years, as the IFRS have restricted alternatives: The proportionate consolidation under IFRS was already abolished with the introduction of IFRS 11 “Joint Arrangements” for financial years beginning on or after January 1, 2013 (IFRS 11.C1). Notably, effective date of abolition was more than two years before UN’s SDG invention (see figure 2), the standard itself was issued even four years before in May 2011 (IAS plus, 2025).

Figure 2: Influence of the SDGs on IFRS



Source: authors' preparation

The strong anchoring of the equity method is the result of efforts towards clearer and more standardized accounting practices. The ban should ensure a precise presentation of the economic impact of investments without making the financial statements unnecessarily complex (IFRS Foundation, 2025b). As inherent to equity method – other than in standard consolidation – the joint venture holding is accounted for in one asset position ("Investments accounted for using the equity method", IFRS 28.10) as well as in one profit-and-loss position ("Share of profit or loss of associates and joint ventures accounted for using the equity method", IFRS 28.14) only. Since mandating the equity method, the IASB has received numerous questions on its application. The IASB met once more in March 2024 to discuss the equity method. The discussion focused on clarifying how to apply the equity method consistently, particularly regarding transitional provisions. The proposed amendments aim to ensure that the equity method is applied in a transparent and uniform manner across entities. The IASB discussed whether these changes should be implemented retrospectively or prospectively, as this decision affects how companies apply the method in the future. To address these, the IASB published proposals to revise accounting using the equity method already in September 2024 via its Exposure Draft *Equity Method of Accounting IAS 28 Investments in Associates and Joint Ventures*, whereby the sole application of the equity valuation is not questioned. Proportionate consolidation is not addressed (IFRS Foundation 2024e). Comments were due by in January 2025. The IASB expects that the feedback will reduce diversity in practice and lead to more comparable and understandable information for users of financial statements (IFRS Foundation 2024e, IN 2 et seqq). During a joint meeting between IASB and FASB held in October 2024, one of the issues discussed was as well the equity method and the proposals in the Exposure Draft *Equity Method of Accounting IAS 28 Investments in Associates and Joint Ventures* (IFRS

Foundation, 2024f). Also, here proportionate consolidation was – according to our sources – not a topic. While the application of the equity method should have led to clearer and more standardized accounting practices, the exclusion of applicable alternatives has led to numerous issues for outside our scope. For example, the IFRIC received a request to clarify how a preparer that is not an investment entity should apply the equity method when accounting for its investment in a joint venture that is an investment entity (IFRS Foundation, 2014).

In October 2023, the IASB decided to discontinue the research project “Business Combinations under Common Control” (BCUCC). The project dealt with non-joint-venture business combinations at the level of subordinated subsidiaries. In April 2024, the IASB published a project documentation stating that there is still diversity in the accounting treatment of BCUCCs. However, investors were satisfied with this diversity. This is reflected in different measurement methods: in addition to applying the acquisition method in accordance with IFRS 3, companies use different variations of the book value method (full book value method/modified book value method). Some jurisdictions have developed specific local requirements to reduce this diversity, but globally reporting remains inconsistent due to different national regulations and practices (IFRS Foundation, 2024g). This leads to a lack of comparability and transparency in financial reporting (IFRS Foundation, 2024h, p. 4). In the authors’ opinion, it should be noted that preparers, users and standard setters seem to have an interest in a corresponding diversity to be able to meet the individual requirements. The strong reduction to just the equity method in joint venture accounting alone raises issues that deserve attention: Sustainability-related information from joint ventures is often not sufficiently included in the financial statements. As investments are only valued with the proportionate equity and no individual items are recorded in the balance sheet or income statement, key ESG data is lost. This can impair transparency regarding e.g. CO₂ emissions, social standards or governance risks. The diversity acceptance though, in our view, is half-hearted. A conferment to joint venture accounting cannot be spotted. Joint-venture contribution to group reporting must be uniformly condensed into summarizing accounting positions. In consequence joint-venture activities and results cannot feed IFRS dependent sustainability formats like the EU taxonomy (European Commission, 2025b). Transforming the saying “you can’t manage what you can’t measure” into “you can’t engage into a collaboration that you can’t measure” (in your reporting) we see SDG 17 adversely affected. The strong influence of reporting on corporate practice is readily apparent: reporting is largely based on corporate activity (Palea, 2018, p. 253 et seq.). If regulatory requirements demand the reporting of certain content, the company is guided by these requirements in its operational practice - in particular by the requirements of the investors for whom the reporting is primarily carried out. A central aspect of corporate reporting is the need for companies to raise capital. This is primarily done through two channels: reporting on financial performance and disclosing sustainability aspects, as these are increasingly demanded by investors (Principles for Responsible Investment, 2025). Companies should be able to provide transparent evidence of their sustainable activities in order to obtain the capital they need. Without this proof, companies risk not being able to find financing opportunities, which can jeopardize their competitiveness and going concern. It is therefore essential that corporate reporting can adequately and comprehensibly document not only financial results, but also sustainability performance in connection. Regulatory requirements – in an ideal world as enabler - demand the reporting of certain content. The company is guided by these requirements in its operational practice. For example, the EU Greenbond Standard (EU GBS), which came into force on December 21, 2024, sets strict requirements for transparency and the use of raised funds. Issuers must

ensure that the funds raised flow into projects that meet the criteria of the EU taxonomy for sustainable activities (Council of the European Union, 2023).

The first bond was recently issued in accordance with the EU GBS: On January 24, 2025, the Italian utility entity A2A S.p.A. issued to institutional investors the first green bond in accordance with the EU Green Bond Standard with a volume of €500 million (A2A, 2025). This issue marks a significant step for the European green bond market and underlines the EU's commitment to sustainable finance. The 'second party opinions' came from Sustainable Fitch via their European Green Bond Assessment (Fitch Group, 2025). The review focused on the compliance of the bond with the requirements of the EU GBS, in particular with regard to the use of funds, the project evaluation and selection process as well as the transparency and reporting standards. Sustainable Fitch confirmed that the projects envisaged by A2A are fully compliant with the EU taxonomy for sustainable activities:

Figure 3: Alignment with EU Taxonomy - Summary of Criteria Applied within the EU

Figure 5: Alignment with EU Taxonomy - Summary of Criteria Applied within the EU																
UoP	Alloc %	G/E/T	Technical Screening Criteria												MS	Full Alignment
			SCC						DNSH							
			EO1	EO2	EO3	EO4	EO5	EO6	EO1	EO2	EO3	EO4	EO5	EO6		
Renewable energy	43%	G, E	✓	—	—	—	—	—	—	✓	✓	✓	—	✓	✓	✓
Energy efficiency	5%	E	✓	—	—	—	—	—	—	✓	—	—	✓	—	✓	✓
Transmission and distribution	40%	E	✓	—	—	—	—	—	—	✓	—	✓	✓	✓	✓	✓
Pollution prevention and control	12%	G	✓	—	—	—	—	—	—	✓	—	✓	—	—	✓	✓
Overall Instrument Alignment																✓
EU Taxonomy Aligned Amount (%)																100%

Source: Fitch Group (2025), p. 8.

This clearly shows how the assessment is based on EU taxonomy values. The placement of this first EU GBS-compliant bond could serve as a model for future issues and strengthen investor confidence in sustainable financial instruments. In the context of the EU GBS, sustainability-related IFRS reporting on which the EU Taxonomy draws on therefore plays a crucial role, as it shows whether the funds have actually been invested in sustainable projects. It is essential to create transparency about the environmental, social and governance impact of an entity. It appears doubtful whether the exclusive use of the equity method can do master this. If the values are not included there due to the non-applicable proportionate consolidation, it appears questionable whether green financing can be obtained for a 'core' green project in accordance with the EU GBS: The EU Taxonomy Alignment Amount must reach 85% or more (European Commission, 2024b).

Applied accounting of Joint Ventures: Focus on faithful representation

In the authors' opinion a joint venture is the business combination most likely to be understood as a partnership: In a joint venture, two or more entities come together to jointly pursue specific business (and/or sustainability) objectives. They share control, responsibility, resources and profits of the joint venture. For accounting reasons, a joint venture shall be accounted for as an investment using the equity method (IFRS 18.24). This

entails in a number of challenges (Meeh-Bunse & Luer, 2024). The following empirical examples were sourced through persistent observation of financial corporate news with focus on Germany. They validate the authors underlying ratio, that through the current regulations prepares are obstructed in clearly reporting their sustainable activities. For creating users' trust in sustainability reporting (Pizzi et al., 2024, p. 1) reporting should be impactful. Germany headquartered automotive industry for example has been facing considerable challenges due to both internal factors and external influences: In the first half of 2024, the industry suffered a decline in turnover of 4.7% to around €269.5 billion. The production of bodies, superstructures and trailers was particularly affected, falling by 11.6%, while exports remained key. Around 70 percent of total turnover is generated abroad (Federal Statistical Office Germany, 2024). The industry is under increasing competitive pressure, particularly from Chinese manufacturers such as BYD and CATL, which are leaders in electromobility. Electromobility and alternative drive systems are considered key technologies for sustainable mobility by reducing CO₂ emissions. German "autos" such as Volkswagen and BMW are perceived to be lagging behind in the transition to electromobility (German Economic Institute, 2024, p. 10 et seqq.). Overall, the industry is facing a complex situation that requires to adapt to new market conditions and technological innovations. Following "you can only win the race to catch up if you find solutions based on partnerships" (Kretschmer, 2023) a number of new joint venture initiative have been set up. In October 2022, Volkswagen announced that it would invest in total €2.4 billion in a joint venture with Horizon Robotics, a promising Chinese start-up in the fields of computer chips, artificial intelligence and autonomous driving (Volkswagen Group, 2022) called "CARIZON". This investment comprises two main components: Volkswagen invested €1 billion directly in Horizon Robotics and in addition, Volkswagen invested €1.3 billion in the establishment of CARIZON. This decision marks a renunciation from the previously dominant strategy of driving forward all developments independently. In the consolidated financial statements of the Volkswagen Group, this investment is - despite an ownership interest of 60 % - accounted for using the equity method (IFRS 11.24, Volkswagen group, 2024a, p. 329). In line with IFRS guidance Volkswagen recognizes its share of the profit or loss of the joint venture in the income statement and adjusts the carrying amount of the investment accordingly in the balance sheet position "Equity-accounted investments" (Volkswagen group, 2024a, p. 267, 270). Separate expense or yield types are by nature of equity method not accounted for. It can be assumed that obtained ownership interest is structured by non-voting preferred shares. Hence, Volkswagen group then would be not in a control position implying full consolidation. The answer on a query to Volkswagen group on that assumption is outstanding.

Figure 4: Balance Sheet 2023 of the Volkswagen Group

Balance Sheet			
of the Volkswagen Group as of December 31, 2023			
€ million	Note	Dec. 31, 2023	Dec. 31, 2022 ¹
Assets			
Noncurrent assets			
Intangible assets	12	89,109	83,241
Property, plant and equipment	13, 33	66,880	63,890
Lease assets	14, 33	64,094	59,390
Investment property	14	632	610
Equity-accounted investments	15	12,239	12,668
Other equity investments	15	4,431	3,489
Financial services receivables	16	94,474	86,944
Other financial assets	17	11,757	13,832
Other receivables	18	2,702	2,477
Tax receivables	19	437	394
Deferred tax assets	19	13,940	12,929
		360,694	339,853
Current assets			
Inventories	20	53,601	52,274
Trade receivables	21	21,849	18,534
Financial services receivables	16	66,381	61,549
Other financial assets	17	16,953	15,148
Other receivables	18	8,799	7,813
Tax receivables	19	1,649	1,732
Marketable securities and time deposits	22	26,772	37,206
Cash and cash equivalents	23	43,449	29,172
Assets held for sale		190	733
		239,644	224,159
Total assets		600,338	564,013

Source: Volkswagen Group (2024a), p. 270.

Additional information on how the investments are valued and recognized can be found in the group management report as well as in the notes:

Figure 5: Entry in the management report

HORIZON ROBOTICS INC.

On December 7, 2023, Volkswagen acquired preferred shares of Horizon Robotics Inc., Cayman Islands (Horizon Robotics), a leading provider of energy-efficient computing platforms for autonomous driving in China, from Horizon Robotics at a purchase price of USD 200 million and issued a convertible loan to Horizon Robotics in an amount of USD 800 million. Both investments are classified as debt instruments in the financial statements and measured at fair value through profit or loss. The measurement resulted in non-cash gains of €0.7 million in fiscal year 2023, which are recognized in the other financial result.

To promote the development of highly automated and autonomous driving in China, Volkswagen has also agreed the establishment of a joint venture with Horizon Robotics. On December 14, 2023, Volkswagen invested an amount of CNY 2 billion to this end in exchange for an interest of 60% in the new company, CARIZON (Beijing) Technology Company Limited, Beijing/China (CARIZON). In addition, Volkswagen has undertaken to make future capital contributions of up to CNY 8.4 billion to the joint venture.

Source: Volkswagen Group (2024a), p. 134.

Figure 6: Note to joint venture with Horizon Robotics

HORIZON ROBOTICS INC.

On December 7, 2023, Volkswagen acquired preferred shares of Horizon Robotics Inc., Cayman Islands (Horizon Robotics), a leading provider of energy-efficient computing platforms for autonomous driving in China, from Horizon Robotics at a purchase price of USD 200 million and issued a convertible loan to Horizon Robotics in an amount of USD 800 million. Both investments are classified as debt instruments in the financial statements and measured at fair value through profit or loss. The measurement resulted in non-cash gains of €0.7 million in fiscal year 2023, which are recognized in the other financial result under gains and losses from marketable securities and loans.

To promote the development of highly automated and autonomous driving in China, Volkswagen has also agreed the establishment of a joint venture with Horizon Robotics. On December 14, 2023, Volkswagen invested an amount of CNY 2 billion to this end in exchange for an ownership interest of 60% in the new company, CARIZON (Beijing) Technology Company Limited, Beijing/China (CARIZON). In addition, Volkswagen has committed to contribute capital in the future of up to CNY 8.4 billion to the joint venture.

Source: Volkswagen Group (2024a), p. 281.

Due to equity consolidation despite a majority in capital the motivation for granting the reported ‘private loan’ and accepting the respective risks (e.g. default) hardly was the “purchasing” of full consolidation advantages. That equity reporting for this arrangement was structured due a bias for a lack of transparency would be speculation. Essential strategies and/or impact are not explicitly mapped - neither a sustainable going concern of the group due to potential future improved competitiveness nor on environmental, social or governance (ESG) targets. The disclosure is actually limited to some narrower sense terminology like “energy-efficient computing platforms”. As an A-rated entity (Fitch Ratings, 2024), Volkswagen group has independently thereof inexpensive funding possibilities and hence is equipped with advantages in funding that can be shared.

The growing efforts of German “autos” on the Chinese market, which is considered a key market for electromobility (Handelsblatt, 2023) is also validated a further transaction: Volkswagen and the Chinese electric vehicle manufacturer XPeng have entered into a strategic partnership to jointly bring forward the expansion of electric mobility in China. In July 2023, Volkswagen invested around US\$700 million (approx. €640 million) in XPeng, acquiring a 4.99% stake in the company. In addition, a technology framework agreement was reached (unrecognised, e.g. CF 4.38 et seqq.) that provides for the joint development of two Volkswagen brand electric vehicle models, which are to be launched on the Chinese market from 2026 (Volkswagen Group, 2023). This strategic cooperation reflects Volkswagen's “In China, for China” strategy, which aims to strengthen the innovative power in the Chinese market and meet the requirements of its tech-savvy Chinese customers (Volkswagen Group, 2024b). The investment is measured at fair value through other comprehensive income (Volkswagen group, 2024a, p. 281). Although Volkswagen is fulfilling its sustainability strategy, named *regenerate+*, (Volkswagen Group, 2025) by investing in this partnership, no sustainability-related disclosures resulting from this joint venture can be directly found in the financial statements:

Figure 7: Note to investment in XPENG

ACQUISITION OF SHARES IN XPENG INC.

On December 6, 2023, Volkswagen acquired 4.99% of the ordinary shares of the electric vehicle company XPeng Inc., Cayman Islands, (XPeng) at a purchase price totaling USD 706 million. The realization of a forward purchase transaction dating from July 26, 2023 resulted in a non-cash gain of €74.2 million in fiscal year 2023, which is recognized in the other financial result. Along with the agreement to acquire the shares, a technological framework agreement was signed with Guangdong Xiaopeng Motors Technology Co. Ltd., Guangzhou/China, a subsidiary of XPeng, for the joint development of electric vehicles in China, among other things. The equity investment in XPeng is measured at fair value through other comprehensive income.

Source: *Volkswagen group (2024a), p. 281.*

The two Germany based car manufacturers Mercedes-Benz and BMW are often publicly perceived as long-standing rivals. However, they have also been cooperating in stationarity related areas, most recently for the Chinese market: Since 2019 the two entities have already joined forces in the domestic market through joint ventures such as “SHARE NOW” and “CHARGE NOW” (Mercedes-Benz Group, 2019, p. 95). The knowledge gained is now apparently to be transferred to the foreign market. In December 2023, the two entities founded a 50:50 joint venture named “Beijing Ion Qi New Energy Technology Co” to build and operate a joint fast-charging network in China. The aim is to set up at least 1,000 stations with around 7,000 fast-charging points by the end of 2026, which will be open to all vehicle brands. Mercedes-Benz and BMW customers will benefit from exclusive functions and the option to reserve charging points in advance (Mercedes-Benz Group, 2023). This joint venture is part of the two entities' efforts to promote electric mobility and to offer customers an improved charging experience. At the same time, it can be perceived as a step towards SDG 13 (clean energy). The joint venture is exemplary of the changes in the automotive industry, particularly in the field of electromobility. New challenges such as the expansion of charging infrastructures imply cooperation even between rivals to stay competitive, both on the customers' and investors' side. It reflects a new way of thinking in the automotive industry: Competitors who have traditionally fought for market share are increasingly recognizing that they need to work together in key areas such as electric mobility to tackle global sustainability challenges such as climate change and infrastructure issues. This alliance between BMW and Mercedes-Benz is a pioneering example of the balance between competition and cooperation in a changing industry. The joint venture is accounted for by both parent companies using the equity method. It is recognized in the balance sheet under the asset item investments applying the equity method with no further differentiation:

Figure 8: Balance Sheet of the Mercedes-Benz Group 2023

	Note	At 31 December	
In millions of euros		2023	2022
Assets			
Intangible assets	10	17,593	15,869
Property, plant and equipment	11	26,090	27,250
Equipment on operating leases	12	41,712	41,552
Equity-method investments	13	13,104	13,530
Receivables from financial services	14	49,742	48,237
Marketable debt securities and similar investments	15	699	823
Other financial assets	16	4,340	4,478
Deferred tax assets	9	4,127	3,725
Other assets	17	1,583	1,677
Total non-current assets		158,990	157,141
Inventories	18	27,294	25,621
Trade receivables	19	7,281	8,100
Receivables from financial services	14	38,469	37,312
Cash and cash equivalents		15,962	17,679
Marketable debt securities and similar investments	15	6,159	6,237
Other financial assets	16	3,599	3,453
Other assets	17	4,473	4,472
Assets held for sale	3	795	-
Total current assets		104,032	102,874
Total assets		263,022	260,015

Source: Mercedes-Benz Group (2024), p. 198.

In this case, the annual financial statements are hardly sufficient to develop a comprehensive understanding of the entity and its cooperation. Although they provide important insights into the general financial situation, earnings position and asset structure, they only show part of the overall picture - especially when it comes to strategy related aspects where standard positions could work as indicators.

Another joint venture with a different focus is the partnership between the BMW Group and Tata Technologies, which is establishing a software and IT development center in India, “BMW TechWorks India”, since April 2024 (BMW Group, 2024a). This joint venture shall not only strengthen the local industry, but also integrates highly qualified Indian specialists into global development projects. Starting with 100 employees, it is planned to expand to a four-digit number of employees by the end of 2025 (BMW Group, 2024b). Sustainable trends through partnership in the sense of SDG 17 can be clearly identified (SDG 10). This investment will also have to be accounted for using the equity method.

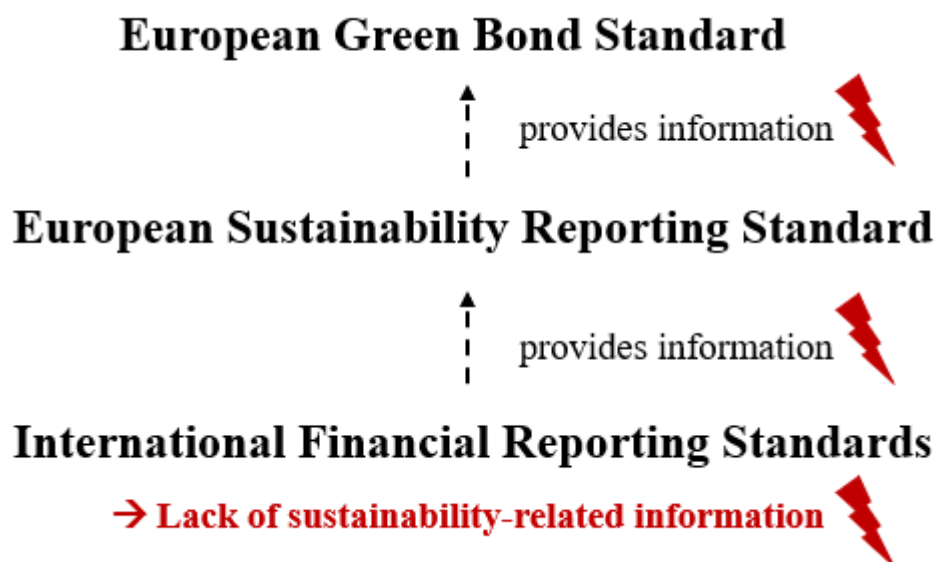
Discussion, implications and conclusion

Entities play a crucial role in the global sustainable development agenda. Through innovation, partnerships, and responsible business strategies, they significantly influence SDGs degree of attainment. Their impact on the economy, society, and the environment is essential to achieving the ambitious goals of the UN 2030 Agenda. IFRS are undergoing continuous change, currently especially through the integration of sustainability features, which are increasingly influencing investment decisions. Financial statements made up under IFRS are intended to be the central data source for investors (CF 1.2). The use of the equity method for accounting for investments in joint ventures has increased in recent years after proportional consolidation was abolished with the introduction of IFRS 11 already in

2013. This amendment was intended to ensure a more precise and standardized presentation of the economic impact of investments. Whether the equity method supports a true and fair view in the context of sustainable projects depends on the specific goals of the reporting and the information needs of users. As shown in the comments on the IASB BCUCC project, a certain degree of diversity in handling accounting issues can remarkably be even desirable to accommodate requirements. The equity method recognizes "investments" in the balance sheet in a condensed form. Attributable proportional profits or losses are condensed into one position in the income statement. This reflects the economic success of the project from the perspective of the reporting company but hides details such as how the results were achieved, the intentions behind the project, various investments, and/or sustainable aspects. From an accounting point of view equal rights equipped joint ventures (here: with a focus on sustainability) are less worth striving for – and thus due to less supportive accounting rules the contribution to the SDGs via SDG 17. The effects of the joint ventures do not only relate to SDG 17 but may have a much broader impact (Morton et al., 2019, p. 66 et seqq.): Joint ventures in the automotive industry also play a key role as indicated above in promoting SDG 13, SDG 9 and SDG 10 in particular. Through joint ventures, entities bring together their expertise, resources and technologies to develop innovative solutions that enable a more sustainable (here: in the automotive) industry. The collaboration has potential to promote knowledge transfer between companies and regions, particularly in the areas of software-defined vehicle (SDV) development, electric mobility and autonomous driving. The focus on research and development (R&D) can foster modern, digital infrastructures and improves efficiency in production as well as the sustainability of the entire value chain. In emerging markets in particular, such partnerships help to expand the technological infrastructure and integrate local talent. Against this background joint ventures may strengthen economic participation in emerging and developing countries by creating jobs there, promoting local talent and giving them access to global markets. They could support the reduction of income disparities by offering fair working conditions and training opportunities. They also can promote the integration of regions and population groups that previously had less access to global value chains. Outside IFRS reporting taking hold of IFRS data lacks information, in the authors' view without awareness of users. Indications of that lack are not provided for. If sustainable projects achieve financial success, this is reflected proportionally in the financial results. As the examples from electromobility in particular show, important environmental investments or long-term obligations of the project are not directly included in the reporting entity's core balance sheet's positions. The financial information extracted therefore does not automatically reflect the environmental or social impact that is often central to sustainable projects. Notwithstanding this, joint ventures are a powerful tool for achieving economic, social and environmental progress and promoting a sustainable future. To transport a fair view, particularly in the area of sustainability, the equity method currently needs to be supplemented with more extensive reporting and qualitative disclosures. For a holistic analysis, it is necessary for the user to research additional information independently. Qualitative factors such as corporate culture, innovative strength or involvement in sustainability projects can provide valuable indications of a company's long-term positioning and potential, but are less obvious at this point. External sources in particular, such as specialist articles, press reports, investor presentations or analyst assessments, then have to supplement the context in order to obtain a fair view and better assess possible risks or opportunities. It should be noted that only a combination of different sources of information can so far provide a holistic view that goes beyond the trimmed down figures. Such combination only enables a deeper understanding of the entity's dynamics and prospects – and as shown: corresponding dynamics can certainly be observed when they even bring direct rivals like Mercedes-Benz and BMW together.

Here the understanding of motives, goals and underlying financial parameters must be increased. A return to optional proportionate consolidation should be considered in this context—either generally or exclusively for SDG projects—to ensure that the assets, liabilities, expenses, and income of a SDG driven joint venture are proportionately included in the balance sheet and income statement. This would enable a more accurate and detailed presentation of the entity's economic interest in the joint venture. The quality of reporting in terms of sustainability aspects would increase following suit necessities for IFRS reports' assigned role as data supplier for referring reporting formats, such as EU Taxonomy.

Figure 9: IFRS as information supplier for European Green Bond Standard



Source: authors' preparation

In the authors' view IFRS are instrumentalized by disregarding the fact that these provide guidance for consolidated financial statements. Instead, the impression may be falsely created that non-consolidated financial statements are drawn upon. As a result, consolidated financial information is used in a way that skews its actual informative value. This is particularly critical in regulatory and/or sustainability-related contexts when far-reaching decisions are made on the basis of such data. The mandatory application of the equity method under IFRS 11 in conjunction with IAS 28 should be reconsidered. From an accounting perspective, a 50:50 joint venture does not appear to be advantageous for either party, as both must use the equity method. It is therefore worth considering to weigh up whether conveying the legal balance of power in joint venture accounting or the advantages of proportionate consolidation (if desired) outweigh its disadvantages. This consideration is particularly relevant as IFRS is based on the principle of "substance over form" (CF 4.59 in conjunction with CF 2.12). In this context, the application of equity consolidation could lead to a structure perceived as "form-over-substance" in rigidity. A more flexible approach – accepted and appreciated as diverse could enable both the environmental and social dimensions of sustainable projects and the financial results to be appropriately presented. This results in the consistent recommendation to supplement IAS 28 by a provision that allows proportionate consolidation to be used when accounting for joint ventures. This rule could be set out in a supplementary standard - possibly developed from a standard that already existed. There is also a requirement for guiding principles that define which economic purposes are considered environmentally sustainable. This may lead to a more

meaningful and holistic reporting. Last but not least joint ventures structures with accounting rule driven unequally allocated power would likely disappear. The same is true for more or less hidden accounting rule driven compensations in favor of the minority partner waiving full consolidation possibility. For non-joint venture investments such as the 4.99% interest of the XPeng-example the authors do not consider the application of proportionate consolidation to be appropriate, even if it is SDG driven. Overall, investment activities are to be promoted. As numerous investors have focused on investing in sustainable activities, this measure appears to make economic and strategic sense to empower, contribute and advocate for SDG 17 to a more significant extend.

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ESG IN THE SPOTLIGHT: UNVEILING THE ROLE OF INTERNAL AUDITS IN THE MONTENEGRIN BANKING SECTOR

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Abstract

Environmental, social and corporate governance issues (ESG factors) have been ubiquitous in the corporate world for many years. However, climate change, social differences and unrest, as well as irresponsible business practices, are phenomena that have recently caused changes in the way organizations function. By facing the aforementioned challenges, internal management mechanisms play a key role in aligning the company's operations with sustainability principles, creating sustainability reports and improving socially responsible code of conduct. In this regard, as the most important driver of a country's economy, the banking sector is the basis for the progress and prosperity of other economic branches through its investment and lending activities, which support environmental and socially responsible initiatives of many companies. To strengthen corporate values, banks should have an established management structure that implements an ESG strategy. The role and responsibilities of the internal audit, the scope of its work and the demands placed on it have changed in the context of the creation of ESG initiatives and company strategies. Hence, in this paper the authors analyze the main responsibilities of the internal audit sector in implementing ESG principles, according to international reporting standards and directives concerning sustainability reporting in the EU. Additionally, the goal of empirical analysis is to determine the responsibilities of the internal audit sector through a survey questionnaire with the internal auditors of the banks in Montenegro. Thus, this research should be the basis for raising awareness among corporate leaders and auditors about the importance of ESG factors and their role in long-term sustainable business operations. Also, the research points to the need for regulation and standardization of practices in the field of ESG reporting and management, which can be an incentive for the further development of future legislation and regulatory initiatives in Montenegro.

Keywords: internal audit, ESG, sustainability, banks, sustainability reporting

JEL: M42, Q01

Introduction

Accelerated degradation of the environment and sudden climate changes, social differences and political instabilities, as well as irresponsible corporate behavior, have caused intensive development of the sustainable practices around the world. By defining sustainable development goals of the UN, a new era in the way companies operate has begun, with companies actively participating as the main driver in achieving these goals. With the growing awareness of the importance of environmental protection, sustainability reporting has become a mechanism for companies to transparently inform the public about their efforts to integrate environmental, social and governance components into their business activities. To face the aforementioned challenges, the bodies at the top of the management pyramid in the banking sector, in cooperation with the internal audit sector, represent the main internal mechanisms that play a pivotal role in aligning business with sustainable practices. As in any risk area, internal audit provides support to the governing body and management, delivering objective assurance. This process encompasses the evaluation of a company's environmental impact, social responsibility, and corporate governance practices.

Studies on sustainable finance are fostered, among other things, by the fact that the financial sector is identified as a key sector for the transition to renewable energy sources (Beretta et al., 2023). If financial institutions require ESG information from manufacturing firms, which have a large impact on environmental pollution, they are obliged to compile sustainability or integrated reports (Tumwebaze et al., 2021). Changing dynamics in relations with stakeholders, their new requirements, and the need to build and maintain trust, have set a task for leading companies to increase transparency about the impact, risks, and practices in the field of ESG aspects of business. In this regard, quality of ESG information in sustainability reports became an essential topic that has been of great importance in this area for a long period.

The sustainable business practices of companies were encouraged and developed in various ways in the previous decade, by adopting many directives and action plans by the European Union. The EU has introduced numerous directives and regulations that oblige companies to report on their ESG practices and transparently display their contribution to sustainable development. Among the key regulations are the Non-Financial Reporting Directive – NFRD (European Parliament & Council of the European Union, 2014) and its successor the Corporate Sustainability Reporting Directive – CSRD (European Parliament & Council of the European Union, 2022), which significantly expand the scope and standards of sustainability reporting. These regulations set a solid foundation for harmonized and comprehensive reporting, ensuring that companies provide relevant and reliable information to stakeholders and the broader public. Hence, as a frontrunner candidate for EU membership, Montenegro is obliged to follow and implement these regulations and trends. Accession to the EU entails an obligation to adhere to its standards and practices, including those related to sustainable business practices and reporting. The banking sector is leading in sustainable practices in Montenegro, which has further shown its commitment this year, when the Association of Montenegrin Banks joined the Sustainable Banking and Finance Network.

Since Montenegro must align its operations with these requirements and develop internal mechanisms for monitoring and reporting on sustainability practices, the authors were motivated to investigate the extent to which internal auditors of the banking sector are involved in the field of ESG reporting. More precisely, this paper aims to answer if the

internal audit sectors in Montenegrin banks are managing to identify sustainable business risks and whether they integrate them into their corporate strategy and business models. Additionally, the goal of this paper is to determine if the internal auditors have a role in creating sustainability reports and enhancing ESG practices in banks in Montenegro.

The remainder of this paper is structured as follows. The next section provides relevant literature review about the ESG field and the role of internal audit on ESG disclosures. The third section gives insight into the methodology and data used in the study. It is followed by Results section, which presents main empirical results that were retrieved. In the final, Discussion and conclusion section, alongside the main insights, the authors compare this study to the existing studies in the field, and highlight the potential implications for the internal audit sector. Lastly, the final section outlines the limitations of the study, suggesting potential areas for future research.

Literature review

Most often, ESG information that is an integral part of the company's sustainability reports is considered from three areas: environmental, social, and governance matters. These components enable the measurement of the company's sustainability efforts, which are highly demanded not only by institutional investors, but also by other shareholders, to strengthen the company's performance in the long term (Atkins, 2020; Fraser et al., 2022). Hence, large steps towards developing ESG reporting are taken by the European Union, which has lastly issued the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS) for compilation of these reports. Along with that, many international frameworks and guidelines have been developed to help companies in making reliable and credible reports, and some of the main ones are: Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), International Integrated Reporting Council (IIRC), etc.

Effective corporate governance is a crucial determinant for the proper functioning of the banking system and, consequently, the broader economy (Basel Committee on Banking Supervision, 2015). In the business environment, a company's improvement and performance depends on good corporate governance (Burcă et al., 2024), which is in the modern business world the key for developing ESG strategies and practices. Regulators and researchers mostly focus on external auditors, who not only verify the financial statements and the management reports of the company, but also ensure consistency of financial and sustainability information (European Union, 2022). However, to reach ESG goals, the internal audit sector is ideally positioned to assist the company and its management by providing impartial assurance, insights, and guidance on ESG issues (Deloitte UK, 2024). According to Lenz & Hoos (2023), on the other hand, internal auditors continue to lack a prominent role in providing assurance and are not involved in potential advisory services related to ESG, which the authors diagnose as "ESG helplessness syndrome". Concerning this and the fact that there is a paucity of research of the internal auditors' role in the ESG field, the authors were inspired to conduct this analysis to raise awareness about the importance of ESG issues in Montenegro.

Soh & Martinov-Bennie (2015) have done research in Australian companies, where they examined the relationship between internal auditor functions and ESG issues. Through a survey from 100 chief audit executives and internal audit service provider partners, the

authors have found out that governance issues are perceived to be of a greatest current importance to internal audit functions, followed by social issues, and lastly environmental issues which are most commonly expected to increase in importance over the next five years. Currently, as environmental issues are viewed as less important compared to governance and social issues, there will be a significant need to further develop the skills and expertise of internal audit functions in this area. Undoubtedly, internal audit functions should improve the quality of ESG reporting, such as: evaluation of the implemented ESG standards by management, auditing ESG data and ESG reporting processes, evaluation of the reliability of ESG KPIs processes and so on (Fraser et al., 2022).

Standardization in this field would enable us to compare ESG performances between companies. However, due to lack of standards about sustainability reports, companies often rely on auditors' opinion, as an argument about fair presented reports. Del Giudice & Rigamonti (2020) analyzed about 70 companies in two groups: one group with audited reports and the other with unaudited reports. Results of their analysis show that the negative influence of controversies on ESG rating appears to be significant only for companies with unaudited reports. This refers to the auditing process in the ESG field leading to trustworthy reports that investors can rely on in their decision-making process.

Having an internal audit function within the company positively impacts the ESG score in Malaysian companies, compared to outsourcing this function to an external provider (Kolsi & Al-Hiyari, 2024). Authors in this study confirm that both the internal and external auditor departments play an important role in improving the quality of ESG reporting, which requires extra funds and resources. On the other hand, internal auditors possess a comprehensive knowledge and understanding of a firm's daily operations, procedures, and policies which exceeds the insights gained by external providers. Because of that, the authors conclude that allocating additional funds to the internal audit function results in increased expertise and scrutiny, which positively impacts the quality of both financial and non-financial reporting.

Burcă et al. (2024) analyzed the influence of internal audit, audit committees and ESG indicators on ESG score. Tested sample included more than 800 companies from European countries, covering the period from 2019 to 2022. For regression analysis, the authors used the Internal Audit Department Reporting Score as an independent variable to represent the influence of internal audit. Based on conducted analysis, authors concluded that internal audit has a positive statistical impact on ESG score, as other variables used in the model, which raises the model effectiveness over time. According to these authors, when talking about sustainability disclosures, both internal audit and audit committees should be given more importance.

Although functions of internal audit appear to be significant for ESG disclosure, answers from the survey conducted by Bonrath et al. (2022) showed that companies mainly engage the Big-Four auditor companies when their opinion about ESG reports is needed. This happens most often because of insufficient knowledge in the ESG field, no strict procedures defined by management, sustainability topics are not a priority in the audit process, etc. Authors' findings indicate that internal auditors should allocate resources to ESG training and professional development to elevate the internal audit functions' ESG maturity level, thereby supporting the company's ESG disclosure initiatives and helping the company in its important mission regarding ESG (Lenz & Hoos, 2023).

Data and methodology

As a candidate for EU membership, Montenegro is required to adopt and implement EU regulations and trends, which further entails adhering to its standards and practices, especially including those related to sustainable business operations and reporting. Given that ESG reporting in Montenegro is still in its infancy phase, it must adjust its operations to meet these requirements and develop internal mechanisms for enhancing sustainability monitoring and reporting. This necessity has driven the authors to investigate the extent to which the internal audit sector in Montenegrin banking system is engaged in the ESG field. The banking system, as a power engine of the economy in every country, is the leading economic branch in sustainable practices. Propelled by this, the authors have decided to investigate to what extent the banking system is included in the ESG area, both through the implementation of ESG practices and through informing the public by developing ESG reports as well.

This study includes internal audit sectors in the Montenegrin banking system, which has eleven banks. Respondents of the survey were the chief internal audit executives from every bank, or they answered the questionnaire together with internal auditors. Since the main focus for the study was to investigate particularly the development of ESG reports in Montenegrin banks, as they are the main drivers of the economy that shapes business environment, the authors decided to involve only internal auditors. Sample selected in that way will enable authors to better get insight into internal auditors' role in preparation of ESG reports, considering they are responsible for all reports validation in the company, including ESG reports. One more reason for examining this particular sector in the bank is that Montenegrin companies have not yet formed special ESG sectors that would deal with the above-mentioned topic, so the authors assume that this sector, considering the main role it plays, for now has to deal with this new field of ESG reporting.

The survey questionnaire is made of three parts: the introductory part, which contains general questions about the bank, the second part, about ESG strategy, and the third part, about ESG reporting of the banks. The last part of the survey is divided into two parts – one set of questions is made for the banks that already create ESG reports, and the other set of questions refers to those banks that still do not have ESG reports. The reason for dividing the third part of the questionnaire like above mentioned is that the ESG field is still in the early development stage in Montenegro, so the authors wanted to both examine how ESG reporting is developing for now in the companies who already create reports, but to find out more about obstacles and challenges in this process as well. Hence, through the perception of internal auditors, this research could give insight into the main problems in developing the ESG field in Montenegro sooner, which could be a good basis for raising awareness of the importance of this topic not only in the banking sector, but in all other branches in Montenegro.

The obtained data from the survey was processed through descriptive statistics. The answers obtained served the authors as a basis for measuring the current level of development of the ESG reporting in Montenegro. Thus, this study represents a pioneering step forward for the ESG field in Montenegro, which is still awaiting the Central Bank regulations and the development of the mentioned field.

Results

The first part of the questionnaire consisted of general questions on the characteristics of the Montenegrin banks. Montenegrin banking sector consists of eleven banks, in which the largest part belongs to banks with foreign, private ownership, while one bank is a domestic private bank, and one is of mixed ownership (private/state). As can be seen in Table 1, 40% of the banks have the annual net profit from 1 to 10 million euros, other 40% have an annual net profit from 10 to 50 million euros, while the remaining banks in the sample are the smallest and largest according to this indicator bank in Montenegro.

Table 1: Net profit of the banks in Montenegro

Annual net profit of the bank	Number of banks
Less than 1 million EUR	1
1 million - 10 million EUR	4
10 million - 50 million EUR	4
More than 50 million EUR	1

Source: authors' preparation

Banks in Montenegro operate on different markets: one bank operates in the countries of the region, two on several international markets, three globally, and four of the banks operate only on the domestic market. Four banks in the sample provide commercial-type services, while the rest of the banks offer several types of services. Additionally, the internal audit sector has existed for more than five years in every bank. In half of the banks surveyed, the internal audit sectors operate with less than three employees, followed by four banks where this sector operates with three to five employees, while in one bank the internal audit sector has more than five employees (as seen in Table 2).

Table 2: Number of employees in the internal audit sector

Number of employees in the internal audit sector	Number of banks
Less than 3 employees	5
3 to 5 employees	4
More than 5 employees	1

Source: authors' preparation

At the very beginning of the second part of the survey, before analyzing the situation with ESG reports, the authors were interested in possible existence of an ESG strategy in Montenegrin banks. In this part of the questionnaire, the authors found out that only four banks implement an ESG strategy, equally for the environmental, social, and governance part, in a period of less than a year (20% of banks) and the period from 1 to 3 years (20% of banks). Out of that subsample, for now only two banks in Montenegro publish ESG reports.

As already mentioned, the following part of the Results section consists of two parts: the first part refers to those banks that have started compiling ESG reports, and the second part refers to challenges in the development of the ESG reporting practices, for those that do not.

For two banks in the sample that have already published ESG reports, besides using GRI, UN and guidelines from the banking group as a methodology for reporting, one of the banks also uses software tools. In their reports, according to the answers of the respondents, there

is data about social initiatives, governance and transparency in both banks, and in one bank data on CO₂ emissions, use of water and energy resources (as seen in Table 3). Banks that publish ESG reports use international guidelines and frameworks for reporting, and they have a special department in the bank that deals with these issues. The validation of ESG reports is not carried out by external or internal audit, but by a specially formed department, after which these reports are additionally reviewed or approved by the bank's board of directors, according to the respondents' answers.

Table 3: Type of data present in existing ESG reports

Type of data	Number of banks
CO ₂ emissions data	1
Financial data connected to ESG	1
Resource use (water, energy)	1
Information on governance and transparency	2
Social initiatives data	2

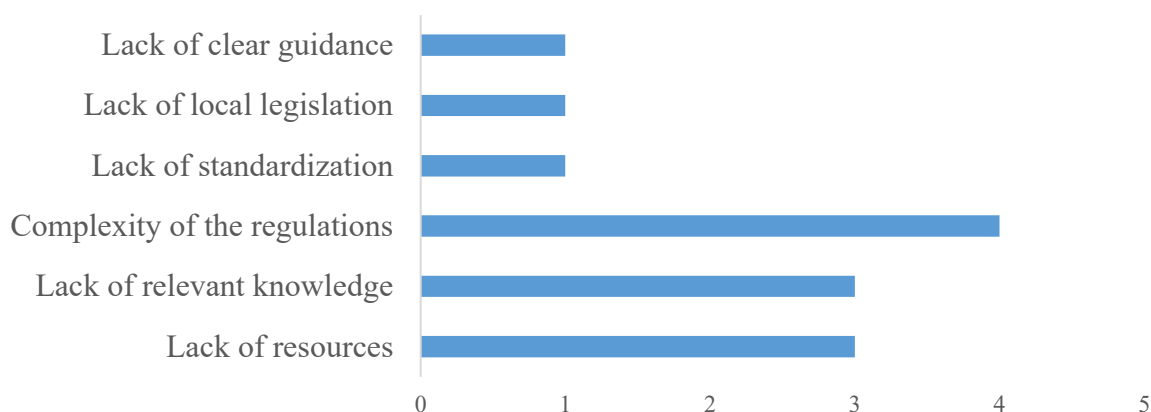
Source: authors' preparation

Internal audit has an insignificant contribution in this process, meaning it has an advisory role when compiling the ESG report, and not a role of control or supervision. Early stage of ESG reporting in Montenegro was further confirmed by inconclusive answers about the cooperation of internal audit and ESG sector, as well as concerning the quality of ESG reports.

The last set of questions for the banks that have published ESG reports are related to the quality and accuracy of the information. According to respondents, the problem of the quality of the ESG information refers to all three components equally: environmental, social, and governance information. The internal auditors also believe that companies in Montenegro could face the problem of publishing inaccurate ESG information in their reports in the future, because greenwashing is a widespread phenomenon all over the world, so this may be an inevitable practice in our country as well. Contrary to that, opinion expressed by other surveyed internal auditors is that the standards and regulations for ESG reporting are sufficiently precise and strict, so Montenegro will not have a problem with the quality of the information in the reports. Hence, the auditors' opinions regarding the fulfillment of EU requirements for credible and valid ESG reports are divided, with one part of the respondents believing that Montenegro can meet the regulatory requirements in the future, compared to the opinion that the quality control of ESG reports in Montenegro is still not sufficiently developed to meet the requirements. In the end, the steps that would contribute the most to improving the quality of ESG reports are training and education of employees, as well as implementation of new software solutions for data collection according to both surveyed banks.

The analysis of the answers in the second part of the questionnaire refers to those banks that do not prepare ESG reports. It represents the perceptions of the auditors for overcoming the challenges that Montenegro is facing that prevent it from becoming more proactive in this area. The main challenges faced by these banks include the complexity of regulations (50%), insufficient knowledge and training of employees (37.5%) and lack of resources (37.5%), as can be seen in Figure 1.

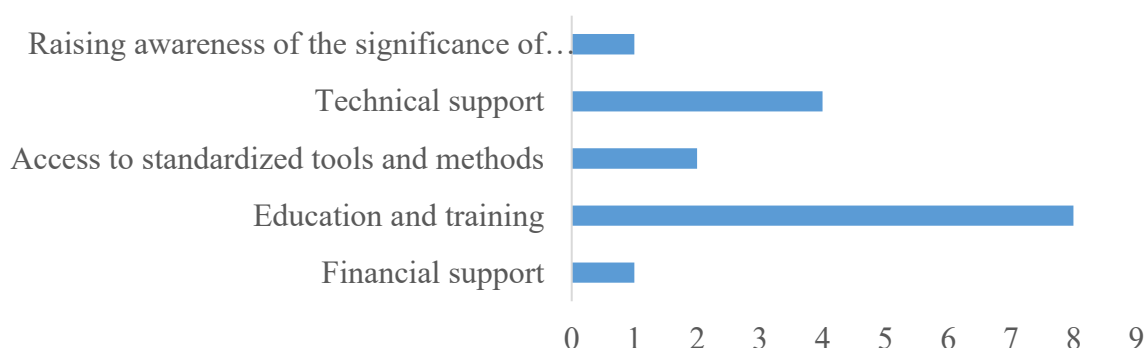
Figure 1: Obstacles in the implementation of ESG reporting practices



Source: authors' preparation

Banks' internal auditors also believe that there is a lack of local legislation, hence they expect an initiative from the Central Bank of Montenegro to start developing the ESG reporting practices. Undoubtedly, all banks plan to introduce ESG reporting - 62.5% within three years, while 37.5% believe that it will be within three years.

Figure 2: Type of support needed



Source: authors' preparation

As seen in Figure 2, in that process, the support of the regulatory authorities is important, and according to the respondents, the required type of support is training and education of employees, technical support, access to standardized tools and methods, as well as financial support and raising awareness of the importance of the ESG concept.

Discussion and conclusion

Although the ESG topic has become a focal point of regulation and business practice in European countries over the past decade, the authors assert that its development in Montenegro remains in its early stages. Although the country is in the process of harmonization with European standards as a frontrunner candidate for membership in the European Union, familiarization with ESG principles and their implementation hasn't significantly advanced in the banking sector.

The results of the research conducted at the level of the banking sector in Montenegro show that awareness of the importance of ESG reporting is present, but particular steps towards the establishment of these practices are still missing. Only 40% of banks in the sample have formally started implementing their respective ESG strategies, while only two of them publish annual ESG reports. Internal audit, which could play a key role in ensuring the transparency and reliability of these reports, is currently marginalized in this process. As stated by Rakipi & D'Onza (2024), the role of internal auditors in companies with low ESG maturity is confined to assuring internal controls, established to ensure compliance with domains such as environmental, health, and safety legal requirements.

Concerns regarding potential problems with the quality of ESG information in reports are becoming the subject of scholarly research and a topic that is experiencing exponential growth, alongside the rise in popularity of the entire ESG field. In our study, part of the respondents expressed the opinion that there is a possibility of the practice of publishing false or misleading information to portray the company as environmentally responsible, while others believe that strict regulations could prevent such occurrences. In this context, one more way for insurance of quality information in ESG reports is through the involvement of audit committees, which play a vital role in enhancing the reliability, transparency and quality of ESG disclosures (Arif et al., 2020; Pozzoli et al., 2022). One of the answers in the study refers to the unawareness and lack of seriousness even in professional circles, which is why a lot of work would be started in Montenegro due to pressure and obligation, and not due to real awareness of the importance of this topic. Certainly, additional work needs to be done to improve standards and methodologies to ensure that reliable and relevant information in ESG reports, which aligns with Cort & Esty (2020) and Wahyuni (2025). According to the respondents, to achieve the aforementioned, it is planned to engage external consultants, experts with experience in this field, and activities to adapt to the legal regulations adopted by the Central Bank of Montenegro. Similar conclusion was reported in a paper by Chopra et al. (2024), where the authors emphasized that traditional accounting systems need to be adapted to incorporate ESG disclosure demands more effectively, mainly through enhanced data accuracy, standardized sustainability metrics, and refined disclosure formats.

As one of the leading economic branches in Montenegro, the banking sector has a key role in the development and implementation of ESG practices, but to achieve notable results, additional engagement and greater proactivity of all involved parties is necessary (Buallay, 2018; Loew et al., 2021). Given that all banks plan to introduce ESG reporting in the coming years, the transition process will require thorough preparation and continuous support, to successfully respond to the complex challenges that this new way of reporting entails. Finally, this paper highlights the importance of integrating the ESG reporting process into business savoir-faire, to accelerate the country's journey towards the European Union. For Montenegro to fully use the advantages of the ESG reporting practices, it is necessary to harmonize regulatory frameworks, which aligns with insights from Tylec (2022). Furthermore, our respondents have equally pointed out the importance of continuous education of employees, which strengthens and defines the competencies of internal auditors. This conclusion is supported by the work of Bonrath et al. (2022), where it is stated that involvement of internal auditors is often limited by the lack of awareness among stakeholders. This would enable the Montenegrin banking system to become an example of good practice for all other economic branches, whose contribution to sustainable development and responsible business is even more important. It is important to mention that a similar lag is noticeable in other economic branches in Montenegro, reflected in the

inexistence of the ESG reports on the corporate level. The insufficient presence of ESG strategy and reporting practices in Montenegrin banks reflects the challenges faced by the entire Montenegrin economy, which is yet to undergo major changes in the way of doing business in the direction of green economy and sustainable business practices. As most of the Montenegrin banks have foreign ownership, they follow the ESG practices of their parent banks, which propels further development in this field. Taking all of the above into account, the rise of ESG reporting is yet to be seen in the Montenegrin banking sector.

The study has several limitations. First and foremost, Montenegrin banking sector is comprised of 11 banks, which imposes limitations on statistical significance of the results retrieved. Second, not all of the banks responded to the survey (response rate was 90%). Thirdly, lack of official standardization in the field of ESG reporting in the country limited the structure of the data used (data was retrieved through a survey). Fourth, the study was conducted for the Montenegrin banking sector, so further studies can explore other branches, to assess the overall level of ESG reporting quality. Hence, the abovementioned limitations represent the avenues for further research.

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VALUATION OF LIFE INSURANCE CONTRACTS WITH SUPPLEMENT INSURANCE - AN APPROACH IN THE CONTEXT OF IFRS 17

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Abstract

New trends in life insurance regulation have a major impact not only on gross written premiums reported in financial statements but also on the overall profit recognition of the insurance products. Since 2023 the IFRS 17 standard has come into force as mandatory in some jurisdictions such as local GAAP and for international insurance groups. This resulted in major changes in the actuarial valuation methods used for technical provision valuation and consecutive financial disclosures. New variables such as contractual service margin and risk adjustment for non-financial risks are part of the insurance company's liabilities and affect the total value of the economic result reported by insurance companies. The paper presents a proposal for a model for valuating portfolio of term insurance contracts with supplement insurance covers critical illness. The amount of the premium depends on the choice of the adequate actuarial assumptions, which describe in detail the actuarial assumptions and their selection. The main output of the paper is a complete valuation of a product with supplement insurance covers in the context of IFRS 17 valuation. The risk adjustment is valued using the Value at Risk method at the 70th percentile. The proper valuation of contractual service margin and risk adjustment is a necessary source of information for insurance company management to manage products not only in life insurance.

Keywords: term insurance, critical illness, IFRS 17, actuarial valuation basis, contractual service margin, risk adjustment

JEL classification: G22, C02, G32, C69

Introduction

Actuaries are highly qualified experts who provide expert advice and appropriate solutions to financial, business, or social problems related to uncertain future events. Actuaries use

mathematics and statistics to estimate the financial impact of risk and uncertainty with aim to better manage overall company's risks, both qualitative and quantitative ones. They collaborate on product design and development, determining the amount of insurance premiums, so-called pricing, the methodology of insurance liabilities valuation and their subsequent quantification, so-called reserving, financial reporting for the purposes of IFRS 17, IFRS 9 (Financial instruments), IFRS 15 (Revenue from contracts with customers), and others, solvency and capital requirement testing, risk management as a function of risk management, (Alhawtmeh, 2023). Currently, more and more actuaries work on data analysis in data science and big data projects, regulatory compliance, e.g. also in validating the results of artificial intelligence (AI), as advisors to ministries or governments and research and development. Another area in which actuaries specialize is enterprise risk management. In the financial sector, this is defined as a risk management function.

In Slovakia, all insurance companies have been required to report their liabilities according to IFRS standards since 2005. All methodologies for insurance companies in Slovakia and also courses at universities are in accordance with the currently valid IFRS 17 standard. We believe that this approach will gradually become mandatory and implemented at least in all countries in the European Union.

In a life insurance company, they perform several tasks that can be divided into four basic groups:

- creation and valuation of insurance products (pricing),
- methodology, best estimate assumption and valuation of the value of the reserve of insurance contracts (reservation), including surrender values, IFRS 17 and Solvency II (European Union, 2009), IASB (2019),
- calculation of capital requirements, solvency testing, and other activities related to quantitative risk management,
- data analysis, use of actuarial techniques in processing big data, data science and AI.

The result of the process of creating and pricing insurance products results in determining the amount known as insurance premium policyholder will pay for the insurance services. The insurance premium is the costs that the policyholder pays to the insurance company to take on certain risks and provide the corresponding guarantees related to the death and/or survival, or the health status of the insured person. The product creation process includes the following actuarial activities:

- insurance product pricing, i.e., insurance rate, in connection with the conditions is the underwriting of health risk (i.e., insurance exclusions, content of insurance coverage, for example in case of illness, disability), employment risk (i.e., office employee, vs. construction worker) or various risky hobbies (i.e., road running, vs. diving, parachute jumping),
- determining the assumptions for valuing the insurance premium (actuarial valuation basis), choosing an appropriate valuation method, and calculating additional guarantees and options into the product price,
- programming, creating an actuarial model that projects cash flows, discounts them in order to determine the expected profit margin of the insurance product,
- creating product documentation in accordance with actuarial standards and internal regulations of the insurance company,
- in the case of life insurance products that are associated with investments, the actuary cooperates in setting the mechanism for determining the value of the interest

guarantees provided, profit shares for the client or also setting the investment strategy of the insurance company or investment fund.

The paper deals with the valuation of term insurance with supplementary critical illness insurance. The aim of the paper is to present a proposal for valuation in the context of IFRS 17 (IFRS 17, 2020), considering the complete methodology and principles that the insurance company must apply. After an introduction to actuarial issues, the methodological part of pricing the product and valuation of risk adjustment (RA) and contractual service margin (CSM) values follows. After defining actuarial assumptions and formulas, actuarial analyses in the context of IFRS 17 follow. The research issue consists in finding the optimal application of the principles described in the IFRS 17 standard. In the results section, CSM and RA are analyzed, because the profit from insurance contracts depends on these values and on their way of calculation.

Literature review

IFRS 17, issued by the IASB in 2017 and effective from 2023, represents a fundamental reform of insurance contract accounting compared to the previous standard IFRS 4. The main difference is a unified approach to measuring insurance liabilities using new values: the Fulfillment Cash Flows, Risk adjustment and the Contractual Service Margin, thereby increasing the transparency and comparability of financial statements (IFRS 17, 2020). PWC (2022) highlights the impact on the volatility of insurance companies' profitability, as IFRS 17 requires updating assumptions. According to Deloitte (2022), the main challenge of implementation is the complexity of calculations and the demands on IT systems. Spigarska (2020) presents the significant changes that IFRS 17 introduces compared to IFRS 4, especially in the area of insurance contract valuation and their impact on insurance companies' financial statements. Broz Tominac (2023) analyzes the key improvements of IFRS 17 compared to IFRS 4, including aspects such as relevance and accuracy, profitability, and comparability of financial statements.

Valuation of life insurance contracts with supplementary insurances under IFRS 17 is a complex process requiring a standardized accounting approach. IFRS 17 introduces the General Measurement Model (GMM) and the Variable Fee Approach (VFA), which significantly impact contract valuation (Palmborg et al., 2020). A key component of IFRS 17 is the contractual service margin, which enables the gradual recognition of profits over the policy's lifetime, ensuring consistency in financial reporting (International Monetary Fund [IMF], 2020). Supplementary insurances, such as disability or critical illness riders, pose challenges in risk assessment and discount rate selection (EIOPA, 2024a). Actuarial assumptions, including mortality, lapse rates, and discounting, are crucial in determining insurance liabilities. The adoption of IFRS 17 has led insurers to reassess their financial models, aligning with a principle-based framework (IMF, 2020). Research suggests that the standard enhances transparency and comparability among insurers, improving stakeholders' decision-making processes (Palmborg et al., 2020). However, implementation challenges, such as data granularity and system modifications, remain significant hurdles (EIOPA, 2024b). European regulators have analyzed the impact of IFRS 17 on insurers' financial statements, identifying variations in liability valuation (EIOPA, 2024b). Further empirical studies are needed to assess the long-term financial effects of IFRS 17 on insurers' profitability and solvency (IMF, 2020). Overall, the framework provides a more accurate representation of insurance obligations, ensuring a fair valuation of contracts with supplementary coverages.

Methodology of pricing of life insurance product

This section introduces term life insurance, including supplementary critical illness coverage, forming a single contract.

- **Term insurance:** The insured event occurs when the insured person dies during the insurance period. The insurance ends when the insurance event occurs, the policy period expires, or the policyholder cancels it. The policyholder is not entitled to payment of the surrender value, nor is he entitled to a profit sharing.
- **Supplementary critical illness insurance:** Insured event: diagnosis of a critical illness defined in the list during the insurance period, such as diagnosis of various types of cancer according to the list, stroke, heart attack, transplantation of various organs, and sclerosis. The lists of covered illnesses tend to be long and varies for different insurance companies. The insurance ends on the date of the earliest event: the insured event occurs, the insured person passes away, the insurance period expires, or the policyholder terminates the insurance early. The policyholder is not entitled to payment of the surrender value, nor is he entitled to a profit sharing.

In Table 1 are described the actuarial assumptions used for product pricing. *The actuarial valuation base consists of* technical interest rate, mortality rate, and incidence rate for critical illnesses. *The initial assumptions* include administrative, settlement expenses, targeted profit margin, and cost of capital. The input information is the parameters of the insurance product: acquisition and maintenance commission. Unisex mortality tables are used for pricing premium (under EU directive 2004/113/ES), but female mortality tables are used for next actuarial analyses, e. g. for estimation of claims. (Statistical Office of the Slovak Republic, 2025).

Table 1: Assumptions used for pricing

Product	Term insurance Supplementary critical illness insurance	
Entry age	50	woman
Sum insured	50,000 €	
Insurance period	5	
Term insurance		
Initial costs	100 €	
First year commission	50 %	from the first year's premium
Administrative costs	25 €	from the 1 st year, increases by inflation
Maintenance commission	10 %	from the 2 nd year and further premiums
Cost of insurance claims	30 €	subject to inflation
Technical interest rate	2 %	
Mortality rate	MT 2022	unisex mortality tables
Target profit margin	15 %	
Supplementary critical illness insurance		
Initial costs	50 €	
First year commission	50 %	from the first year's premium
Administrative costs	5 €	from the 1 st year, increases by inflation
Maintenance commission	10 %	from the 2 nd year and further premiums
Cost of insurance claims	150 €	subject to inflation
Incidence rate	+ 15 %	unisex mortality tables 2022
Target profit margin	10 %	

Source: own processing

The gross premium is created by adding costs to the net premium. It can also be referred to as an adequate premium. The basic principle of calculating the total premium is to cover the costs of a specific insurance contract, IFRS 17 (2020). First, all expenses are divided into individual groups of insurance products and assigned to activities related to the creation, operation, and sale of the given insurance. These costs include distribution expenses, such as commission and operational costs of the insurance company, which are allocated per insurance contract. All costs are then calculated into the insurance premium.

Equivalence equation for the gross premium is in the form

$$PV(B) = PV(SA) + PV(C) \quad (1)$$

where

- $PV(B) = B \times \ddot{a}_{\overline{xn}|}$ - the present value of the premium,
- $PV(SA) = SA \times A_{\overline{xn}|}^1$ - the present value of the benefits,
- $PV(C)$ - the present value of the costs.

The present value of the costs of distribution - commissions depends on the way they are determined by the insurance company.

Let

C_i – initial commission, which is a percentage of the premium for the first year,

C_r – maintenance commission, which is a percentage of each subsequent premium.

Then, the present value of the commissions is obtained from

$$C_i \times B + C_r \times B \times {}_1|\ddot{a}_{\overline{xn-1}|} \quad (2)$$

We denote the value of a temporary due one-year deferred annuity with inflation

as ${}_1|\ddot{a}'_{\overline{xn-1}|}$.

The present value of an insurance company's expenses related to a product can be expressed as either a fixed component or as a percentage of the premium or sum insured. We consider fixed expenses, such as

E_i – initial expenses,

E_r – renewal/administration expenses,

E_c - expenses associated with insurance claims.

The present value of additional costs can be expressed in the form

$$E_i + E_r \times {}_1|\ddot{a}'_{\overline{xn-1}|} + E_c \times A_{\overline{xn}|}^1 \quad (3)$$

The present value of costs, after adding the present value of costs to the present value of commissions, is given by the formula

$$PV(C) = C_i \times B + C_r \times B \times {}_1|\ddot{a}_{\overline{xn-1}|} + E_i + E_r \times {}_1|\ddot{a}'_{\overline{xn-1}|} + E_c \times A_{\overline{xn}|}^1 \quad (4)$$

We put present values $PV(B)$, $PV(SA)$ a $PV(C)$ into premium equivalence equation

$$B \times \ddot{a}_{\overline{xn}|} = SA \times A_{\overline{xn}|}^1 + C_i \times B + C_r \times B \times {}_1|\ddot{a}_{\overline{xn-1}|} + E_i + E_r \times {}_1|\ddot{a}'_{\overline{xn-1}|} + E_c \times A_{\overline{xn}|}^1 \quad (5)$$

and thus, we obtain the relationship for premium for term insurance in the form (Krčová et al., 2022):

$$B = \frac{SA \times E_c \times A_{\overline{xn}|}^1 + E_i + E_r \times {}_1|\ddot{a}'_{\overline{xn-1}|}}{\ddot{a}_{\overline{xn}|} - C_r \times {}_1|\ddot{a}_{\overline{xn-1}|} - C_i} \quad (6)$$

We add the profit margin that covers the cost of capital expenses to get the resulting insurance B_v for the main coverage is

$$B_v = \frac{B}{1 - \text{profit\_margin}} \quad (7)$$

We utilized mortality tables from the Statistical Office for the year 2022, assuming an incidence rate for critical illness at 115 % of the mortality rate. A fixed inflation rate of 2 % was applied. This approach allows for the explicit inclusion of cost inflation in the calculation of the insurance premium. We applied inflation by using the following formula (Krčová et al., 2022).

$$\dot{i} = \frac{i - f}{1 + f} \quad (8)$$

To calculate the premium for supplementary critical illness insurance, we used the formula

$$B_{CI} = \frac{SI \times A_{\overline{xn}|}^1 + E_i + E_r \times {}_1|\ddot{a}'_{\overline{xn-1}|} + E_c \times A_{\overline{xn}|}^1}{\ddot{a}_{\overline{xn}|} - C_r \times {}_1|\ddot{a}_{\overline{xn-1}|} - C_i} \quad (9)$$

Next, we have calculated the profit margin and the resulting insurance B_v for the critical illness supplement, using formulas (6), (7) and (9).

Table 2: Premium for each part of insurance

Premium	Term insurance (€)	Critical illnesses (€)
Net premium	247	284
Total amount of premium	415	408

Source: own processing

When determining the best estimate of the interest rate, we will base our calculations on the spot risk-free interest rate curve for the euro as of 31 December 2023 published by (EIOPA, 2024a). The best estimate of the inflation rate is determined based on the quarterly forecast of Consumer price index published by the National Bank of Slovakia (NBS, 2024). These are shown in Table 3.

Table 3: Discount rates used in pricing process

Year of insurance	Spot risk-free interest rate (%) 31.12.2023	1-year forward interest rate (%) 31.12.2023	Annual cumulative discount rate (%) 31.12.2023	Inflation rate NBS (%)	Cumulative inflation rate NBS (%)
1	3.357	3.357	0.9675	3.00	3.00
2	2.690	2.027	0.9483	5.30	8.46
3	2.439	1.939	0.9303	3.80	12.58
4	2.350	2.083	0.9113	2.80	15.73
5	2.323	2.215	0.8916	2.80	18.97

Source: own processing based on EIOPA, 2024a and NBS, 2024

The formula for converting a spot interest rate to a forward interest rate forms a fundamental element for understanding the term structure of interest rates and financial transactions and is as follows (Hull, 2018)

$$F_{t,T} = \left[\frac{(1 + S_T)^{\frac{T}{T-t}}}{(1 + S_t)^{\frac{t}{T-t}}} \right] - 1 \quad (10)$$

where $F_{t,T}$ - forward interest rate between time t and T ,

S_t - spot interest rate at time t ,

S_T - spot interest rate at time T .

The actuarial valuation basis is static as seen as interest rate and inflation and does not change in the future based on market development, creating the basis for the valuation of financial options and guarantees. (Furrer, 2024).

In the context of an insurance company, a credit spread is used to discount future cash flows to consider the credit/counterparty risk associated with investments in assets that are not completely risk-free. According to the valuation framework, we distinguish further adjustments to the risk-free interest rate to determine the present value of cash flows. In the Solvency II methodology, a volatility adjustment is used to express the riskiness of the increase in credit spreads because of the financial crisis, and a matching adjustment, which adjusts the discount rate by the return on assets that are closely matched to liabilities. The methodology for calculating these adjustments is complex and is described in the Solvency II regulation, issued by EIOPA (2024b). For IFRS 17 purposes we will use only the risk-free interest rate as in the insurance products in example are pure risk covers and thus corresponding discount rate shall not be adjusted.

Lapse rate is company specific assumption and thus is difficult to observe in the markets. We used 10% in the first year, 9% in the second year, 8% in the third year and in the next years is 7%. For critical illness they are increased by 10% as supplementary insurance can be cancelled without cancelling whole policy. The best estimates of expenses are equal to the pricing ones as stated in Table 1.

Actuarial analyses in the context of IFRS 17

Each insurance company is required to justify the choice of accounting policy and the method of applying the valuation method for insurance contracts. The choice of accounting methodology is stated in the notes section, which is part of the financial statements. In this part of the paper, we will present the actuarial research methods that we applied to achieve the practical results described in the Results and Discussion chapter.

Valuation methods under IFRS 17 are described in detail by Widing and Jansson (2018), Páleš et al. (2021). The GMM method is critically analyzed by the German authors Ewelt-Knauer et al. (2018). Palmborg et al. (2021) demonstrate valuation and allocation method and profit-and-loss algorithm for a realistic size life insurance portfolio under IFRS 17. According to IFRS 17, an insurance company must report CSM and RA for a group of insurance contracts always profitable as profit margin is positive thus sum up term insurance and critical illness both creating one insurance policy into one portfolio. If the result of the GMM method is a contractual service margin, then the group of insurance contracts is profitable. If the result is a negative value, then it becomes a loss component, which must be reported in the income statement. However, the insurance company must monitor the development of the loss component in case the insurance contract becomes profitable again and a contractual service margin is formed (Páleš et al., 2021). Coverage units were calculated under the sum assured. CSM release through coverage units' pattern (Zelinová et al. 2022b).

The mathematical relationship for cash flow modelling of best estimate of liabilities:

$$CF_t = B_v \times l_{t-1} - SA \times d_t - E_i \times l_{t-1} - B_v \times C_i \times l_{t-1} - l_t \times E_r - d_t \times E_c - SA \times ci_t \quad (11)$$

where

l_t - is number of alive of year t ,

d_t - is number of deaths of year t ,

ci_t - is number of critical illnesses of year t .

The present value of future cash flows is calculated as follows

$$PVFCF_t = \sum_{t=1}^n \left[\frac{CF_t^{BoP}}{(1+r_{t-1})^{t-1}} + \frac{CF_t^{EoP}}{(1+r_t)^t} \right] \quad (12)$$

where

$PVFCF$ - present value of future cash flows,

CF_t^{BoP} - cash flow at the beginning of the year t ,

CF_t^{EoP} - cash flows at the end of year t .

r - locked in 1-year risk free interest rate,

t - time period – year.

Determining of CSM and RA

Contractual service margin (CSM) is part of the liability of insurance contracts and represents the unearned profit that the insurer will recognize when it provides services under the insurance contracts in the future. At initial recognition, the insurer measures the CSM at an amount that is recognized in balance sheet and not income statement (IFRS 17, 2020). The CSM corresponds to the difference between cash inflows and cash outflows, factoring the risk adjustment and discounting to time zero. Once the insurance contract period, the service margin must be fully written off and recorded in the income statement. The contractual service margin cannot be reported as a negative value. In case the difference between present value of cash flows and risk adjustment from non – financial risk has a negative value, then it is a loss component, that is reported in the income statement as a loss (Yousuf et al., 2021).

The CSM calculation is performed for the initial valuation using the GMM (General model measurement) method

$$\begin{aligned} CSM_0 &= PVFCF_0 - RA_0 \succ 0 \\ LC_0 &= PVFCF_0 - RA_0 \prec 0 \end{aligned} \quad (13)$$

where

$PVFCF_0$ - present value of the future cash flows at initial recognition,

RA_0 - risk adjustment for non-financial risk at initial recognition,

LC_0 - loss component at initial recognition.

The insurance coverage units provide a pattern for the releasing of the contractual service margin over time by using the amortization factor AF_t

where

$$AF_t = \frac{CU_t}{\sum_{t=1}^n PVCU_t} \quad (14)$$

CU_t - coverage units for the period t ,

$\sum_{t=1}^n PVCU_t$ - the sum of all coverage units for the remaining period (Zelinová et

al.,

2022a).

IFRS 17 does not specify the exact methods for calculating insurance coverage units, but it does provide guidelines within which to operate. One approach is to work with the amount of insurance benefits that are to be paid in the insured events (England et al., 2019). The benefit amounts are determined for each type of insurance coverage based on the maximum amount that the policyholder might receive. The expected duration of insurance coverage is

determined by the expected number of policies for each type of main coverage/risk separately. It is used to express the probability that insurance events occur only to the extent that they affect the expected duration of the contracts in the group. The calculation of CU is as follows

$$CU_t = \sum_{i=1}^n SA \times no\_pols\_if_t \quad (15)$$

where

SA - sum assured for all insurance coverage,

$no\_pols\_if_t$ - an expected number of insurance contracts in force.

IFRS 17 does not prescribe specific techniques that insurers should use to assess risk adjustments for non-financial risks. However, to fulfill its intended purpose, IFRS stipulates that the assessment should adhere to the following characteristics:

- a risk with a lower frequency and higher severity will result in a higher risk adjustment compared to a risk with a higher frequency and lower severity,
- for the same type of risk, a contract with a longer duration has higher risk premiums than a contract with a shorter duration,
- risks with a broader probability distribution will have higher risk adjustments than risks with a distribution based on estimates,
- the less information about the insurer's current estimates and trends is available, the higher the risk adjustment. (Páleš et al., 2021).

Longer experience reduces uncertainty, which decreases risk adjustment value. One method for risk adjustment calculations is the Cost of Capital method, commonly used by most insurance companies. However, some insurance companies determine the risk adjustment amount using fixed percentage based on projected cash - flows or simpler calculations of Value at Risk or Conditional Value at Risk. In the modelling, we expressed the necessary capital by applying the shocks specified by the Solvency II methodology for the selected risks. The risks affecting term life insurance are mortality risk, expense risk, and lapse risk. These risks have correlation coefficients, shown in Table 4. For Critical Illness, the morbidity is added, and dependency coefficients are shown in Table 5.

Table 4: Risks for term insurance

Correlation matrix	Mortality	lapse	expenses
mortality	1	0	0.25
lapse	0	1	0.5
expenses	0.25	0.5	1

Source: Solvency II, European Union, 2009

Table 5: Risks for rider's Critical illnesses

Correlation matrix	mortality	morbidity	lapse	expenses
mortality	1	0.25	0	0.25
morbidity	0.25	1	0	0.5
lapse	0	0	1	0.5
expenses	0.25	0.5	0.5	1

Source: Solvency II, European Union, 2009

When calculating the risk adjustment, we chose a confidence level for the Value at Risk (VaR) of 70%. The VaR percentile represents the probability that the actual outcome will be less than the VaR value for the selected time period and is therefore equal to the target confidence level. The risk adjustment is defined as the difference between the VaR and the best estimate, which represents the present value of future cash flows as part of the fulfilment of cash flows. In the paper, we work with the values of the shock scenarios for non-financial risks offered by Solvency II at a confidence level of 99.5% in one year. Using a standardized normal distribution with parameters $\mu = 0$ and $\sigma = 1$, we adjusted the shock applied to 70% confidence level. The formula for distribution function is:

$$\phi(z) = \frac{1}{\sqrt{2\pi}} \times \int_{-\infty}^z e^{-t^2/2} dt \quad (16)$$

That will result for term insurance to an increase in mortality up shock by 3.05% instead of 15% used in Solvency II, an increase in cancellations in lapse mass shock by 10.18% instead of 40% used in Solvency II, and an increase in expenses by 1.9% instead of 10%, with a subsequent increase in inflation by 0.2% instead of 1%. In the case of critical illnesses with a 4.05% reduction in mortality down shock, instead of 20%, an increase in morbidity of 7.13% in the first year instead of 35%, 5.09% in the following years instead of 25%, shock for cancellation and inflation are same as for term insurance. Based on these shock scenarios, we express the value of additional capital using capital requirements.

$$\begin{aligned} NFR_t^{mt} &= PVFCF_t^{mt} - PVFCF_t \\ NFR_t^l &= PVFCF_t^l - PVFCF_t \\ NFR_t^e &= PVFCF_t^e - PVFCF_t \\ NFR_t^{md} &= PVFCF_t^{md} - PVFCF_t \end{aligned} \quad (17)$$

where

NFR_t^{mt} - Non – financial risk – mortality value of additional capital in a shock scenario with increased mortality,

NFR_t^{md} - Non – financial risk - morbidity, value of additional capital in a shock scenario with increased mortality,

NFR_t^l - Non – financial risk – lapse, value of additional capital in a shock scenario with increased cancellation,

NFR_t^e - Non – financial risk - expenses, value of additional capital in a shock scenario with increased costs and inflation,

$PVFCF_t^{mt}$ - Present value of Future cash flows, after applying shock for mortality,

$PVFCF_t^{md}$ - Present value of Future cash flows after applying shock for morbidity,

$PVFCF_t^l$ - Present value of Future cash flows after applying shock for lapse,

$PVFCF_t^e$ - Present value of Future cash flows after applying shock for expenses and inflation.

The value of the total capital for term insurance expressed by mortality, lapse and cost shocks is determined by the relationship similar, defined in Solvency II, (2015)

$$RA_t = NFR_t = \sqrt{\sum_{i,j} CorrL_{(i,j)} \cdot NFR_t^{mt} \cdot NFR_t^l \cdot NFR_t^e} \quad (18)$$

where

$CorrL_{(i,j)}$ - correlation parameter for life insurance underwriting risk shown in Table 4.

The value of the total non – financial risk for critical illness of supplementary insurance expressed by mortality, morbidity, cancellation and cost shocks will be determined by the relationship, like Solvency II, (2015)

$$RA_t = NFR_{SLTh} = \sqrt{\sum_{i,j} CorrSLTH_{(i,j)} \cdot NFR_t^{mt} \cdot NFR_t^{md} \cdot NFR_t^l \cdot NFR_t^e} \quad (19)$$

where

$CorrSLTH_{(i,j)}$ - correlation parameter for Health SLT underwriting risk shown in Table 5.

Results and discussion

The above assumptions and mathematical relationships can be used to project the future development of the insurance contract portfolio. For term insurance, we consider the number of contracts to be 1,000 for simplification, contracts for women will be used, for critical illness insurance we consider 900 units.

Table 6 shows the decrements involved in the calculation of cash flows for term insurance and Table 7 for critical illness, mortality tables and incidence rates used for projecting of claim cash – flows are specific for women and not unisex which were used in premium pricing, because insurance companies use for best estimates mortality tables for calculation of insurance liabilities.

Table 6: Projection of decrements for term insurance

Year	Age	Probability of mortality	Probability of lapses	is	Number of deaths	Number of lapses
t	x	$q(x)$	$s(x)$	$l(t)$	$d(t)$	$s(t)$
θ				1,000		
1	50	0.0020	0.1000	898.20	2.00	99.80
2	51	0.0022	0.0900	815.56	1.98	80.66
3	52	0.0026	0.0800	748.37	2.12	65.08
4	53	0.0032	0.0700	693.75	2.39	52.22
5	54	0.0033	0.0700	643.06	2.29	48.40

Source: own processing based on mortality tables, Statistical Office of the Slovak Republic, 2025

Table 7: Projection of decrements for critical illness

Year	Age	Probability of mortality	Probability of lapses	Probability of critical illness	Number of alive	Number of deaths	Number of critical illnesses	Number of lapses
t	x	$q(x)$	$s(x)$	$i(x)$	$l(t)$	$d(t)$	$ci(t)$	$s(t)$
θ					900			
1	50	0.0020	0.1100	0.0022	797.64	1.80	1.98	98.58
2	51	0.0022	0.0990	0.0026	715.22	1.75	2.07	78.59
3	52	0.0026	0.0880	0.0030	648.63	1.86	2.15	62.59

Year	Age	Probability of mortality	Probability of lapses	Probability of critical illness	Number of alive	Number of deaths	Number of critical illnesses	Number of lapses
4	53	0.0032	0.0770	0.0037	594.55	2.08	2.40	49.60
5	54	0.0033	0.0770	0.0038	544.88	1.96	2.26	45.46

Source: own processing based on mortality tables, Statistical Office of the Slovak Republic, 2025

Table 8 shows the variables entering the cash flow calculation according to formula 11. The profit margin is 38.07%, so the product is profitable. In this case, the insurance company should create a CSM and gradually release it throughout the insurance period.

Table 8: Cashflows for portfolio of insurance contracts

Premium (€)	Sum insured (€)	Acquisition costs (€)	Administrative costs (€)	Cost of claims settlement (€)	Cash-Flows (€)
782,200	199,000	536,100	29,500	357	17,243
698,188	202,495	-	97,002	381	398,310
630,269	213,310	-	88,920	416	327,623
575,213	239,735	-	82,093	483	252,901
530,486	227,435	-	76,381	468	226,202
3,216,356	1,081,975	536,100	373,896	2,106	1,222,280
				Profit margin:	38.07%

Source: own processing

We use the GMM method to value the cash flows of portfolio, according to formulas (11) and (12). Cash flows were distributed and discounted based on their timing within the period. At the beginning of the period (BoP) there were premium and acquisition costs. At the end of the period (EoP) there were administrative costs, insurance claims and costs of claims settlement.

Table 9: Amounts of CSM, RA

PV Future cash flows BoP	Risk free rate (forward curve) (%)	Risk adjustment BOP (€)	Release RA (€)	CSM BoP (€)
-1,185,481	3.357	66,817	2,663	1,118,664
-1,199,773	2.027	64,154	21,245	861,974
-811,630	1.939	42,910	17,491	624,231
-487,524	2.083	25,419	13,431	402,970
-232,796	2.215	11,988	11,988	195,752
-3,917,204			66,817	

Source: own processing

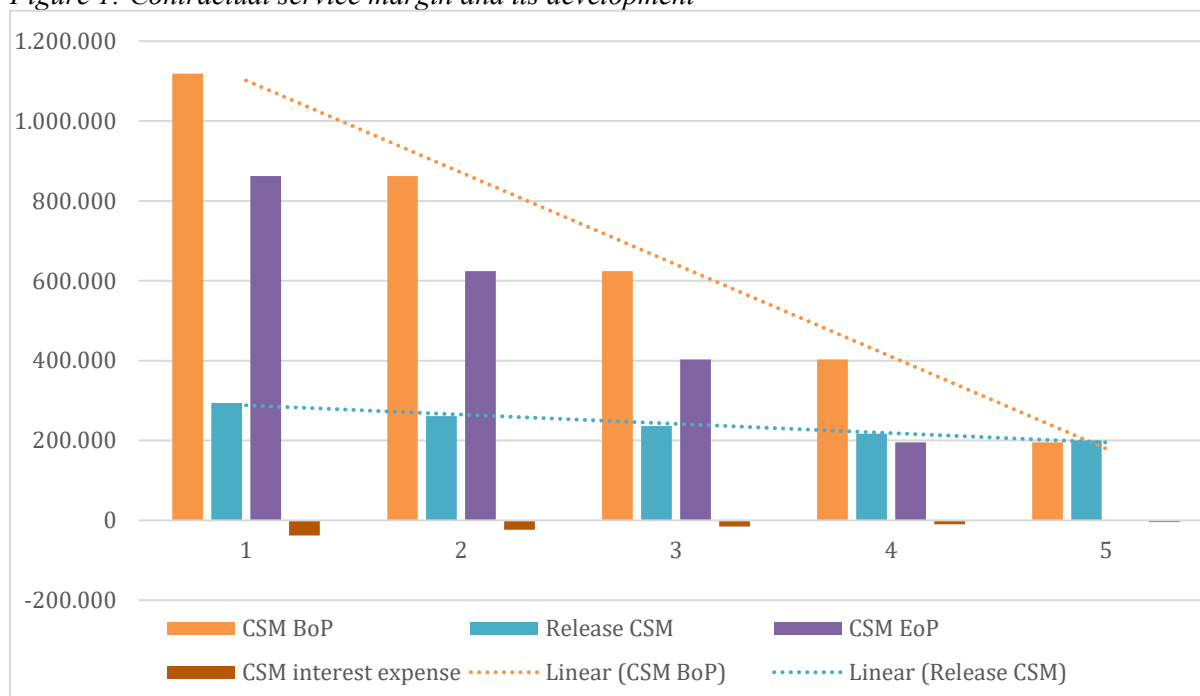
The present value of coverage units is used to calculate the amortization factor by which the CSM is released over the entire period. At the end of the period, the entire CSM and RA must be released in the income statement. CSM interest expense is calculated by unwinding effect of the present values CSM at beginning by applying the locked-in interest rate for corresponding year. The sum of the CSM interest expense and sum of the CSM at initial recognition is together sum of release CSM.

Table 10: Development of CSM

CSM BoP	Coverage units in period	PV Coverage Units	Amortization factor AF	Release CSM	CSM EoP	CSM interest expense
1,118,664	95,000,000	373,298,649	25.45%	294,244	861,974	-37,554
861,974	84,791,790	287,641,134	29.48%	260,931	624,231	-23,187
624,231	76,539,200	206,961,101	36.98%	236,486	402,970	-15,225
402,970	69,849,790	132,950,781	52.54%	216,688	195,752	-9,470
195,752	64,415,385	64,415,385	100.00%	200,299	0	-4,547
				1,208,647		-89,983

Source: own processing

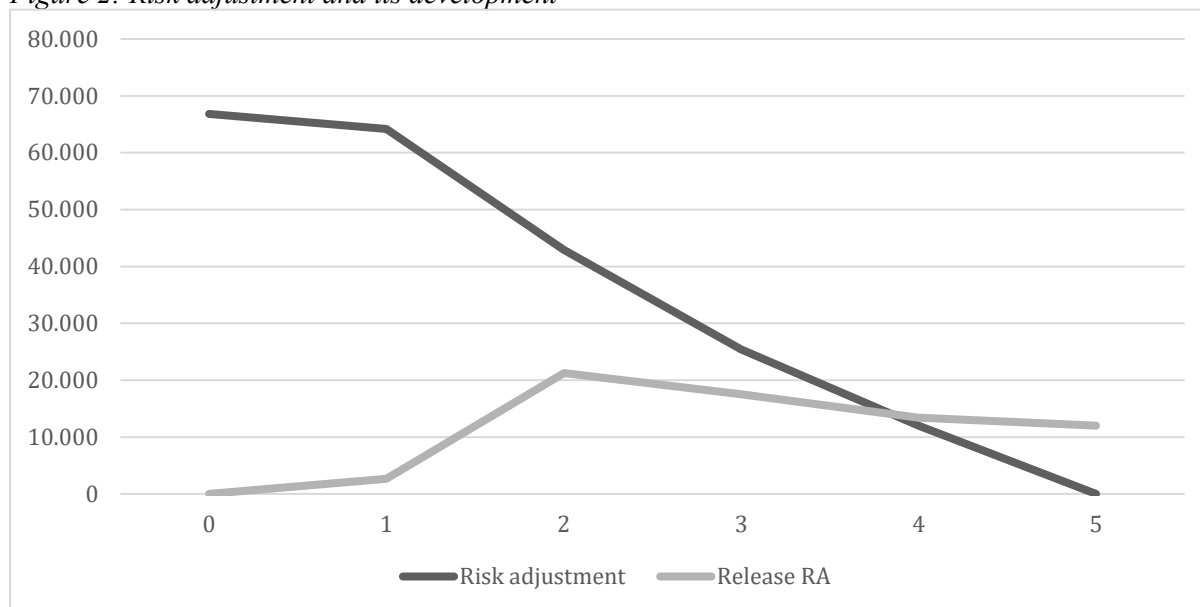
Figure 1: Contractual service margin and its development



Source: own processing

Figure 1 shows the CSM and its release over the years. The amount of released CSM is equal to the amount of CSM created at the initial recognition increased by the interest expenses. All projections are made at the time of initial recognition of a group of insurance contracts. Figure 2 represents development of risk adjustment from non – financial risk and its releasing value. Regarding the confidence level, Solvency II determines the risk margin based on the Solvency Capital Requirement (SCR) and applies a predefined cost-of-capital rate. In contrast, IFRS 17 permits insurers to select a confidence level that aligns with their specific risk profile and business model. This flexibility has resulted in a broader dispersion of confidence levels, typically ranging between 75% and 85%, with an observed industry average of approximately 80 % across both life and non-life insurance portfolios, (EIOPA, 2024).

Figure 2: Risk adjustment and its development



Source: own processing

Conclusion

In the paper, we presented a proposal for valuing a portfolio of life insurance contracts, detailing the initial recognition procedure and subsequent measurement using the GMM method. The insurance portfolio consists of 1,000 term life insurance contracts, with 900 critical illness supplementary coverage. It discusses the selection of appropriate actuarial assumptions and the compilation of an actuarial base. The valuation of an insurance portfolio leads to several conclusions. Actuarial assumptions play an important part in initial recognition of insurance portfolio, and their appropriate setting at the outset leads to satisfactory outcomes. The contractual service margin represents the profit derived from the portfolio of insurance contracts over the entire duration of insurance services. Consequently, the insurance company cannot immediately recognize it at inception of policy. Instead, it recognizes by gradually releasing portion throughout the duration of policy. With this approach, IFRS 17 ensured that the insurance company recognizes the profit in parts throughout the insurance period. Nonetheless the loss is recognized and reported immediately in the income statement. The risk adjustment reflects uncertainty in insurance contracts arising only from non-financial risks such as uncertainty in level of costs, mortality, morbidity, cancelations and inflation. Figure 2 illustrates the dissolution of the risk adjustment and its value at the beginning of each year. The risk adjustment can be seen as either a reward for insurers bearing risk or an amount to cover expected adverse effects under normal conditions, with solvency capital covering unusual circumstances. In conclusion, setting actuarial assumptions correctly and the accurate valuation of insurance contracts in initial recognition lead both to a saleable and competitive product.

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risk management methods in implementing partial internal models for determining solvency capital requirements, by ESG grant A-25-103/3020-17 Improving students' knowledge and skills in project management using the IPMA methodology and by VEGA 1/0124/24 Slovakia in the context of the pension index and population ageing index - future perspective.

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ECONOMICS

Economics, as a discipline, critically examines the production, distribution, and consumption of goods and services, alongside the forces that drive growth, shape markets, and influence societal well-being. In an increasingly interconnected and dynamic global environment, understanding economic phenomena, policy implications, and human capital dynamics is paramount. The empirical and theoretical papers presented across Economics tracks offer diverse perspectives on economic development, the effectiveness of public and environmental policies, and the evolving role of human capital in driving prosperity, therefore contributing to achieving the defined aim and scope of the Odyssey conference. To reflect the breadth of contemporary economic research, submissions have been organized into three thematic tracks.

TRACKS:

TRACK 1: Growth, Development, and Economic Resilience

TRACK 2: Public Policy, Governance, And Sustainability

TRACK 3: Human Capital Dynamics



ECONOMICS

TRACK 1: Growth, Development, and Economic Resilience

PREFACE

ECONOMICS – TRACK 1: GROWTH, DEVELOPMENT, AND ECONOMIC RESILIENCE

Economic growth and sustainable development in modern economies are shaped by a dynamic interplay of factors, ranging from institutional quality and policy effectiveness to global economic integration and the impact of environmental changes. This thematic section explores determinants and challenges to fostering robust progress, highlighting the multifaceted nature of development and the critical role of sound policies and adaptive strategies. The papers within this track collectively offer diverse perspectives on how various elements contribute to, or hinder, a country's economic trajectory and long-term prosperity. The papers in this track are unified by their focus on the mechanisms and conditions that facilitate or impede economic growth and development. They examine crucial aspects such as institutional frameworks, the integration of economies into global networks, the impact of significant financial inflows, methodological approaches to assess convergence, and the emergent challenges posed by climate change on economic stability, along with the convergence of regional innovation ecosystems.

Specifically, Frljak and Biber investigate the critical role of institutions in supporting entrepreneurship and driving economic growth within selected European transition countries, highlighting how institutional quality directly influences entrepreneurial activity and overall developmental success. Markušić explores the methodological implications of time series filtering methods on the detection of economic convergence, offering crucial insights for robust analysis of developmental trends and policy effectiveness. Mikulić quantifies the short-term economic effects of investments financed by EU funds on Croatia's gross added value and employment, illustrating the significant impact of external financial support on national economic activity. Petrylé empirically analyzes the development of the Baltic countries' export network after the collapse of the Soviet Union, identifying key factors that influenced their integration into the global economy and their extensive trade margin development. Vlačić examines the regional convergence of innovation ecosystems, specifically in Central and Eastern European countries, by analyzing collaboration in academic projects and shared patent activity to understand the impact of de-globalization trends on knowledge flow and convergence toward the EU's innovation landscape. Finally, Žmuk and Jošić introduce and explore the concept of "heatflation", analyzing how climate change, specifically extreme heat, contributes to inflationary pressures, particularly in low-income countries, thereby presenting a novel environmental challenge to economic stability and development.

THE ROLE OF INSTITUTIONS IN SUPPORTING ENTREPRENEURSHIP AND THE ECONOMIC GROWTH OF SELECTED EUROPEAN TRANSITION COUNTRIES

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Abstract

This paper explores the relationship between institutions and entrepreneurship and their role in a country's economic growth. Institutions play a major role in shaping the business environment, either encouraging or hindering entrepreneurial initiatives. On the other hand, the role of entrepreneurship is crucial, as entrepreneurs contribute to job creation, increased productivity, and thus to the improvement of all components of GDP, which leads to higher economic growth. This research covers eighteen European transition economies in the period from 2014 to 2023. The sample is divided into two groups; the first group includes countries with the lowest average GDP per capita (Ukraine, Kosovo, Albania, Bosna and Herzegovina, North Macedonia, Serbia, Montenegro, Bulgaria, Romania), while the second group includes countries with the highest average GDP per capita (Slovenia, Czechia, Estonia, Lithuania, Slovak Republic, Latvia, Hungary, Poland, Croatia). We conclude that more developed economies (higher average GDP per capita) perform better on institutional quality which contributes to stronger entrepreneurial activity and serves as a driver of growth. In contrast, countries with lower average GDP per capita often face institutional weaknesses that hamper entrepreneurship development and slow down their convergence towards more advanced transition economies. Given the importance of institutions in the economy, policymakers should focus on gradually improving institutional quality by achieving progress in certain indicators that have been below average. The aim of this approach is to develop entrepreneurship as a driving force in the progress of transition economies. Reforms and improvements in institutional infrastructure should be a priority for transition economies to ensure synergy between entrepreneurship and economic growth for the overall progress of society.

Keywords: institutions, entrepreneurship, economic growth, transition economies

JEL Classification: O10, O11, O12, O43, E02

Introduction

Economic growth and development represent fundamental goals for every national and regional economy, and recognizing the factors that stimulate them is essential for the creating effective policies and strategies (Todaro & Smith, 2012). Neoclassical theories of economic growth traditionally consider capital, labor and technology as factors of economic

growth, while contemporary models emphasize the importance of entrepreneurship. Entrepreneurship is regarded as a key driver of economic growth, given its crucial role in creating new jobs, fostering innovation, and encourages competition and competitiveness. On the other hand, through the prism of institutional theory, many economists believe that institutions influence entrepreneurial activities by providing an environment that can encourage or hinder entrepreneurship (Bruton et al., 2010).

Accordingly, as institutions and entrepreneurship are indispensable factors contributing to the economic growth of countries, the aim of the paper is to examine the institutional quality of European transition economies, analyze the differences between countries, and connect the quality of the institutional framework with entrepreneurship by analyzing key indicators for entrepreneurial development. Their interconnection significantly influences the country's economic growth, which is especially important to analyze for transitional economies, which face the challenges of shifting from central planning to market-oriented economies.

The first part of the paper presents the theoretical aspect of institutions, entrepreneurship as well as connection between institutions and entrepreneurship, forming the conceptual basis for the empirical analysis that follows. A literature review is given in the second chapter. The third part of the paper presents an analysis of institutional quality, specifically indicators of the index of institutional quality for eighteen transition countries in the period from 2014 to 2023, along with indicators reflecting the level of entrepreneurial development. In the last part of the paper, concluding considerations are given and certain policy recommendations are incorporated into the chapter.

Theoretical aspect of institutions and entrepreneurship in the economy

The concept of institutions in economics

According to North (1990), institutions represent the rules of the game, or the constraints that shape human interactions. Efendić (2010) further explains, suggesting the conclusion that institutions are not only state organizations, but represent a set of written and unwritten rules, as well as implementation mechanisms.

It is sometimes possible, and which is a very common case in transition economies, to have good state organizations and written laws, but if there is a lack of efficient implementation mechanism, the final effectiveness of the institutions will be questionable. Without adequate implementation of institutions, the link between institutions and the market is weak, the transaction costs of institutions are high, and the overall efficiency of the economic system is diminished (EC, 2010).

Rodrik (2008), defining efficient institutions, states that they ensure safe protection of property rights, enforcement of contracts, support of macroeconomic stability, risk management, strengthening of world integration, providing social security and accountability, and especially important for our work – fostering entrepreneurship.

The concept of entrepreneurship in economics

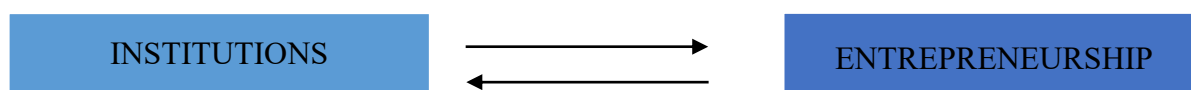
Entrepreneurship represents an approach that includes a way of thinking, and the processes of creating and developing economic activities through combining creativity, innovation and risk-taking, either within a new or existing organization (Commission of the European Communities, 2003). There are significant links between starting a business and the environment in which it should be started. Entrepreneurial success is determined not only by the behavior and characteristics of the individual, but also by the environment (Lee & Peterson, 2000).

Furthermore, it is very important to consider the entrepreneurial environment for making the decision to start a business, because it includes different policies, laws, regulations, programs and strategies. The entrepreneurial environment is defined as the total economic, sociocultural and political factors that influence people's willingness and ability to engage entrepreneurial activity (Gnyawali & Fogel, 1994). The country needs to create and improve framework conditions for entrepreneurship. Entrepreneurial activities are significantly facilitated in a stable macroeconomic environment (OECD, 1998).

The connection between institutions and entrepreneurship

Through reliance on institutional theory, numerous economists have considered institutions as precursors of entrepreneurial activities (Bruton et al., 2010). Depending on their ability to provide a conducive environment for the development of entrepreneurship, institutions can encourage or hinder entrepreneurship. On the other hand, numerous studies emphasize the importance of entrepreneurial activities in institutional changes. Authors Kozul-Wright & Rayment (1997), Yu (2001), Baez & Abolafia (2002), Greenwood & Suddaby (2006), Otahal (2012), Kalantaridis & Fletcher (2012), Kuchar (2015) and Fuentelsaz et al. (2015) have explored this topic, and the main conclusion of their research is that entrepreneurs play a key role in creating institutional changes, which is particularly relevant in developing countries.

Illustration 1: The Interconnection Between Institutions and Entrepreneurship



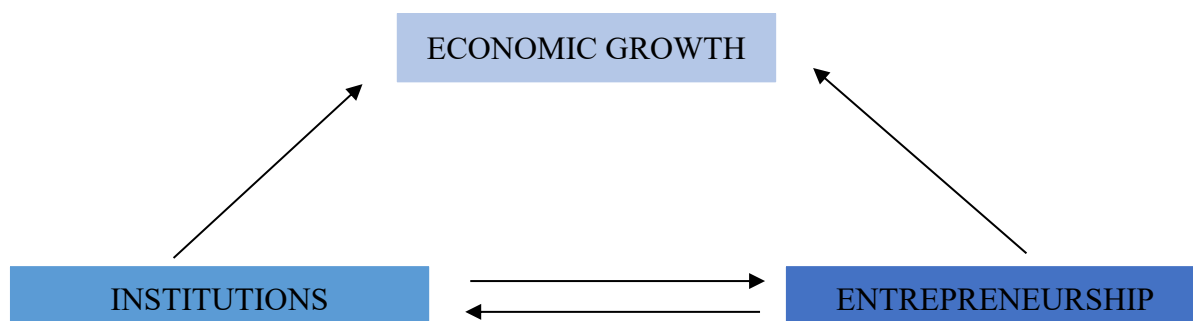
Source: Prepared by the author (based on Bruton et al., 2010; Kozul-Wright & Rayment, 1997; Yu, 2001; Baez & Abolafia, 2002; Greenwood & Suddaby, 2006; Otahal, 2012; Kalantaridis & Fletcher, 2012; Kuchar, 2015; and Fuentelsaz et al., 2015)

Institutions are key factors for entrepreneurship, because entrepreneurial activity often relies on institutional support. North (1990) claims that economic productivity and performance depend on the efficiency of institutions in the country, and that changes in institutions affect all sectors of the economy. On the other hand, entrepreneurs can influence institutions in different ways, change them, and improve those on which their business activities depend. In the previous part, the connection between institutions and entrepreneurship was presented, as well as the effects they leave on each other.

Now the question arises: *What does this relationship contribute to, and what does it create?* According to some studies, entrepreneurship is considered a driver of economic growth, and is included as the fourth production factor in the macroeconomic production function

(Audretsch & Keilbach, 2004). According to Acemoglu et al. (2004) production factors capital, labor, technology and entrepreneurship are the immediate causes of economic growth, while institutions are taken as the fundamental cause of it. This can be visualized as a triangle, where these two elements interact to drive a country's economic growth.

Illustration 2: The Interconnection Between Institutions and Entrepreneurship and Their Impact on Economic Development



Source: Prepared by the author (based on Bruton et al., 2010; Kozul-Wright & Rayment, 1997; Yu, 2001; Baez & Abolafia, 2002; Greenwood & Suddaby, 2006; Otahal, 2012; Kalantaridis & Fletcher, 2012; Kuchar, 2015; Fuentelsaz et al., 2015; and Acemoglu et al., 2024)

Literature review on the relationship between institutions, entrepreneurship and economic growth

Many economists have examined how institutions and entrepreneurship influence a country's economic growth, using various analyses and numerous variables to explore their roles in national development.

According to research conducted by Alexiou et al. (2020) with the aim of determining the relationship between institutional quality and economic growth in 27 post-socialist economies, it was confirmed that the quality of institutions affects economic growth. Research on the causal relationship between the variables of the global governance indicator (rule of law, voice and accountability, corruption control, regulatory quality, government efficiency) and GDP showed that improvements in the quality of regulations have a positive impact on GDP growth, as well as that improvements in governance rights, voice and responsibility positively associated with long-term economic growth.

According to Efendić (2010), the visual simulation of the estimated panel model suggests that the relationship between the quality of institutions and economic outcomes in transition countries is not only positive, but extremely strong. The correlation coefficient for the indices used (indicator of structural and institutional changes, index of economic freedom and index of countries in transition) is greater than 0.80, which suggests that there is a strong relationship between these variables and confirms that institutions are an important determinant of the economic performance of countries.

On the other hand, the results of the research conducted by Aparicio et al. (2016) show that for all Latin American countries, informal institutions have a greater impact on opportunity-

driven entrepreneurship than formal institutions. The research produced three key results. First, there is evidence of a positive relationship between the institutional factor and opportunity-oriented entrepreneurship. Second, there is a positive relationship between opportunity-oriented entrepreneurship and economic growth. Third, combining these two perspectives, it can be suggested that informal institutions, such as corruption control and confidence in one's own skills, encourage entrepreneurship, which is crucial for achieving economic growth.

Khalil et al. (2007) investigated the influence of structural, legal and economic institutions on the economic growth of OECD countries. The results showed that more than 80% of the variation in GDP per capita (GDPpc) can be explained by economic and legal factors, which would mean that the appropriate legal and economic environment can explain changes in economic growth. Other significant variables in our model include trade, population, unemployment, loans given by banks to the private sector, market capitalization as a percentage of GDP and government expenditures, and all variables are very significant and are related to economic growth, except for imports and unemployment.

Based on the research by Sari & Prastyani (2021), it was proven that there is a significant influence of institutional factors on economic growth in ASEAN. More specifically, factors such as voice and accountability, regulatory quality and the rule of law play a key role and contribute significantly to fostering economic growth. On the other hand, government efficiency and corruption control did not show a significant impact on economic growth for ASEAN countries, although corruption control had an effect within the framework of the common effects model.

Uddin et al. (2017) studied the impact of institutions on economic growth in developing countries from 1996 to 2014, with a special emphasis on the role of institutions. According to this research, the development of financial institutions is crucial for economic growth, while the institutional framework can significantly influence the growth of GDP per capita. Political stability is shown to be an important factor for economic development, while the poor quality of institutions can have negative consequences. Furthermore, institutional indicators, economic freedom and political risk, influence economic efficiency and growth. The development of institutions and policies that improve the business environment can have a positive effect on growth, while inefficient and weak institutions can limit growth.

According to a study conducted by Siyakiya (2017), there is clear evidence that entrepreneurship and institutional quality are determinants of economic growth, and that improvements in institutions have the greatest impact on economic growth. A combination of efficient institutions and increased entrepreneurship stimulates economic growth. Understanding the factors and barriers that affect entrepreneurship and institutions is key to improving economic growth. Quality and efficient institutions can be a reason for future investments, because they provide security and increase the optimism of entrepreneurs, so that improvements in institutional quality can influence an increase in investment due to expected high returns.

Analysis of the institutional environment in European transition countries

Sample and methodology

The aim of this chapter is to examine institutional qualities between countries through a comparative analysis. The research focuses on the relationship between the institutional structure of European transition countries. A total of 18 countries were considered; 11 are members of the European Union: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia and 7 are not members of the European Union: Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, Serbia and Ukraine. The analysis was performed for a ten-year time period covering the period from 2014 to 2023. The countries are classified into two groups based on the average level of GDP per capita in the specified period, thus forming a group of countries with the lowest average GDP per capita and countries with the highest average GDP per capita in order to cover the difference in economic performance of countries and to be able to make comparisons and gain better insight into the institutional environment in economies with different growth rates.

Table 1: Countries with the lowest average GDP per capita for the period 2014-2023

Country	Average level of GDP per capita (current US\$)
Ukraine	3.434,61
Kosovo	4.482,45
Albania	5.521,81
Bosna and Herzegovina	6.203,20
North Macedonia	6.668,56
Serbia	8.063,66
Montenegro	8.596,01
Bulgaria	10.222,11
Rumunia	12.666,68

Source: www.worldbank.org

Table 2: Countries with the highest average GDP per capita for the period 2014-2023

Country	Average level of GDP per capita (current US\$)
Slovenia	25.672,69
Czechia	23.644,86
Estonia	23.593,34
Lithuania	19.908,48
Slovak Republic	19.618,19
Latvia	17.258,53
Hungary	16.333,09
Poland	16.038,09
Croatia	15.715,13

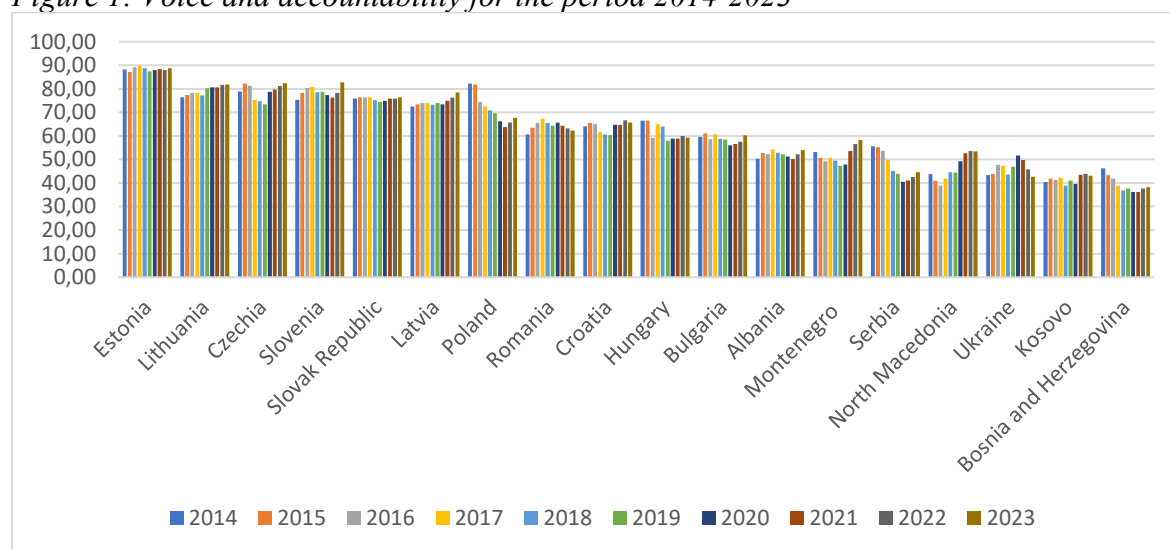
Source: www.worldbank.org

Voice and responsibility

Voice and responsibility include the perception of the degree to which citizens of a country can participate in government, expression, expression and free media (Kaufmann & Kraay, 2023).

The graph shows countries ranked by the average value of the indicator, with Estonia being the country with an average value of 88.34% for this indicator during the period from 2014 to 2023, which are also the best results in the observed period. Lithuania, Czechia, the Slovak Republic and Slovenia also achieved remarkable results. In the mid-range, there is countries like Poland, Romania, Croatia, Hungary, and Bulgaria, which show relatively stable trends, although with slight variations year over year. The lowest percentage of citizen participation in government, expression, and free media was recorded in Bosnia and Herzegovina with an average value of 39.34% and Kosovo with 41.61%. Improvements in the citizen involvement over time were particularly noted in North Macedonia. In Croatia, the indicator shows relatively stable trends over time, although there is room for progress in this area.

Figure 1: Voice and accountability for the period 2014-2023



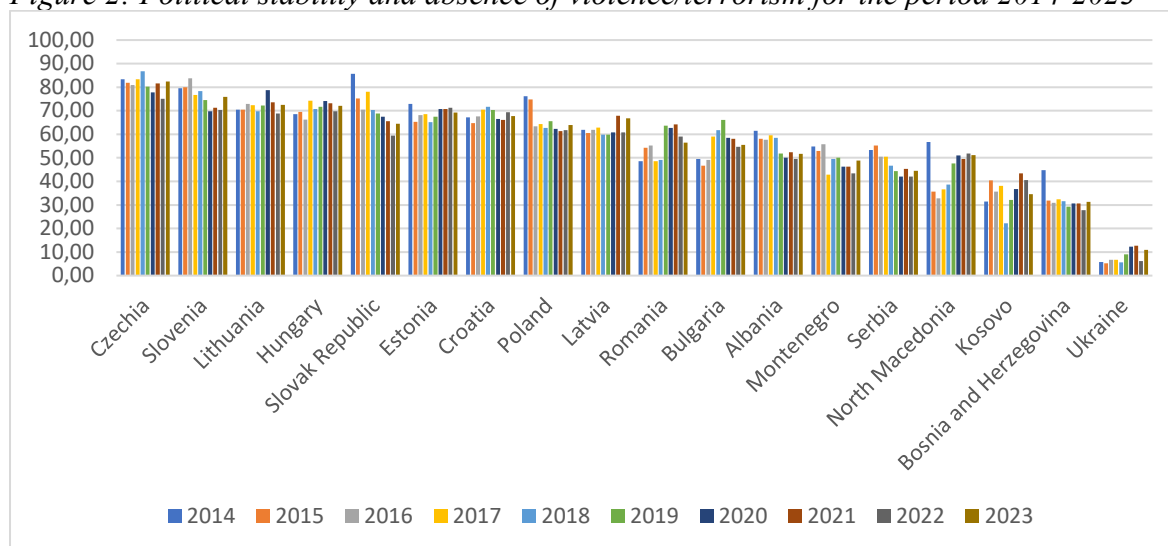
Source: www.worldbank.org

Political stability and absence of violence/terrorism

Political stability and absence of violence/terrorism measures the perception of the likelihood of political instability and/or violence motivated by political reasons, including terrorism (Kaufmann & Kraay, 2023).

Considering the current situation in Ukraine, it is not surprising that the indicator of political stability and absence of violence/terrorism from 2014 to 2023 has such low values. According to the available data, Czechia has the highest political stability indicator, with an average value of 81.34%, followed by Slovenia at 76.00% and Lithuania at 72.19%. Other countries with relatively high levels of political stability and absence of violence/terrorism include Hungary, Slovak Republic, Estonia, Croatia, Poland and Latvia. Besides Ukraine, the graph shows that Bosnia and Herzegovina, Kosovo and North Macedonia have a significantly lower amount of political stability compared to the rest of the countries in the sample.

Figure 2: Political stability and absence of violence/terrorism for the period 2014-2023



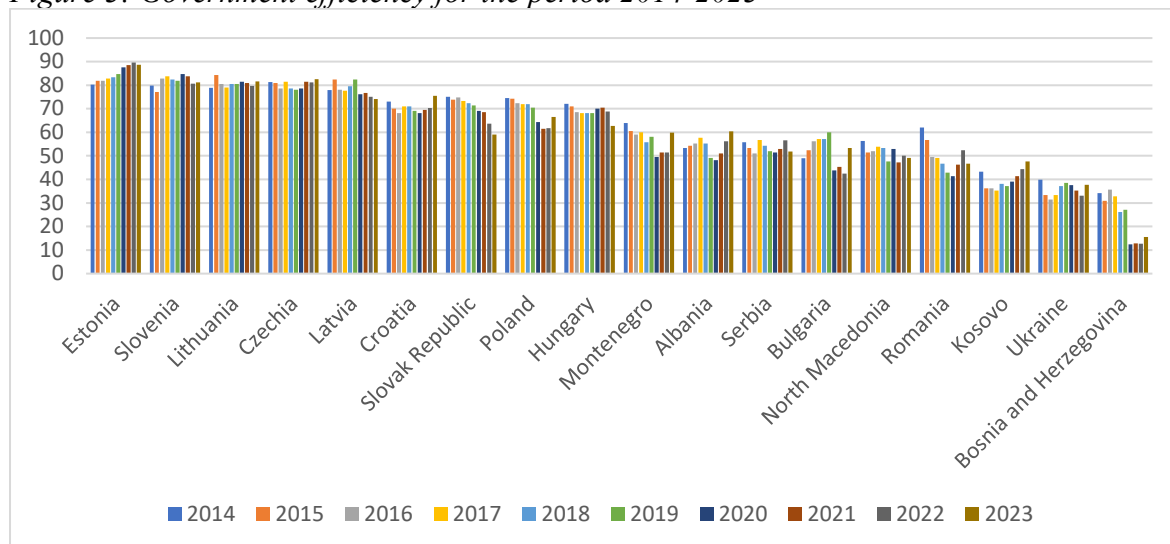
Source: www.worldbank.org

Government efficiency

Government efficiency measures perceptions of the quality of public services, civil service, as well as the degree of independence of the state from political pressure, the quality of policy creation and implementation, and the credibility of the government's commitment to these policies (Kaufmann & Kraay, 2023).

In period of 2014 to 2023, Estonia is the country with the highest government efficiency rate of all 18 countries, with an average value of 84.95% without significant fluctuations during the observed period. Slovenia is slightly behind with an average value of 81.83%, which also indicates a high level of government efficiency. Government efficiency in Lithuania, Czechia and Latvia remained consistently high and without significant fluctuations. In the mid-range, there is countries like Croatia, Slovak Republic, Poland, Hungary where The Slovak Republic recorded a more noticeable decline in government efficiency during the period from 2014 to 2023, but the average value is still at an enviable level (70.10%). Croatia has shown a growth trend since 2020. Bosnia and Herzegovina, Ukraine and Kosovo have lower amounts without significant fluctuations, with an average value of 24.05% for Bosnia and Herzegovina, 35.73% for Ukraine, and 39.86% for Kosovo. Bosnia and Herzegovina recorded a significant drop in government efficiency indicators comparing the first (2014) and last year (2023) in the sample (a decrease from 34.13% to 24.05%).

Figure 3: Government efficiency for the period 2014-2023



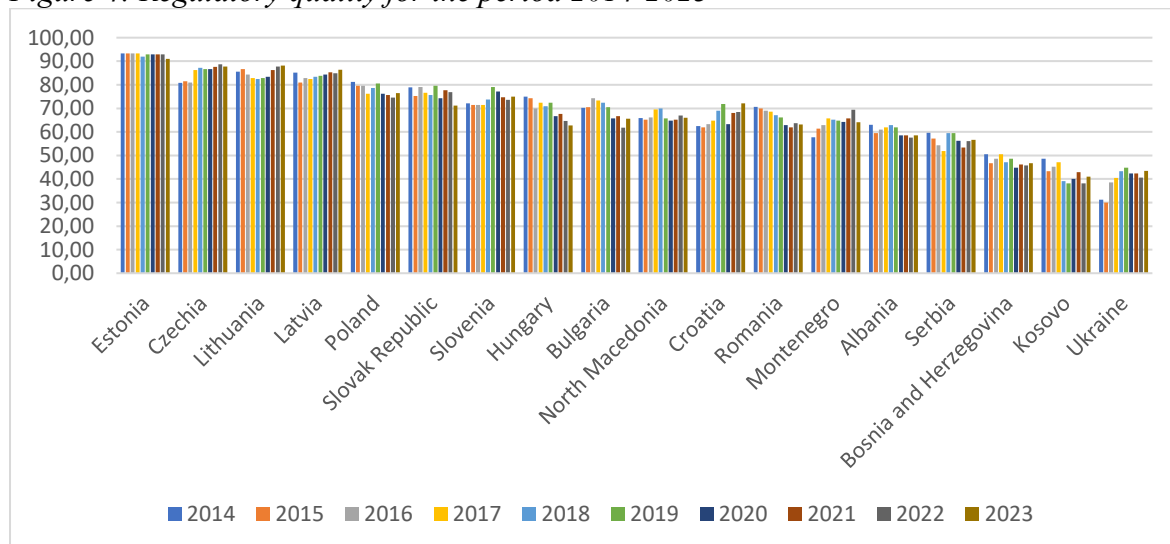
Source: www.worldbank.org

Regulatory quality

Regulatory quality refers to the perception of the government's ability to create and implement sound policies, as well as regulations that enable and promote the development of the private sector (Kaufmann & Kraay, 2023).

Ukraine had an increase in regulatory quality during the observed period from 38.57% in 2016 to 44.76% in 2019; however, it remains the country with the poorest regulatory quality compared to other countries in the sample. Estonia, with an average value of 92.77%, has the best regulatory quality compared to other countries in the sample. Czechia, Lithuania, Latvia, Poland, the Slovak Republic, and Slovenia are countries that have a high indicator of regulatory quality, without significant fluctuations. With slightly lower values, North Macedonia maintained a stable regulatory quality without major fluctuations. In contrast, Croatia displayed a growth trend in regulatory quality over the years.

Figure 4: Regulatory quality for the period 2014-2023



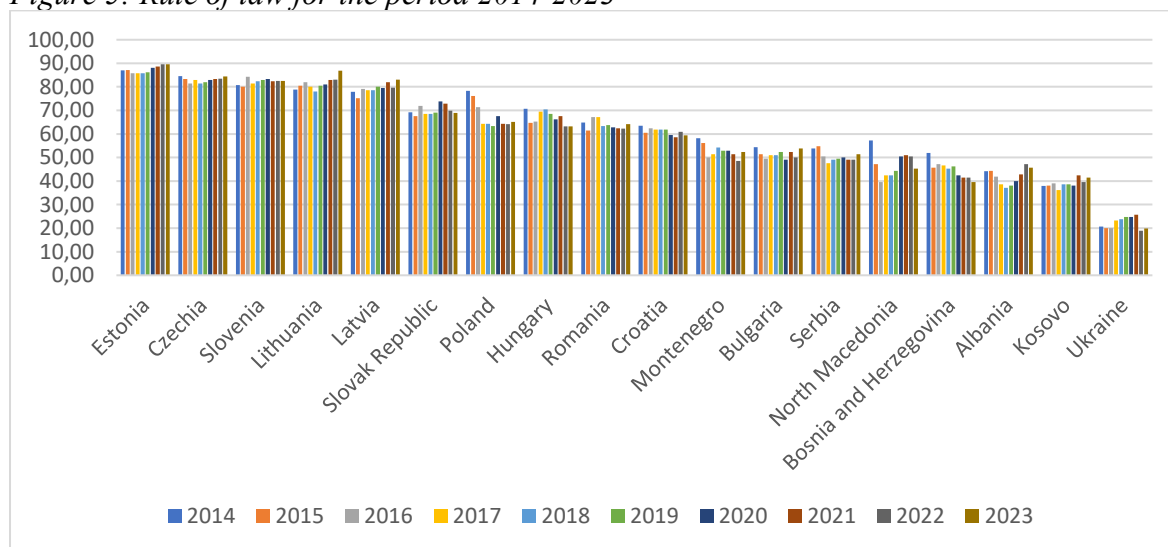
Source: www.worldbank.org

Rule of law

Rule of law assesses the extent to which agents have confidence in social rules and adhere to them, especially regarding the quality of contract enforcement, property rights, police and court work, and the likelihood of crime and violence (Kaufmann & Kraay, 2023).

Based on the graph, we can see that the least trust in social rules regarding contract enforcement, property law, police and court work, and likelihood of crime and violence is recorded in Ukraine, with the lowest amount of 18.87% in 2022 and an average value of 22.17%. A low level of the rule of law was also recorded in Kosovo, with an average value of 39.01%. Estonia, Czechia, Slovenia, and Lithuania have the largest amount of indicators with average values of 87.34%, 82.97%, 82.25%, and 81.34%, respectively. In Bosnia and Herzegovina, a significant decline in the rule of law was observed, as the index dropped from 51.92% in 2014 to 39.62% in 2023. Croatia, Poland, and Romania showed no major fluctuations.

Figure 5: Rule of law for the period 2014-2023



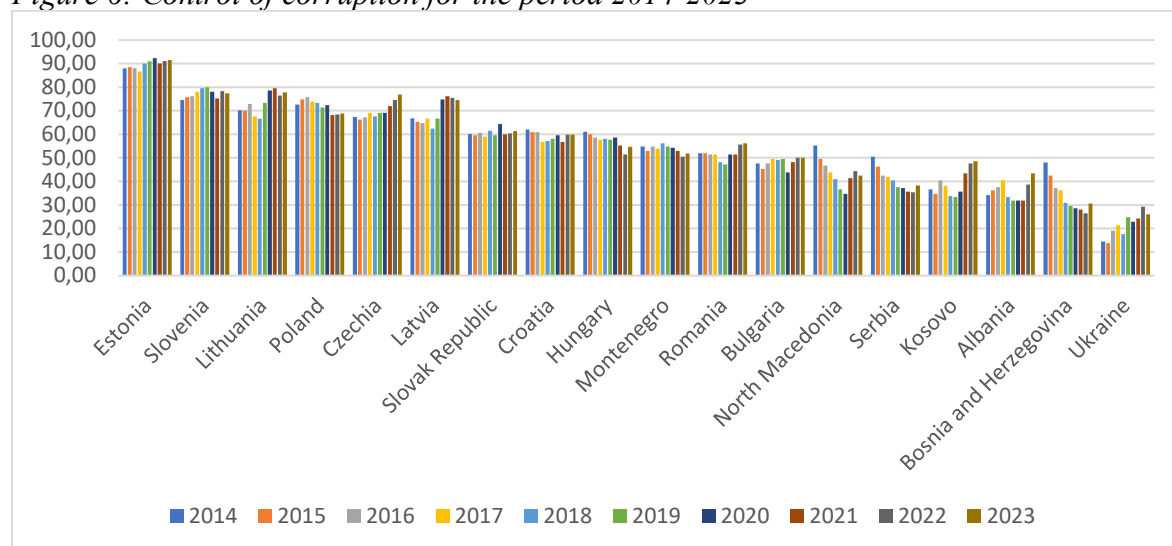
Source: www.worldbank.org

Corruption control

Control of corruption assesses the perception of how and to what extent public power is used for private benefit, including small and large forms of corruption, and "capture" of the state by elites and private interests (Kaufmann & Kraay, 2023).

Estonia, Czechia, Slovenia, Lithuania and Latvia had stable corruption control with high indicator values, which shows successful anti-corruption policies and transparency in public institutions. Countries that performed worse on indicators of corruption control include Ukraine, Kosovo, Albania and Bosnia and Herzegovina. Ukraina and Kosovo have shown progress of improvement in corruption control: Ukraina increased from 14.42% in 2014 to 25.94% in 2023, while Kosovo increased 36.54% in 2014 to 48.58% in 2023. Nonetheless, all these countries still need to further strengthen anti-corruption policies and institutional transparency.

Figure 6: Control of corruption for the period 2014-2023



Source: www.worldbank.org

Institutional index indicator average

Table 3: Average indicators of institutional quality for the period 2014-2023

Country/ Indicator	Voice and Account ability	Polit. Stability and Absence of Violence/Terr	Govern. Effective ness	Regul. Quality	Rule of Law	Cont. of Corruption	Average value
Estonia	88.34	68.92	84.95	92.77	87.34	89.72	85.34
Czechia	78.79	81.34	80.25	85.39	82.97	69.87	79.77
Lithuania	79.26	72.19	80.73	85.01	81.34	73.30	78.64
Slovenia	78.69	76.00	81.83	73.97	82.25	77.30	78.34
Latvia	74.39	62.34	77.98	83.92	79.35	69.35	74.55
Poland	71.46	65.62	68.95	77.84	67.90	71.94	70.62
Slovak Republic	75.76	70.56	70.10	76.51	70.03	60.61	70.59
Hungary	61.63	71.00	68.80	69.66	66.95	57.29	65.89
Croatia	63.90	68.16	70.55	66.54	61.04	59.18	64.90
Romania	64.24	56.16	49.35	66.33	63.94	51.66	58.61
Bulgaria	58.74	55.88	51.67	69.09	51.48	48.05	55.82
Montenegro	51.71	49.04	56.95	64.12	52.82	53.67	54.72
North Macedonia	46.36	45.18	51.34	66.56	47.01	43.59	50.01
Albania	52.20	55.06	54.04	60.33	42.00	35.95	49.93
Serbia	47.22	47.44	53.57	56.43	50.48	40.55	49.28
Kosovo	41.61	35.53	39.86	42.35	39.01	39.23	39.60
Bosnia and Herzegovina	39.34	32.13	24.05	47.53	44.78	33.80	36.94
Ukraine	46.28	8.09	35.73	39.71	22.17	21.34	28.89

Source: www.worldbank.org

Table 3 shows the total average values of six institutional indicators for all 18 countries, ranked from the highest to the lowest. This ranking provides a clear overview of the relative quality of institutions across the countries. Estonia has a strong institutional framework (average value is 85.34 for six indicators) with the highest average amount in the observed period for five indicators: voice and responsibility, government efficiency, regulatory quality, rule of law, and corruption control, positioning it as a country that is favorable in terms of long-term economic and political sustainability. Through the tables of the sum of the average values of the indicators, the results for the countries of Czechia, Lithuania and Slovenia show that it is very positive, where Czechia achieves an average value of 79.77, Lithuania 78.64, while Slovenia records 78.34. This means that these countries have strong institutions, which confirms their ability to maintain stable political and administrative frameworks. If we return to Table 2, which presents the average GDP per capita, it is evident that these four countries also recorded the highest average GDP per capita during the period from 2014 to 2023, emphasizing that countries with higher GDP per capita achieve better results in institutional quality.

In contrast, Serbia, Kosovo, Bosnia and Herzegovina, and Ukraine exhibit significant challenges in governance and institutional development, as evidenced by their consistently low average scores on six institutional indicators. Ukraine, with an average score of 28.89, has the lowest institutional quality among the countries considered. Nevertheless, Ukraine is currently experiencing a difficult period, and given the war situation, it could be considered an outlier in our sample due to the logical deterioration of its indicators. Apart from Ukraine, which records the lowest institutional quality in the sample, Bosnia and Herzegovina shows one of the weakest institutional profiles, with an average score of 36.94, followed by Kosovo with 39.60 and Serbia with 49.28. Countries in the middle of the table according to the given values should assess their performance across all indicators and direct their policies towards those where weaker results are evident. In general, we conclude that higher institutional indices tend to correlate with higher average GDP per capita growth rates, which is evident from the comparative analysis of institutional indices and economic performance of the countries in the sample.

Analysis of the entrepreneurship environment in European transition countries

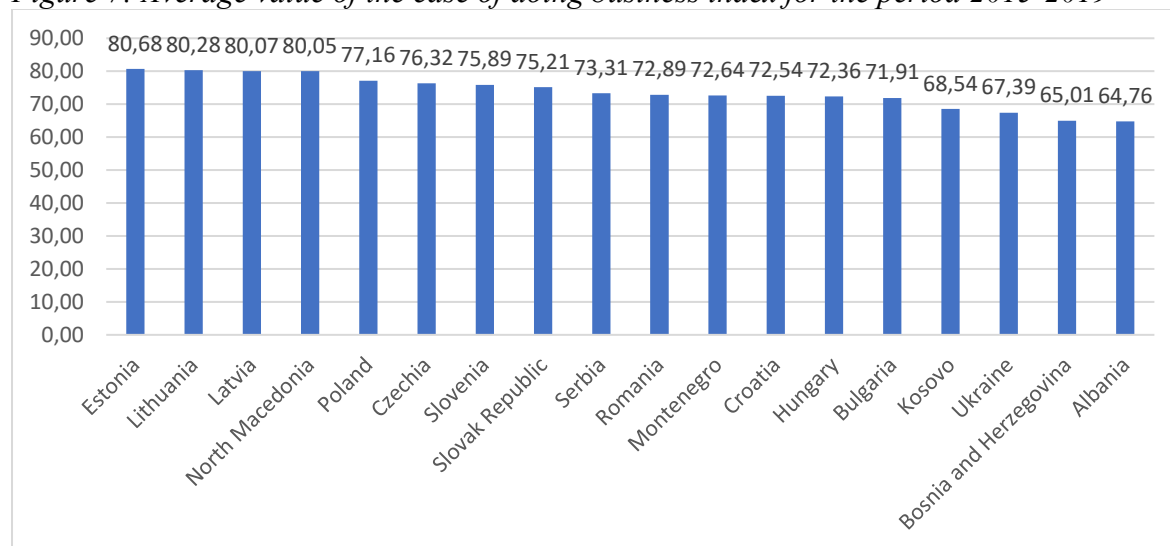
The following section will present some of the key indicators related to the strengthening of entrepreneurship in the sample countries. This will, in line with the theory presented, establish a link between the quality and development of entrepreneurship and the institutional quality of these countries. The focus is on the ease of doing business index, the cost of starting a business, and the number of days needed to start a business. The entrepreneurship-related indicators used in the analysis were obtained from credible international databases, primarily the Global Entrepreneurship Monitor (GEM) and the World Bank Entrepreneurship Database (Doing Business, 2021).

Ease of Doing Business Assessment

To analyze the complexity of conducting business in the sampled countries, we evaluate the Ease of Doing Business Index. This index reflects the regulatory practices of countries, ranking them so that 0 is the worst result and 100 is the best. The best results are achieved

by Estonia, Lithuania, Latvia, North Macedonia, Poland, although even Czechia, Slovenia, Slovak Republic, Serbia, Romania, Bulgaria, Montenegro, and Croatia are not far behind the previously mentioned economies. Albania and Bosnia and Herzegovina, on the other hand, has a lower score. Ukraine also does not have a significant problem with the ease of doing business and as such has seen a slight growth over the years. The most notable progress was achieved by Kosovo, with an increase in the index from 63.03 in 2015 to 73.18 in 2019, moving closer to more developed economies in terms of business environment simplicity.

Figure 7: Average value of the ease of doing business index for the period 2015-2019

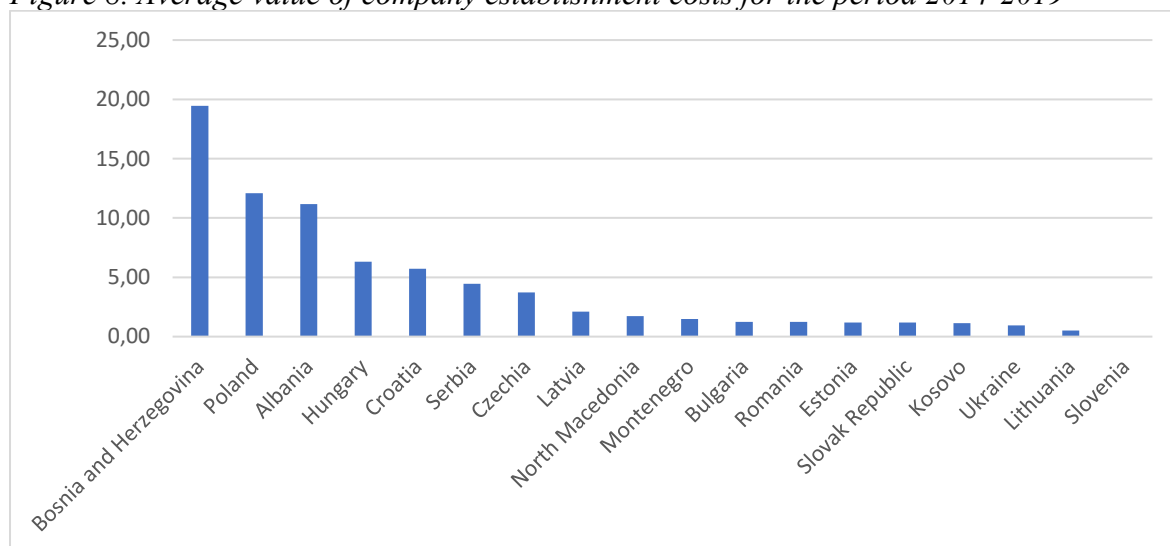


Source: www.worldbank.org

Costs of establishing a company

The costs of establishing a company are the costs of registering a company expressed as a percentage of the gross national income (GNI) per capita. These costs are normalized to show the financial burden of starting a company as a percentage of the average income per capita in the country. The indicator costs of procedures for starting a business estimates the number of required procedures, the duration of the process, as well as the costs and minimum capital required to start a business (Doing Business, 2021). In the period 2014-2019 (due to the availability of data until 2019), the highest amount of average costs for the establishment of a company (% GNI) has Bosnia and Herzegovina with an average value of 19.45% of GNI. Poland followed with 12.10%, Albania with 11.17%, Hungary with 6.32% and Croatia with 5.73%. Countries with lower business start-up costs include Lithuania, Ukraine, Kosovo, Estonia, Slovakia, Romania, and Bulgaria. Slovenia is the only country in the sample that records start-up costs equal to 0.

Figure 8. Average value of company establishment costs for the period 2014-2019

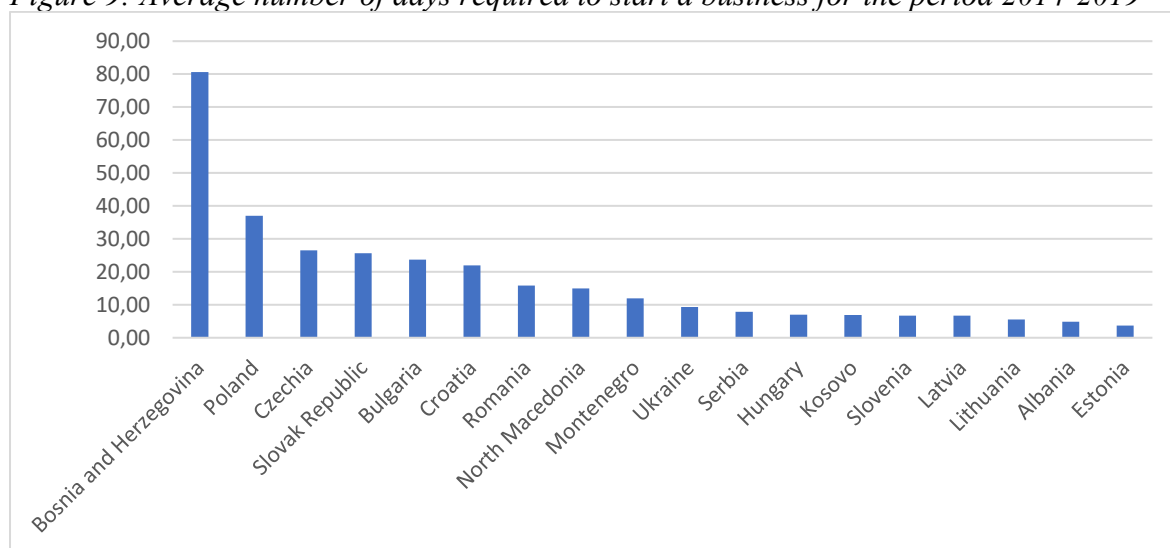


Source: www.worldbank.org

The number of days required to start a business

Figure 9 shows the average number of days needed to start a business during the period from 2012 to 2019 (no more recent data is available). In the period 2012-2019, the average number of days needed to start a business in Bosnia and Herzegovina was 81 days. This represents the slowest process of starting a company compared to eleven other countries from the database. The fastest process for starting a company was in Estonia (4 days on average), Albania (4.83 days on average), Lithuania (5.5 days on average), Latvia (6.67 days on average) Slovenia (7 days on average) and Kosovo (7 days on average), indicating efficient administrative procedures.

Figure 9: Average number of days required to start a business for the period 2014-2019

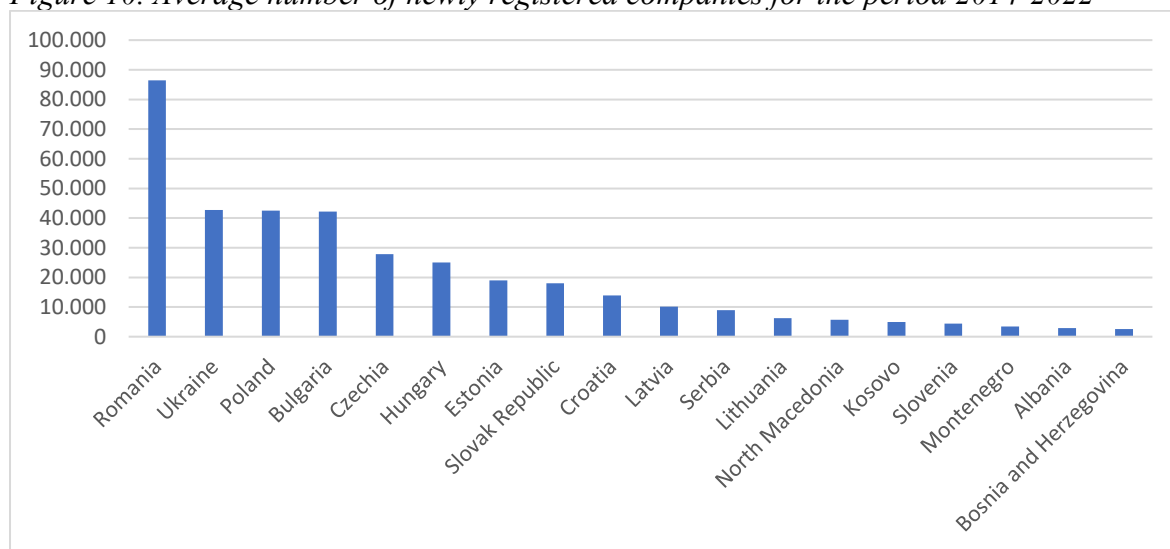


Source: www.worldbank.org

Number of newly registered companies

The number of newly registered companies refers to companies operating as limited liability companies. Based on the table, we can see that Romania, Ukraine, Poland and Bulgaria have the highest number of newly registered companies in the period 2014-2022 (data for 2023 is not available). Average number of newly registered companies in Romania for the period 2014- 2022 is 86.39. They are followed in the middle by Estonia, the Slovak Republic and Croatia. The countries with weaker results according to this indicator include Bosnia and Herzegovina (average number of newly registered companies is 2.58), Albania (average number of newly registered companies is 2.87), Montenegro (average number of newly registered companies is 3.45), Slovenia (average number of newly registered companies is 4.37). Data for Ukraine indicated a tendency of growth in terms of this indicator; however, they are available only until 2017, so no conclusive insights can be drawn. However, considering the circumstances, a decline is to be expected.

Figure 10. Average number of newly registered companies for the period 2014-2022



Source: www.worldbank.org

Channels such as innovation, value creation, employment, and competition are factors through which entrepreneurship influences economic growth. Primarily, entrepreneurs are creators of business and innovation. They create new jobs and increase the level of productivity through various technological changes, which, as a result, leads to the growth of the economy. Through innovation, entrepreneurs bring new products to the market. Given the awareness of entrepreneurs that they can be rewarded for their knowledge and innovations, competition is stimulated, and thus the production of high-quality products (Van Stel et al., 2005; Bosma, 2013; OECD, 2008; Acs & Armington, 2006).

Higher costs of establishing a company, more complicated procedures, and a longer period of time needed to start a business, associated with poorer institutional performance in general, have a negative effect on both domestic and foreign investments and, in this context, the development of entrepreneurship (Moura & Forte, 2013; Uddin et al., 2017). Given that econometric research proves such an impact, the question arises whether we could expect such trends in the countries from our sample. The qualitative analysis conducted in the paper indicates the possibility of such patterns of indicator movements (this should be examined in more detail in future works), which can be seen in Chart 10 (shows the average number

of new enterprises in the economies). Countries with better institutional quality generally have lower costs, and fewer days are needed to establish a company, which, when combined, acts as a motivating factor and creates a favorable environment for starting a business, contributing to economic progress. On the contrary, Bosnia and Herzegovina and Kosovo have poor performances according to these as well as according to WGI indicators, which makes it difficult to strengthen the entrepreneurial base and invest as a key component of GDP on the way to greater development. Ukraine represents a special case in this research because the war significantly affects both institutional quality and entrepreneurial indicators. Therefore, the data for this country are considered an outlier and cannot be treated as a representative example for drawing conclusions. The circumstances of the war lead to additional challenges, economic insecurity, and changes in capacity for business, which negatively affect the reform process and the stabilization of the economy.

Conclusion

The paper analyzes the role of institutions and entrepreneurship in the economic growth of countries, with a focus on European transition economies. Based on a comparison of institutional quality and entrepreneurial activity in eighteen transition countries in Europe, a clear link was observed: countries with more developed and stable institutional frameworks generally perform better results in entrepreneurial indicators and achieve higher levels of economic development, as reflected in their GDP per capita. Estonia, the Czech Republic, Slovenia, and Lithuania, for example, had the highest average GDP per capita in the period 2014-2023, demonstrating both strong overall results on WGI indicators and favorable results in entrepreneurial performance. On the other hand, countries with lower GDP per capita had worse values of WGI indicators and showed weaker entrepreneurial activity. From the above analysis, we conclude that Ukraine, Bosnia and Herzegovina, and Kosovo had the worst results for both types of indicators.

This would be confirmed by the literature review, where, based on the literature of numerous authors, with special emphasis on the research of the author Siyakiya (2017), it is claimed that there is clear evidence that entrepreneurship and institutional quality are determinants of economic growth and that improvements in institutions have the greatest impact on economic growth. From this comes the view that the combination of efficient institutions and entrepreneurship promotes the economic growth of the country (Sari & Prastyani, 2021).

In the case of transitional European countries analyzed in this paper, the type of analysis conducted does not allow us to draw a definitive conclusion that improved institutional quality directly leads to higher economic growth rates. Although existing literature, such as the study by Siyakiya (2017), Aparicio et al. (2016), Sari & Prastyani (2021), indicates that entrepreneurship and institutional quality are key determinants of economic growth and that institutional improvements have the greatest impact, the evidence from this particular analysis is not sufficient to confirm such causality.

Comparing countries by average GDP per capita cannot confirm a causal relationship between the quality of institutions and growth. Moreover, there are significant external shocks that could affect the quality of institutions, entrepreneurial activity and GDP per capita. Some of these shocks are the period after the debt crisis, the COVID-19 pandemic, and the war in Ukraine, which significantly affected the economic flows of countries regardless of the quality of the institutional framework. These external shocks can partially

or completely obscure the impact of institutional factors on economic growth in a shorter time horizon. Nevertheless, the paper offers a good basis for future research. An emphasis for future research is the application of econometric analyses in the context of examining the impact of institutional quality on the economic performance of the sample countries. Such methodological approaches could facilitate more rigorous examination of cause-and-effect relationships and contribute to the generation of stronger empirical evidence, thereby informing the development of more effective and evidence-based policy interventions.

In general, through the improvement of institutional quality, reforms, and support for initiatives, there are more favorable conditions for entrepreneurship and, implicitly, the economic growth of countries. Reforms and improvement of institutional infrastructure should be a priority to ensure synergy between entrepreneurship and economic growth, enabling comprehensive progress and prosperity in society. Therefore, in order to achieve sustainable economic growth of the country, it is crucial not only to support entrepreneurial initiatives but also to continuously work on strengthening the institutional framework by improving the components of the WGI indicators, especially those in which the country performs worse compared to the average of transition economies, in order to create conditions for long-term and stable development of the country.

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IMPACT OF FILTERING METHODS ON CONVERGENCE DETECTION: A MONTE CARLO ANALYSIS USING THE PHILLIPS AND SUL MODEL

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Abstract

This paper explores the impact of various time series filtering methods on the detection of economic convergence using the Phillips and Sul (PS) method. The PS method, a nonlinear approach incorporating individual heterogeneity, is widely applied to assess convergence in macroeconomic variables. Filtering, used to remove short-term fluctuations and extract long-term trends, may significantly influence results. Through Monte Carlo simulations, the study evaluates the performance of the PS method under six filtering techniques, across varying sample sizes and time periods. Findings reveal that smaller samples and shorter periods exacerbate errors, with filters like Hodrick-Prescott and Butterworth over-smoothing data, causing convergence signals to be lost. Conversely, the Hamilton filter retains more data structure, demonstrating conservative detection rates. The study underscores the need for researchers to explicitly report and test the robustness of filtering methods to enhance reliability. Limitations include the focus on random walk with drift time series, suggesting future research could explore other characteristics like structural breaks. This work contributes original insights into the methodological implications of filtering, offering practical guidance for robust convergence analysis.

Keywords: convergence, Phillips-Sul method, time series filtering, Monte carlo simulation

JEL classification: C15, C33, O47

Introduction

Testing for convergence has been a long-standing practice in economics, especially in the field of economic growth (Kremer et al., 2022; Ong, 2024), but in various other areas like income inequality (Arčabić et al., 2021), stock markets (Caporale et al., 2015), housing prices (Ganioğlu & Seven, 2021) and even military spending (Clements et al., 2021). The concept of convergence is used to evaluate policy achievements. For example, the European Union conducts and finances cohesion policy which is just another name for income convergence among member states.

The concept of convergence is not unique. As Smith (2024) states in his survey of econometric aspects of convergence, convergence can mean absolute, conditional or club convergence. It can also be measured in different ways, such as beta convergence, sigma convergence or the presence of a common trend. One of the often-used methods to test for convergence was developed by Phillips and Sul (2007). It is a nonlinear time varying factor model that takes into account individual heterogeneity when testing for convergence. Tomal (2023) provides a review of this approach. He emphasizes that previous researchers have

used different time series filtering methods, which can have a significant impact on the results, but there has not been a systematic analysis of this impact.

The goal of this paper is to test the size of the Phillips and Sul (2007) model for detecting convergence when different filtering methods are applied to the time series data. Filtering is used to extract the long-term trend from time series data while removing short-term fluctuations, such as business cycles, from the convergence analysis. This is crucial because the Phillips and Sul convergence test is focused on long-run behavior and transitional dynamics, which means noise from short-term movements can obscure the true underlying trend of convergence or divergence.

By filtering out these fluctuations, a smoothed version of the data is obtained that reflects the structural or long-term growth components. The filtering process helps isolate the common trend across units from the idiosyncratic factors driving transitional dynamics. Different filters can produce different results, which is why testing the effect of different filters is important for robustness checks.

We use Monte Carlo simulation to test the size of the model. We perform the analysis by using different period lengths and different number of observations to compare how successful the model is in detecting convergence when different filtering methods are used. Our results show that the choice of filtering method has a significant influence on convergence detection for small sample sizes and time periods. Convergence detection improves for all filters when the sample and periods grow. The contribution of this paper is in highlighting the importance of filtering methods on the results of convergence in the PS approach. Research that uses this approach should clearly state which filter was used and perform robustness checks by using different filtering methods.

The rest of the paper is organized as follows. The second part provides a literature review of papers that have used different filtering methods to test convergence results within the PS approach. The third part explains the method used in this paper. It explains in detail how the PS method works, characteristics of different filtering methods and how the Monte Carlo simulation was implemented. The fourth part summarizes simulation results and part five gives a conclusion with an emphasis for further research.

Literature review

Phillips and Sul (2007) state that if the focus of interest is long run behavior, it is advisable to remove business cycle fluctuations from the data. They propose using Whittaker–Hodrick–Prescott filter because it does not require prior specification of the nature of the common trend or a trend filtering method which is a regression method for extracting an unknown trend function.

In their empirical application to the convergence of cost of living of US metropolitan areas they report that there is no change in the results when these two different filters are used. On the other hand, they also perform Monte Carlo simulations testing size and power. But since the simulation design is set up in a way that the common trend component cancels out in the application, there is no need for filtering. Therefore, the conclusion from the empirical

application that different filtering methods do not influence results cannot be generalized because it could be the result of specific time series characteristics.

Previous studies have used different filtering methods to check the robustness of their results. Tomal (2022) tests for overall and cluster convergence of housing rents across Polish provincial capitals to identify drivers of convergence club formation. This work uses several different filtering methods to extract the trend component from the data. In particular, the Hodrick-Prescott (HP), Butterworth, Christiano-Fitzgerald and boosted HP filters. The results show that club membership changes for some cities but not for others depending on the filtering method used. Therefore, the filtering method has a significant impact on convergence results.

Other papers also report a change in their results when different filtering methods are used. Tomas & Gumieniak (2020) report that HP filter indicated divergence, while the Hamilton filter indicated club convergence when applied to agricultural land prices. Clements et al. (2021) show a change in the number of convergence clubs from three to two when they change from the HP filter to the Hamilton filter in the case of military spending. Similarly, Arčabić et al. (2021) report a change in the number of clubs from two to one when shifting from HP filter to Hamilton filter in the case of income inequality convergence.

On the other hand, several studies show no change in their results when different filtering methods are applied. Cavallao & Villani (2021) use HP and Butterworth filters in the case of convergence of EU countries, Desli & Gkoulgkoutsika (2019) use HP and Butterworth filters in the case of convergence of top 40 high income countries, Ganioglu & Seven (2021) use HP and Hamilton filters to test house price convergence and Apergis et al. (2014) use HP and Stock and Watson filters to explore the difference in convergence results for equity markets. All these studies report that their results do not change when different filtering methods are applied.

From this discussion we cannot generalize which filter is the most appropriate to use since the PS method has been used in such a variety of contexts and shows different results. A more general approach is needed to compare convergence results with different filtered series.

Tomal (2023) reviews the Phillips-Sul approach-based club convergence tests. They find that most research papers that use this approach do not specify the filtering method. When they do, the most common is the HP filter. Other filters that have been used in past research were the Hamilton filter, Butterworth, Christiano-Fitzgerald, boosted HP, time-varying parameter model, Beveridge-Nelson and backward moving average.

Of special interest for this paper is the research by Fritsche & Kuzin (2011). They investigate convergence in European price level, unit labor cost, income and productivity data over the period of 1960–2006 using PS approach. The authors stress the importance of the influence of data filtering on convergence. They emphasize that the often-used HP filter has an end point bias so they perform a Monte Carlo simulation closely following the procedure proposed by Phillips & Sul (2007). First, they simulate results of the log t test for unfiltered series. Then they filter the series using the HP filter and compare the results. They conclude that using the HP filter causes size distortions (i.e. they reject the null of convergence more often than in the unfiltered case). But they also conclude that the end point bias is diminished with higher speed of convergence and bigger sample size and time periods. The authors do

not check the results using different filters. Our study builds on their work by using several other filters that have been used in the literature as reported by Tomal (2023).

Methodology

The PS model starts with a time varying factor representation

$$(1) X_{it} = \delta_{it}\mu_t$$

where δ_{it} is a time varying coefficient that shows the distance and possible convergence behavior of observation i in relation to a relevant aggregate variable or representative agent behavior μ_t . In this approach, units converge to a single steady state if $\lim_{k \rightarrow \infty} \delta_{it+k} = \delta$ for all $i = 1, 2, \dots, N$.

Since δ_{it} cannot be estimated from this equation due to overparametrization, Phillips and Sul (2007) propose a semiparametric form

$$(2) \delta_{it} = \delta_i + \sigma_i \xi_{it} L(t)^{-1} t^{-\alpha}$$

where δ_i is fixed, ξ_{it} is weakly dependent over time and iid (0,1) across i , $L(t)$ is a slowly varying function like $\log(t)$ or $\log\log(t)$, for which $L(t) \rightarrow \infty$ as $t \rightarrow \infty$. This ensures that δ_{it} converges to δ_i for all $\alpha \geq 0$ and this becomes the null hypothesis of interest. Even though with time δ_{it} converges, there is still room for transitional heterogeneity. The null hypothesis of convergence takes the form of $H_0: \delta_i = \delta$ and $\alpha \geq 0$ while the alternative is $H_A: \delta_i \neq \delta$ for all i or $\alpha < 0$.

Phillips and Sul (2007) suggest using relative versions to model δ_{it} to eliminate the common component

$$(3) h_{it} = \frac{X_{it}}{\frac{1}{N} \sum_{i=1}^N X_{it}} = \frac{\delta_{it}}{\frac{1}{N} \sum_{i=1}^N \delta_{it}}$$

where h_{it} is the transition path of unit i compared to the panel average. Convergence is implied by $h_{it} \rightarrow 1$ for all i as $t \rightarrow \infty$. Simultaneously, under convergence the cross-sectional variance $H_t \rightarrow 0$:

$$(4) H_t = N^{-1} \sum_{i=1}^N (h_{it} - 1)^2 \rightarrow 0 \text{ as } t \rightarrow \infty$$

Testing for convergence uses the log t regression of the form

$$(5) \log\left(\frac{H_1}{H_t}\right) - 2\log L(t) = a + b\log t + u_t$$

where $\left(\frac{H_1}{H_t}\right)$ is the cross – sectional variance ratio, $b = 2\alpha$ is the convergence speed parameter and $-2\log L(t)$ is the penalization function which improves the performance of the test. A one – sided t -test using b and a HAC standard error is used to test the null hypothesis of convergence. Convergence is rejected at the 5% level if $t_b < -1.65$. To improve estimation, the authors recommend trimming a third of the data sample. Difference

in the trimming ratio can have an impact on convergence results as shown by Arčabić et al. (2024).

Hodrick & Prescott (1997) have developed one of the most commonly used filters in the literature. A series is decomposed into its trend and cycle using the formula

$$(6) \frac{1}{T} \sum_{t=1}^T (x_t - \mu_t)^2 + \frac{\lambda}{T} \sum_{t=2}^{T-1} ((\mu_{t+1} - \mu_t) - (\mu_t - \mu_{t-1}))^2$$

where μ_t is chosen to minimize the sum of squares. Hamilton (2018) criticized the usage of the HP filter on the grounds that it produces series with spurious dynamic relations, filtered values at the end of the sample are different from those in the middle and a statistical formalization of the problem typically produces values for the smoothing parameter vastly at odds with common practice. He proposes an alternative as a projection of series x_{t+h} on a constant and four most recent values of x as of date t . Quast & Wolters (2022) show that the Hamilton filter can amplify longer-term cycles. Also, the extracted trends are not smooth, i.e. the extracted trend is very noisy. They propose a modification that shares the favorable real-time properties of the Hamilton filter, but leads to an even coverage of business cycle frequencies and a smooth trend. They average forecast errors based on forecast horizons ranging from 4 to 12 quarters instead of 8 quarters used by Hamilton in case of quarterly data.

Christiano & Fitzgerald (2003) derive a band-pass filter that minimizes mean squared error between filtered series and an ideal band-pass filter that would perfectly separate out components driven by stochastic cycles. The CF filter constructs a set of weights that are applied to the data. These weights determine how much influence each data point has when extracting the cyclical component. The weights are chosen in such a way to minimize the mean squared error. The filter is particularly suitable for series that are close to a random walk with a drift, which many macroeconomic series are.

Baxter & King (1999) also develop a band-pass filter which is based on a symmetric moving average, meaning it gives the same weights to past and future observations around a central point (unlike the CF filter which does not apply symmetric weights). The weights sum to zero. It is well suited for identifying medium frequency components (like business cycles) because it removes both low frequency (long term trends) and high frequency components.

Butterworth (1930) filter is a high pass filter which removes slow moving trends. It has its origins in engineering, but it can also be used in time series filtering. Pollock (2000) shows that the Butterworth filter corresponds to the following time-series model:

$$(7) y_t = \frac{(1+L)^m}{(1-L)^m} v_t + \varepsilon_t$$

where y_t is the original time series that is decomposed into a shock driving the cyclical component (v_t) and a shock driving the trend component (ε_t). L is the lag operator. The numerator $(1 + L)^m$ captures high-frequency cycles, while the denominator $(1 - L)^m$ filters low-frequency trends. This model is then used to estimate the cyclical component. The order m determines how sharply the trend and cycle are separated with higher values making them more distinct, but at the cost of more computational complexity.

The Monte Carlo simulation for testing the size of the PS method builds on the research by Fritsche & Kuzin (2011) who also closely follow Phillips & Sul (2007). The following data generating process is assumed:

$$(8) X_{it} = (\delta_i + \delta_{it}^0)\mu_t$$

$$(9) \delta_{it}^0 = \rho_i \delta_{i,t-1}^0 + \varepsilon_{it}$$

$$(10) \mu_t = a + \mu_{t-1} + \omega_t$$

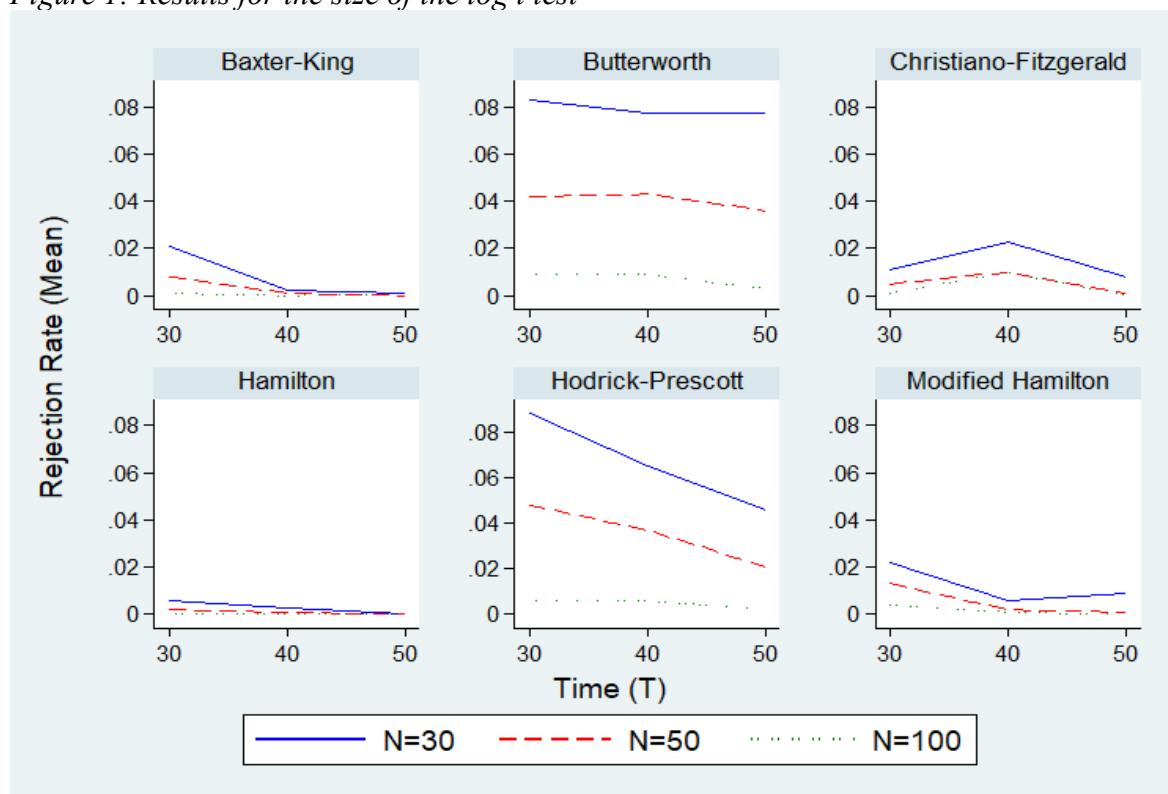
for $t = 1, \dots, T$ and $\text{Var}(\varepsilon_{it}) = \sigma_i^2 \log(t+1)^{-2} t^{-2\alpha}$. Random disturbances ε_{it} and ω_t are normally i.i.d. and have zero means. Following Fritsche & Kuzin (2011), $\sigma_i^2 \sim U[0.02, 0.5]$, $\rho_i \sim U[0.7, 0.9]$, $\text{Var}(\omega_t) = 0.1$, $a = 0.3$, $\mu_0 = 10$, and $\alpha \sim U[0.02, 0.4]$. We also work under the null hypothesis $\delta_i = \delta = 1$. In other words, we test for pure convergence. Phillips & Sul (2007) do not model equation (10) since they assume the common component cancels out in the application of the procedure. Fritsche and Kuzin (2011) stress that using different filtering methods requires explicit modelling of μ_t . μ_t is modelled as a random walk with a positive drift that asymptotically dominates the loadings δ_{it}^0 .

We perform 1.000 Monte Carlo simulations to compute numbers for 5% nominal size using the following filters: Hodrick–Prescott filter ($\lambda = 100$), Christiano-Fitzgerald, Hamilton, Butterworth, Baxter-King and modified Hamilton filter (based on Quast & Wolters (2022)). The choice of filters is based on those commonly used in the literature and reported by Tomal (2023). The analysis is performed for $N = 30, 50$ and 100 and $T = 30, 40$ and 50 . We run the log t test by using the logtreg command in STATA developed by Du (2018) and a cutoff rate of 30%. The results are shown in Table 1 and in Figure 1.

Table 1: Size of the log t test (5% nominal size)

T	N	Filtering method					
		Hodrick-Prescott	Butterworth	Hamilton	Modified Hamilton	Baxter-King	Christiano-Fitzgerald
30	30	0.088	0.083	0.006	0.022	0.021	0.011
30	50	0.048	0.042	0.002	0.013	0.008	0.005
30	100	0.006	0.009	0.000	0.004	0.001	0.001
40	30	0.065	0.077	0.003	0.006	0.002	0.023
40	50	0.037	0.043	0.001	0.002	0.001	0.010
40	100	0.006	0.009	0.000	0.001	0.000	0.010
50	30	0.046	0.077	0.000	0.009	0.001	0.008
50	50	0.021	0.036	0.000	0.001	0.000	0.001
50	100	0.002	0.003	0.000	0.000	0.001	0.000

Figure 1: Results for the size of the log t test



Discussion

The results indicate that the choice of filtering method has a significant influence on the detection of convergence. Increasing sample size and time periods reduces the mean rejection of convergence across all filters, which is expected.

As stated by Fritsche & Kuzin (2011) and other researchers, the HP filter is prone to end-point bias. The results also demonstrate this bias in small sample sizes, which leads to higher rejection rates in small samples in comparison to other filters. Butterworth filter also shows higher rejection rates for smaller datasets and although decreasing, they remain higher even for larger samples compared to other filters. This is the result of the order of the filter being applied. Small order causes excess smoothing where medium-frequency dynamics are suppressed, missing convergence signals.

On the other hand, the Hamilton filter displays extremely low rejection rates across all scenarios, reaching zero for larger datasets (e.g., $n=100$, $t=50$: 0.0). This suggests that the Hamilton filter is highly conservative. Since the Hamilton filter does not smooth the series extensively, the trend it produces often retains much of the original data's structure. This was actually a criticism made by Quast & Wolters (2022) when they stated that the trend data is very noisy. In this case, filtering did not smooth out the convergence signals leading to low rejection rates. The modified Hamilton filter produces slightly higher rejection rates than the original Hamilton filter for smaller datasets (e.g., $n=30$, $t=30$: 0.022), but still drops to zero for larger datasets. This is expected since the modification was introduced precisely to make the trend smoother, which could lead to a loss of convergence signals.

Baxter-King and Christiano-Fitzgerald filters show more moderate rejection rates for small sample sizes. Both filters rely on giving weights to observation so these filters struggle more with small sample sizes leading to somewhat higher rejection rates, but perform well as sample size and periods grow.

The results emphasize that the choice of filtering method significantly impacts the detection of convergence. Researchers should carefully consider the context and characteristics of their data when selecting a filter. Over-smoothing methods like Hodrick-Prescott and Butterworth can produce misleading results. This is especially true of small samples and shorter time periods.

Empirical example: Cost of living

In this part of the paper we give an example of the influence of different filtering methods on convergence results. The example extends the one given in Phillips & Sul (2007). The aim is to measure the relative cost of living of 19 metropolitan areas in the United States and show if there is convergence. Cost of living is measured with the Consumer price index (CPI) of US cities for the period 1918 – 2001 available at the Bureau of Labor Statistics. The cities are the following: New York, Philadelphia, Boston, Cleveland, Chicago, Detroit, Washington, DC, Baltimore, Houston, Los Angeles, San Francisco, Seattle, Portland, Cincinnati, Atlanta, St. Louis, Minneapolis/St. Paul, Milwaukee, and Pittsburgh.

The authors use the HP filter to extract the trend series and use a trimming ratio of 1/3. Their results show there is no convergence of cost of living among US metropolitan areas at the 5% significance level. Instead, they demonstrate club convergence.

We extend this example by using different filtering methods on the same dataset. The results are shown in Table 2. At the 5% significance level, the results are not significant for Baxter-King and modified Hamilton filters. On the other hand, other filtered series demonstrate divergence of cost of living among US metropolitan areas. The results show that different filters give different results based on significance level. Except for the modified Hamilton filter which has a positive beta estimate indicating club convergence, but is not statistically significant, all the filters indicate divergence of cost of living. We conclude that when applying the PS method, results should be checked comparing the filtered series to ensure that results are not a consequence of specific filtering method.

Table 2: Convergence of CPI for 19 US metropolitan areas for the period 1918 – 2001

Filter	Beta estimate	t-statistic	St. dev.	p-value
Hodrick-Prescott	-0.53	-5.90	0.09	0.00
Baxter-King	-0.06	-0.27	0.24	0.79
Christiano-Fitzgerald	-0.40	-3.80	0.11	0.00
Butterworth	-0.56	-5.16	0.11	0.00
Hamilton	-0.89	-2.06	0.43	0.04
Modified Hamilton	0.13	1.25	0.10	0.10

Source: Bureau of Labor Statistics

Conclusion

Phillips & Sul (2007) method of convergence testing has become a popular approach in economics. In their paper they recommend filtering time series to extract trends before applying the log t test. Previous research has emphasized that filtering methods can have a significant impact on convergence results. But there has not been a systematic test of this impact. Research has mostly focused on applying two different filters as robustness checks. The conclusions on the importance vary because of differences in types of time series and types of filters being used. The results could not be generalized.

The goal of this paper is to test the size of the Phillips & Sul (2007) method when different filtering methods are applied to the time series data. We perform 1.000 Monte Carlo simulations to test absolute convergence for a range of observations and time periods with six filters: Hodrick–Prescott filter, Christiano–Fitzgerald, Hamilton, Butterworth, Baxter–King and modified Hamilton filter.

Our results show that filtering time series and using the PS method on extracted trends has a significant impact on convergence detection. How successfully the method detects convergence depends on sample size, number of time periods and characteristics of filters. Generally, false rejection of convergence drops for larger sample sizes and time periods. Filters differ in the way they manage to detect convergence in small sample sizes. This is due to the way the filters are constructed and their consequent drawbacks. Research should carefully consider the characteristics of time series in order to apply the most appropriate filter.

This paper has focused on a time series modelled as a random walk with drift. But time series can exhibit a vast range of other characteristics like non linearities and structural breaks. Filtering methods have been developed to deal with such time series. Further research could investigate how well the PS method performs in the presence of structural breaks. Furthermore, in order to complement size test performed in this paper, research should also check the power of PS method when different filtering methods are applied.

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EFFECTS OF THE INVESTMENTS FINANCED BY EU FUNDS ON THE ECONOMIC ACTIVITY IN CROATIA

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Abstract

As the newest EU member, Croatia is the largest recipient of European funds in per capita terms. In 2021-2027, approximately EUR 26 billion from EU funds will be available to Croatia, which on an annual basis present, on average, EUR 3.7 billion or nearly 5% of the current Croatian GDP. The paper aims to quantify the short-term effects of investments in fixed assets financed from EU funds on gross added value and employment in Croatia. The study is based on an input-output method that estimates the increased demand's direct, indirect, and induced effects on economic activity. In addition to the direct impacts on suppliers of investment goods, investments also indirectly stimulate other economic sectors that supply materials, energy, and business services used as intermediate inputs by producers of capital goods. Furthermore, the increase in employment and income induces additional demand for products and services intended for personal consumption. Results suggest that 2.3 percent of the total Croatian gross value added and employment in 2023 is caused by investments financed by EU funds. The increasing volume of investments resulted in an increased share of induced GVA in the period analyzed. The technological structure of investments financed by EU funds largely determines the sectoral structure and economic effects of such investments. More than a third of the effects are related to construction (37.2%), followed by other private services, industry, and distribution sectors (trade and transport). In construction, investments financed by EU funds generated almost 12% of gross value added in 2023. An above-average share was also recorded in the industry sector, while the increase in investment contributes the least to public and communal services. Orientation towards non-productive investments can result in negative consequences when such extensive sources of funds dry up at the end of the financial perspective.

Keywords: EU funds, input-output model, induced multiplicative effects, investments in fixed capital

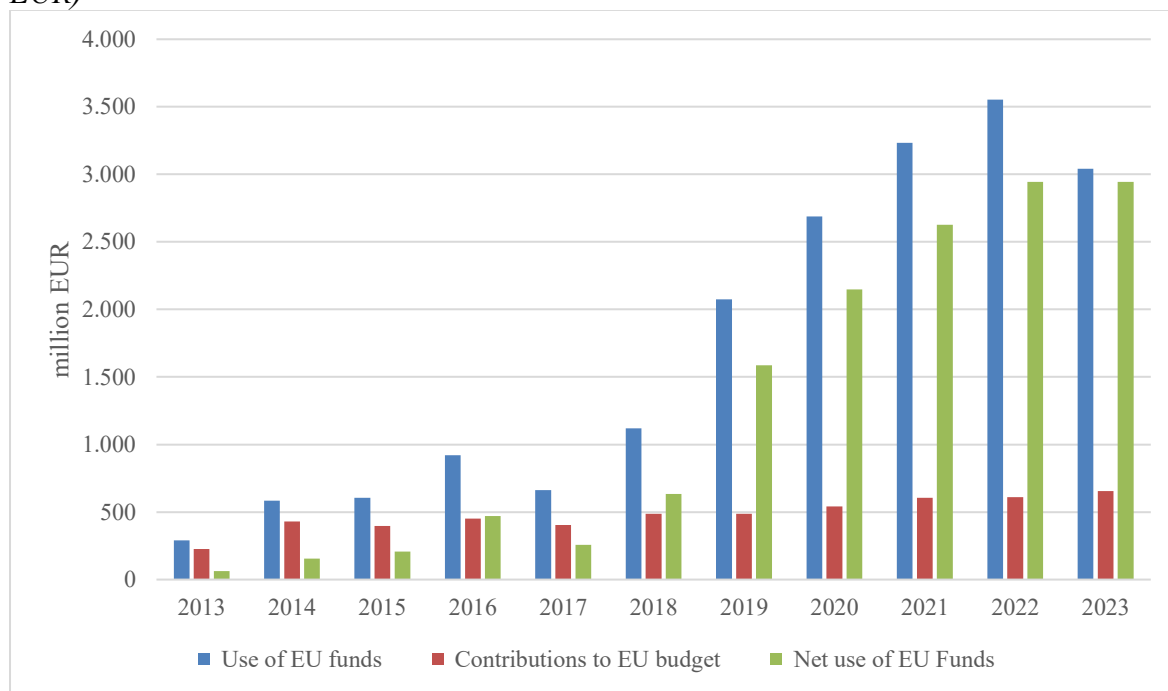
JEL classification: E20, C67

Introduction

The crucial goal of the European Union (EU) cohesion policy is to achieve balanced and harmonized growth in EU countries and regions (European Commission, 2022, 2024). Using European funds plays a significant role in the economic development of less developed areas. In 2013, Croatia became a full member of the EU, achieving its primary foreign policy goal. In addition to removing trade barriers, integration ensures the availability of European funds to achieve common EU goals. As the newest EU member, in per capita terms, Croatia is the largest recipient of European funds. In 2013-2023, Croatia paid EUR 5.3 billion into the EU budget, while at the same time, it received EUR 17.1 billion, resulting in a surplus

of almost EUR 12 billion. Annual distribution of use of EU funds and Croatian contributions to EU budget are presented by Figure 1.

Figure 1: Net use of EU funds in the Croatian economy in the 2013-2023 period (million EUR)

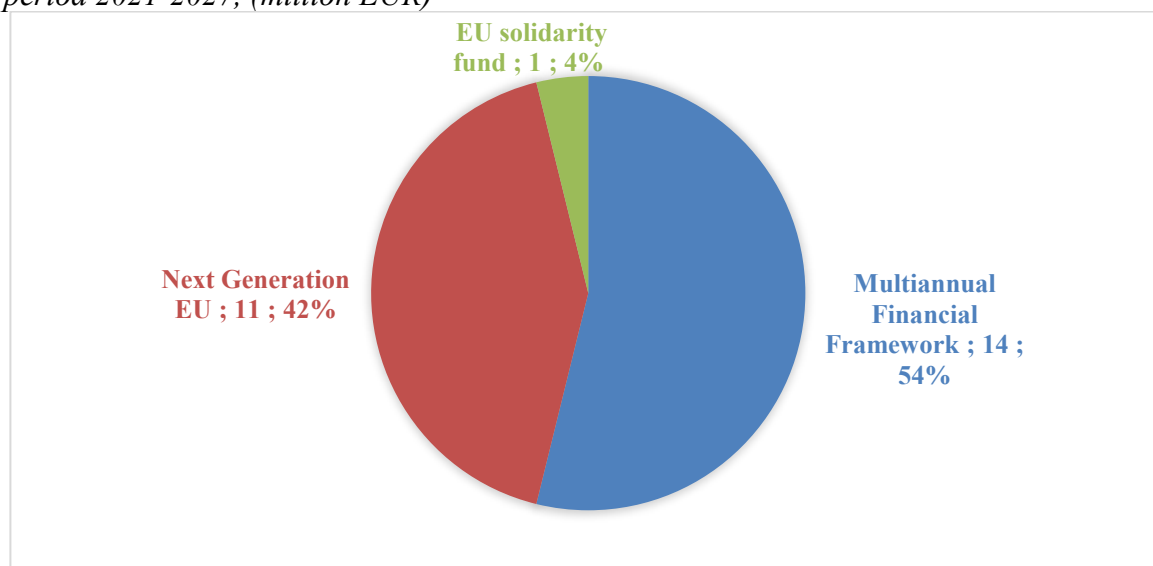


Source: European Commission, https://commission.europa.eu/strategy-and-policy/eu-budget/long-term-eu-budget/2021-2027/spending-and-revenue_en

The funds available from European funds to member countries in 2021-2027 are expected to increase further and will be allocated from two sources. The first source, known from earlier financial perspectives, is the Multiannual Financial Framework (MFF). Another source is Next Generation EU (NGEU), which is the innovation introduced as the most effective way to fight the negative consequences of the crisis caused by the coronavirus outbreak. European funds are allocated as part of the agreed financial perspective for the seven-year 2021-2027 period. The financial envelope foreseen by the budget of the European Union in the analyzed period is more significant than ever before, totaling €1,824.3 billion. Funds allocated from the MFF in the seven years amount to EUR 1 074 billion, while EUR 750 billion is financed from the NGEU instrument. Of EUR 750 billion from the NGEU, EUR 390 billion is allocated to grants, while EUR 360 billion is used to finance member-state loans.

The funds made available to the Republic of Croatia for the financial period 2021-2027 in current prices amount to almost €14 billion from the MFF and slightly more than €11 billion from the NGEU (Figure 2). Additional funding is available for reconstructing buildings devastated by the Zagreb earthquake in 2020. Almost EUR 1 billion came from the EU Solidarity fund, while EUR 926 million is included in NGEU. In summary, in 2021-2027, approximately EUR 26 billion from EU funds will be available to Croatia, which on an annual basis present, on average, EUR 3.7 billion or nearly 5% of the current Croatian GDP.

Figure 2: Programmed resources for the Croatian economy from the EU budget in the period 2021-2027, (million EUR)



Source: European Commission, https://commission.europa.eu/strategy-and-policy/eu-budget/long-term-eu-budget/2021-2027/spending-and-revenue_en

The experiences of other countries have shown that the improvement of the institutional environment plays a significant role in the efficient use of the availability of EU funds (Houbenova-Delisivkova, 2007). Various studies indicate the positive contribution of funds to economic development and growth (Picek & Schröder, 2017; Verwey et al., 2020). From the macroeconomic point of view, the additional sources for financing multiple projects imply an increase in demand in the short term and, thus, stimulation of economic activity. In the long term, investments, especially those aimed at developing the digital economy and sustainability, contribute positively to the productivity and competitiveness of the economy. In addition to the positive aspects, the increase in demand financed by European funds can also stimulate an increase in prices, especially if there are limitations in the availability of specific production inputs, as is the case with the available workforce in Croatia.

The paper uses the input-output method to quantify the effects of investments financed from EU funds on gross added value and employment in Croatia. In addition to the direct impacts on suppliers of investment goods, investments also indirectly stimulate other economic sectors that supply materials, energy, services, and other intermediate inputs that direct producers of investment goods use. Furthermore, increased employment and labor income induce additional demand for products and services intended for personal consumption. The paper aims to estimate the range in which the availability of European funds stimulates economic activity in Croatia at both the aggregate and sectoral levels. If investments are directed at economic transformation to ensure the growth of competitiveness and productivity, it can also stimulate long-term growth. In contrast, orientation toward non-productive investments in communal infrastructure and the public sector, with a high share of administrative costs and inefficient projects, can result in negative consequences. Adverse effects of decreasing demand could be recorded at the end of the period predicted by the financial perspective when extensive EU sources of funds could dry up.

The paper is structured so that the introductory chapter is followed by a brief review of the literature on the macroeconomic effects of using European funds and methods of measuring

such effects. This is followed by a description of the methodology used in this study and a central chapter that presents the research results. The paper's conclusion discusses the results for Croatia and earlier works for other economies and gives recommendations for the effective management of EU funds.

Literature review

One of the most critical goals declared by the European Union is to achieve territorial cohesion at the EU and national levels (Faludi, 2013; Monzon et al., 2019). The efficient functioning of the common market requires a certain level of homogeneity in the level of development, which is not necessarily the result of integration itself and the action of the free market forces. Balanced development should, therefore, be encouraged by active political interventions aimed at improving the competitiveness of less developed regions (European Commission, 2022, 2024). Increasing competitiveness requires implementing a particular set of programs and investments, and the source of financing for such programs is the EU budget, previously called Structural Funds and later transformed into ESI Funds. The redistribution of financial sources from the more developed areas of the EU stimulates investments, productivity, and competitiveness in the poorer regions (Römisch, 2020).

Interest in the effectiveness of EU structural policies in achieving the goal of convergence of less developed countries dates to the time before the expansion of the EU to new members located in Central and Eastern Europe that belonged to the group of socialist countries. Using a cross-section analysis, Sala-i-Martin (1996) determined the failure of the EU's structural policy, showing that the pattern of regional economic growth in the EU does not differ significantly from other areas that did not implement the targeted cohesion program. Boldrin & Canova (2001) also found similar results indicating the ineffectiveness of EU structural policies by analyzing regional growth within the EU and comparing the development of net recipients of European funds with other areas. On the other hand, the results of Middelfart-Knarvik & Overman (2002), Beugelsdijk & Eijffinger (2005), and Ederveen & Nahujs (2006) establish the existence of a positive effect of the Structural Funds Program at the national level on GDP per capita growth and convergence towards more developed members. Destefanis & Giacinto (2024) found the existence of highly significant multipliers and the positive impact of exogenous demand shocks on local GDP induced by expenditures financed by structural funds.

Theoretically, the origin of cohesion policies and empirical studies that valorize the effects of such policies are based on the neoclassical growth model, where investments are the central tool in ensuring economic growth. Securing funds from the EU budget for financing reports is among the priorities of most new members.

A comprehensive review of empirical studies on the effectiveness of the EU's cohesion policy is available in Mohl & Hagen (2010) and Rogalska et al. (2017). Generally, those studies did not provide convincing findings on whether the abundant EU resources could have produced better results. In addition to direct effects, programs financed from the European budget also generate a wide range of indirect effects on the economy of the recipients of the funds. Still, spillover effects on other European and world economies sometimes occur. For example, programs aimed at specific sectors or branches of the economy can, in addition to positive impacts, induce positive but also, in some instances, adverse effects on the economic activities of other sectors. The increased production level

of the recipient sector can increase the demand for intermediate or investment goods produced by different industries or even other economies if it is about imported products, and positive spillover effects can be determined (Crucitti et al., 2023). On the other hand, a crowding-out effect may occur if public support crowds out private-sector investment.

The significance of EU funds in the convergence process is tested in previous literature by applying various methodological approaches. Econometric models are usually based on a panel data technique (Ederveen & Nahuis, 2006) and the confirmation of unconditional β - convergence across European regions (Sala-i-Martin, 1996). The European Commission developed a spatial computable general equilibrium model (Christou et al., 2024).

The results of the RHOMOLO model developed and maintained by the Joint Research Centre of the European Commission suggest that the impact of the cohesion policy is significant, and the development gap decreases in European regions due to policy intervention (Christou et al., 2024). The model estimates that investments financed by European funds positively affect GDP growth, which is almost 0.6% higher than the scenario in the absence of a cohesion policy. The impact of structural funds in a few studies is estimated by applying a simple static input-output model in which an economy's grant receipts are treated as a positive demand shock, which induces an increase in GDP. In the methodological sense, the spillover effects of increased demand could positively impact other economies through cross-border trade (Picek & Schröder, 2017).

Verwey et al. (2020) estimated that real GDP levels in the EU will be higher from 1% to 2% (the highest effects are expected for 2024) because of the NGEU program. Even more developed member states are expected to experience an increase in GDP levels of 1% in 2024. Picek (2020), based on the international input-output model, concludes that economic effects are significantly higher than the initial investments financed by NGEU. The highest resources will be available for Croatia, Greece, and Bulgaria. On an annual basis, funds available from NGEU for Croatia averaged 1.6 percent of GDP. If spillover effects are included, the IO model estimates an increase in GDP of 2.9 percent (compared to the scenario without NGEU funds). In the Croatian case, most effects are concentrated on direct effects, while induced impacts are expected to be less pronounced than in Greece and Bulgaria. On the EU level, it is concluded that Keynesian multiplier effects of NGEU funds are substantial, and total effects are higher than original expenses. While the most significant economic growth in less developed economies results from domestic spending, more developed economies also benefit from increased exports delivered to original investors, mainly due to favorable industrial structure and comparative advantages in producing equipment and other capital goods.

Data sources and methodology

As stated in the introduction of the paper, the research is limited to quantifying the impact of the investments financed by EU funds on the Croatian economy. Official statistical data on the structure of investments in Croatia is used to estimate direct, indirect, and induced effects by applying the input-output model.

Data sources

The Croatian Bureau of Statistics (CBS) has regularly conducted an annual survey on the value of gross investments completed by Croatian investors in fixed assets. Investments are defined as acquiring tangible and intangible fixed assets in domestic and foreign markets. The total value of investments is broken down into several components. The structure of investments is available for each economic sector, depending on the type of investments (construction works, equipment, transport vehicles, and intangible assets). In addition, the survey provides data on sources of financing: investors' funds, loans, national or regional budgets, and funds from EU funds (Table 1).

In the analyzed period, the gross fixed capital formation shares in Croatian GDP increased by 3.1 percentage points from 13.8 percent in 2014 to 16.9 percent in 2023. The share of investment financed by EU funds in 2023 was 2.6 percent of GDP and almost 16 percent of total investments. The availability of EU funds did not adversely impact private investments.

Table 1: The importance of EU funds in financing gross fixed capital formation in Croatia, (thousand EUR)

	Gross fixed capital formation	Investments financed by EU funds	Gross fixed capital formation, % of GDP	The share of investments financed by EU funds	The share of investments financed by EU funds in GDP
2014	6.180.986	81.479	13.8	1.3	0.2
2015	6.163.593	297.851	13.4	4.8	0.6
2016	6.448.657	397.617	13.6	6.2	0.8
2017	6.979.258	307.849	14.0	4.4	0.6
2018	7.259.089	377.686	13.9	5.2	0.7
2019	8.387.762	748.842	15.3	8.9	1.4
2020	7.868.759	849.338	15.5	10.8	1.7
2021	8.377.300	1.031.572	14.4	12.3	1.8
2022	9.857.856	1.288.389	14.6	13.1	1.9
2023	13.198.005	2.052.383	16.9	15.6	2.6

Source: Croatian Bureau of Statistics (CBS), <https://podaci.dzs.hr/en/statistics/gdp-and-national-accounts/gross-investment/>.

An input-output for the Croatan economy of 2020 and 2021 is applied to calculate the indirect and induced effects of the investments. Due to the complexity of the data required, input-output tables for EU members are usually constructed with a time lag of 3 years after the reference period. Thus, the IO table for 2021 has been used to estimate multiplicative effects in 2021-2023. Methodology of compilation and input-output data for EU economies, including Croatia, are available at <https://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/information-data#Data%20release%20and%20dissemination>.

Input-output model

The input-output model allows the calculation of direct, indirect, and induced effects of a macroeconomic shock caused by an increase in final demand. In the first round, funds from EU funds imply an increase in demand for investment goods and services. Part of the growing demand satisfied by domestic products and services results in increased domestic gross output added value and employment in Croatia. On the other hand, a part of capital goods produced abroad directly increases imports. The second round of expansion of

multiplier effects refers to the increase in demand for intermediate goods required to make equipment, construction, and other domestic investment goods and services. The third round of the spread of effects includes the so-called Keynesian consumption multiplier, based on the increase in demand for goods and services used for personal consumption, financed by wages generated by the producers of investment goods and their suppliers.

The standard IO model is in detail described in previous literature (Leontief, 1986; Miller & Blair, 2009; ten Raa, 2006) for a given vector column of final demand ($\mathbf{f}$), assuming that the matrix $(\mathbf{I} - \mathbf{A})$ is not singular, i.e., that there is $(\mathbf{I} - \mathbf{A})^{-1}$, it is possible to determine the production of each sector, which is determined by exogenously determined final demand. Columns in matrix $\mathbf{A}$ present technological coefficients, i.e., the share of intermediate inputs required from other economic sectors to produce a unit production value for each economic sector. The unique system solution is:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1} * \mathbf{f} \quad (1)$$

Type I multipliers are based on the Leontief inverse matrix: $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$. Elements l_{ij} of $\mathbf{L}$ ($i, j = 1, 2 \dots n$), n is the number of economic sectors, presents direct and indirect requirements of the output of each industry required to produce a unit value of the production in sector j . The sum of direct and indirect output ($\mathbf{x}$) needed to create and deliver investment goods in this study is calculated by equation (1), where the vector column of final demand ($\mathbf{f}$) presents the value of investment goods bought by domestic producers but financed from EU funds.

In addition to direct and indirect effects, the IO model includes induced personal consumption financed by increased employment, wages, and salaries. Type II multipliers are based on the expanded matrix. $\hat{\mathbf{L}} = (\mathbf{I} - \hat{\mathbf{A}})^{-1}$. Matrix $\hat{\mathbf{A}}$ is a matrix of technical coefficients $\mathbf{A}$ expanded with an additional row (the share of wages in the output of each sector) and column (personal consumption). Total domestic output ($\mathbf{x}^*$), which, besides direct and indirect output ($\mathbf{x}$), includes induced personal consumption financed from increased wages and salaries, is calculated by the following equation:

$$\mathbf{x}^* = (\mathbf{I} - \hat{\mathbf{A}})^{-1} * \mathbf{f} \quad (2)$$

Gross value added and employment induced by an increase in investment are calculated by a multiplying vector containing value added and employment coefficients with output determined by equations (1) and (2). Gross value-added coefficients for each economic sector present the share of GVA of the sectoral production, while employment coefficients present the employment/output ratio for each sector.

The paper assumes no crowding-out effects, meaning grants and loans directly increase investment demand in the Croatian economy and do not lead to decreased investments financed from other sources. As shown in the section on data sources, in the case of the Croatian economy in the analyzed period, the increase in total investments is evident even if EU funds are excluded. Thus, the crowding-out effect is not noticeable.

In standard input-output models, a simple assumption of linearity of production functions and unlimited availability of inputs is applied. The assumption about the linearity of the production function implies the existence of stable technological coefficients, which means that with the increase in production, the consumption of all used inputs in the production process increases linearly. The key assumption is that the economy is not limited by the

ability of domestic producers to supply the required amount of goods and services at prevailing prices.

Results

This section analyses the structural characteristics of investments financed by EU funds by economic sectors, types of investments, and origins. It estimates the indirect and induced effects of the investments on the Croatian economy.

The origin and structural characteristics of investments

IO data, in detail, presents the sectoral structure of deliveries for each component of the final demand. Some investments, such as construction works, are almost exclusively contracted to domestic companies. In contrast, acquiring transport equipment, machinery, ICT, and similar, more complex equipment is mainly imported because of a lack of domestic production. The multiplicative effects in the national economy are effective only for investments of domestic origin. Based on the structure of supply in the Croatian market, it is estimated that nearly one-quarter of total investments financed by EU funds are imported and thus do not stimulate domestic economic activity (Table 2).

Table 2: Estimate of the structure of investments financed by EU funds by origin and type of fixed asset, (million EUR)

	2020	2021	2022	2023	Index, 2020=100	Structure, in % of the total in 2023
Domestic	627	1,021	1,056	1,574	251.1	76.7
Construction works	484	827	824	1,246	257.6	60.7
Transport equipment	14	19	28	47	341.2	2.3
Machinery, computers, and other equipment	82	94	108	147	180.0	7.2
Other investments	47	81	96	133	282.0	6.5
Imported	206	259	323	479	232.7	23.3
Construction works	6	10	10	15	257.6	0.8
Transport equipment	55	74	111	187	341.2	9.1
Machinery, computers, and other equipment	138	158	181	248	180.0	12.1
Other investments	7	16	21	29	393.4	1.4
Total	832	1,280	1,380	2,052	246.6	100.0

Source: Author's calculations based on the Croatian Bureau of Statistics (CBS), <https://podaci.dzs.hr/en/statistics/gdp-and-national-accounts/gross-investment/>.

Almost half of the investments from EU funds in 2023 are directed to public services (44.9 % of total EU funds), while 23.3 % are used by communal services (electricity, water, and environment). In those sectors, over 30 percent of total investments are financed by EU funds (Table 3). The industry share in total EU funds available for investments in 2023 has been only 4.5 percent.

Public and communal services are invested mainly in construction works, which constitute 61.2 % of total investments in public services and 72.2 % in investments conducted in the electricity, water, and environmental services sectors. Machinery and equipment are the most critical items in the structure of investments in the industry, which the funds of companies or credits mainly finance.

Table 3: Technological structure of investments in 2023 (million EUR)

	Total investments	Inv. financed by EU funds	The share of EU funds	Sectoral structure of investments from EU funds	Construction works	Machinery and equipment	Transport equipment	Other
Agriculture, forestry and fishing	304	27	8.8	1.3	28.4	29.7	6.8	35.1
Industry	2,052	93	4.5	4.5	29.3	51.6	5.5	13.6
Electricity, water, environment	1,532	479	31.3	23.3	72.2	22.5	3.9	1.4
Construction, transport, trade and hospitality	3,568	297	8.3	14.4	53.3	21.0	16.7	8.9
Public services	2,862	921	32.2	44.9	61.2	17.8	13.4	7.6
Other private services	2,881	236	8.2	11.5	34.2	21.5	23.4	20.9
Total	13,198	2,052	15.6	100.0	48.8	25.6	14.0	11.7

Source: Authors calculations based on the Croatian Bureau of Statistics (CBS), <https://podaci.dzs.hr/en/statistics/gdp-and-national-accounts/gross-investment/>.

Total output, GVA and employment induced by investments financed by EU funds

The direct effects of investments on the output of the Croatian economy are equal to the revenues domestic entrepreneurs earn from the production of demanded capital goods. Indirect effects include the production of domestic intermediate inputs incorporated into investment goods, which are lower than direct effects throughout the period. The slower growth of the indirect effects indicates the lower integration of domestic producers into the supply chain of investment goods and services. Although they are the smallest category in absolute value, the fastest growth was recorded for induced impacts, which more than tripled in the period analyzed. Such dynamic growth of induced effects is associated with growing wages in the economy and, thus, increased demand for goods and services intended for personal consumption.

GVA induced by investments financed by EU funds is estimated at EUR 1.5 billion in 2023, representing 2.31 percent of the total Croatian GVA (Table 4). The increasing volume of investments increased the share of induced GVA by 0.9 percentage points (from 1.41 percent of GVA in 2020 to 2.31 percent in 2023).

Table 4: Impact of investments financed by EU funds on the Croatian GVA (million EUR)

	2020	2021	2022	2023	Structure of effects in 2023	Index, 2023/2020
Direct output	627	1,021	1,056	1,574	45.1	251.1
Indirect output	464	705	722	1,080	31.0	232.8
Induced output	287	540	560	833	23.9	290.6
Total output	1,377	2,266	2,338	3,486	100.0	253.2
Direct GVA	240	381	403	627	41.6	261.5
Indirect GVA	206	299	304	467	31.0	226.5
Induced GVA	149	272	279	413	27.4	278.0

	2020	2021	2022	2023	Structure of effects in 2023	Index, 2023/2020
Total GVA	595	952	987	1,507	100.0	253.5
<i>Induced GVA, share in total Croatian GVA</i>	<i>1.41</i>	<i>1.99</i>	<i>1.75</i>	<i>2.31</i>		<i>164.2</i>

Source: Author's calculations

Similar trends as in GVA are recorded for employment effects (Table 5). Investments financed by EU funds induce 40 thousand jobs in Croatia in 2023, an increase of 67.2 percent compared to 2020. As in the case of output and GVA, induced effects were the most dynamic part of the total effects. The lower growth rate in employment compared to output and GVA results from the increased productivity in the period analyzed.

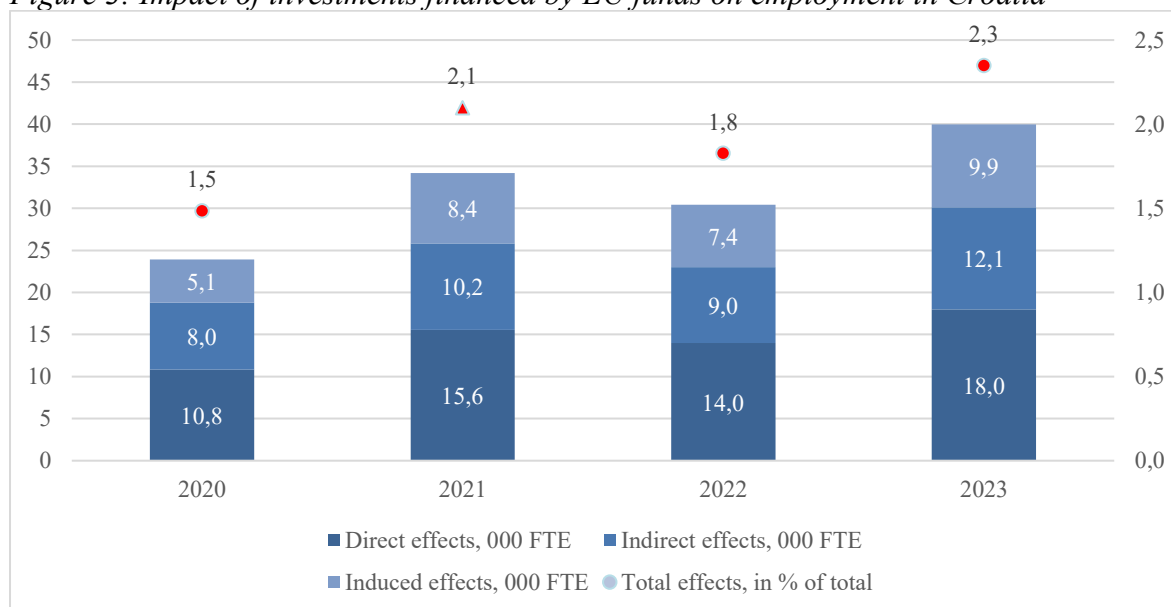
Table 5: Impact of investments financed by EU funds on employment in Croatia, in thousands of full-time equivalent (FTE) jobs

	2020	2021	2022	2023	Index 2023/2020
Direct employment	10.8	15.6	14.0	18.0	166.4
Indirect employment	8.0	10.2	9.0	12.1	151.9
Induced employment	5.1	8.4	7.4	9.9	192.7
Total employment	23.9	34.2	30.4	40.0	167.2
The share in total employment in Croatia	1.48	2.10	1.83	2.35	158.1
The structure of employment effects					
Direct employment	45.2	45.5	46.0	45.0	99.5
Indirect employment	33.3	30.0	29.6	30.3	90.8
Induced employment	21.4	24.5	24.4	24.7	115.3
Total employment	100.0	100.0	100.0	100.0	100.0

Source: Author's calculations

Figure 3 presents the structure of employment effects in the analyzed period. Direct effects prevail over all years, although the increase is most evident in induced effects, which increased from 5.1 thousand FTE in 2020 to 9.9 thousand in 2023. A slight decrease in effects recorded for 2022 is probably related to the reconciliation of investment programs with the requirements defined by a new financial perspective and new mechanisms introduced by NGEU.

Figure 3: Impact of investments financed by EU funds on employment in Croatia



Sectoral effects of the investments

The technological structure of investments financed by EU funds largely determines the sectoral structure and economic effects of such investments. Of the EUR 1.5 billion induced GVA (Table 6), more than a third relates to construction (37.2%), followed by other private services, industry, and distribution sectors (trade and transport). A similar order of sectors was also recorded according to the relative indicator (share in sectoral GVA). In construction, almost 12% of GVA was generated by investments financed by EU funds. An above-average share was also recorded in the industry sector (2.39%), while the increase in investment contributes the least to public and communal services.

Table 6: Impact of investments financed by EU funds on the sectoral GVA (million EUR)

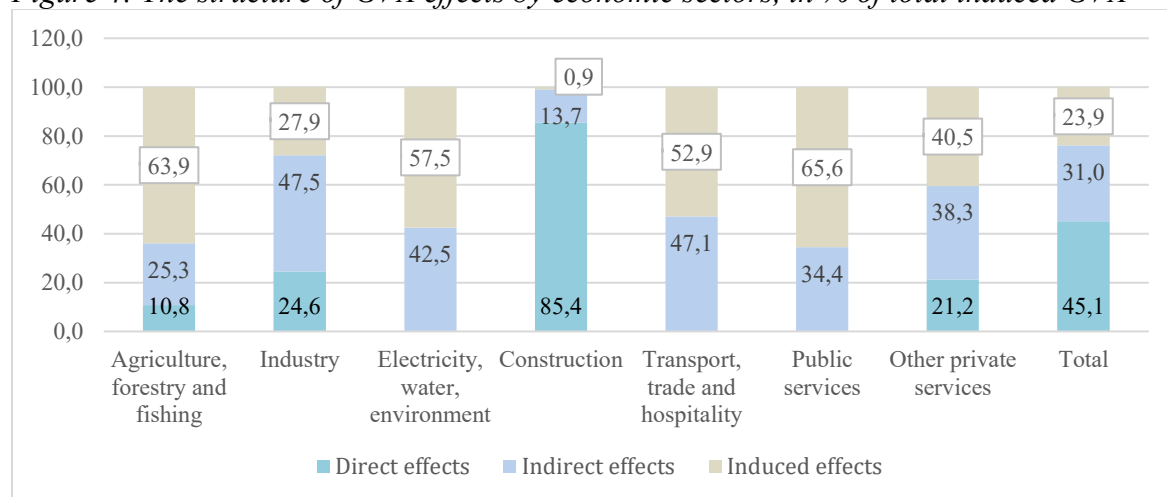
	2020	2021	2022	2023	Structure 2023	Index, 2023/2020	Share in sectoral GVA, 2023
Agriculture, forestry and fishing	10	21	22	33	2.2	315.9	1.39
Industry	133	184	189	296	19.6	221.9	2.39
Electricity, water, environment	15	18	15	24	1.6	164.0	1.09
Construction	204	341	351	561	37.2	274.8	11.61
Transport, trade and hospitality	72	132	140	209	13.9	292.1	1.38
Public services	17	27	27	42	2.8	243.7	0.41
Other private services	143	228	243	342	22.7	239.2	1.90
Total	595	952	987	1,507	100.0	253.5	2.31

Source: Author's calculations

Figure 4 highlights the differences between economic sectors in the distribution of effects. Direct effects are the most critical category of induced GVA effects in construction (85.4 %

of total effects). The dominance of the direct effects in the construction sector suggests that investment spending primarily drives growth in this sector through labor and material demand. However, since construction is a labor-intensive industry with relatively slow productivity gains, its contribution to overall economic growth remains limited. Indirect effects are visible in industry and other private services (mainly related to software production). Agriculture and public services benefited from increased investment demand mainly through induced effects, estimated to be almost two-thirds of the total effects in those sectors.

Figure 4: The structure of GVA effects by economic sectors, in % of total induced GVA



As in the case of GVA, the employment effects significantly differ among economic sectors. Direct effects dominate the construction sector (Table 7), where indirect and induced effects are limited. Indirect impact related to the production of intermediate inputs is the highest for manufacturing industries producing various materials, energy, and other inputs; distributive sectors and other private services such as ICT services, consultancy, and other business services. Induced effects are most visible in sectors delivering goods and services for personal consumption, such as transport, trade and hospitality, manufacturing, communal and other private services. In the agricultural sector, the total effects of investments are relatively low and mainly include an increase in sales of products for induced personal consumption.

Table 7: Impact of investments financed by EU funds on sectoral employment in thousands of full-time equivalent (FTE) jobs in 2023

	Direct effects	Indirect effects	Induced effects	Total
Agriculture, forestry and fishing	0.1	0.2	0.6	0.9
Industry	2.0	3.6	2.6	8.2
Electricity, water, environment	0.0	0.1	0.3	0.5
Construction	14.4	2.3	0.1	16.8
Transport, trade and hospitality	0.0	2.8	3.0	5.9
Public services	0.0	0.5	1.0	1.5
Other private services	1.5	2.6	2.2	6.3
Total	18.0	12.1	9.9	40.0

Source: Author's calculations

Conclusions

As a new and less developed EU member, Croatia has generous sources of financing from EU funds to achieve common EU goals in various areas, including more balanced regional development of the EU. In the period of using additional resources for investment financing, it was estimated that the economic activity induced by investments financed from EU funds was responsible for the substantial increase in economic activity in Croatia. The results suggest that in 2023, the total economic activity is 2.3% higher than in the scenario where funds for financing investments would not be available. Approximately 40 thousand jobs are induced by the growth of investment demand. Starting with the structure of investments, the effects are most significant for the construction sector, for which the sources of financing are the largest. In addition to the program of energy renovation of buildings and the improvement of public services, such as education and healthcare, it should be emphasized that in Croatia, a certain amount for financing renovation is also available from the solidarity fund for renovation after the devastating earthquake in Zagreb 2020. Regarding sectoral effects, it is evident that a specific range of positive multiplicative effects is transferred abroad, especially investments in high-tech equipment and inputs not produced domestically, which aligns with results from other studies (Crucitti et al., 2023).

The results on the positive short-term effects of the availability of EU funds align with the results of earlier research (Beugelsdijk & Eijffinger, 2005; Ederveen & Nahuis, 2006; Picek, 2020). However, it should be emphasized that despite the positive effects on the growth of economic activity in the period of increased demand, there are also certain risks. This primarily relates to the lack of labor since a significant amount relates to the increase in demand for products and services in sectors in which productivity growth is limited. The increased demand when the supply is limited affects price growth, which is evident for construction services and goods for personal consumption. Furthermore, the structure of such investments in construction facilities and the public sector does not guarantee that the economy will be transformed in addition to short-term positive effects, raising competitiveness and ensuring long-term sustainable growth. There is a specific risk that in the period after 2027, when the availability of EU funds for the Croatian economy decreases, there will be a negative shock and a slowdown in economic growth. Although the EU budget generally determines the main purpose of available resources, the Croatian government and local units should include the business and academic community in identifying eligible projects that could boost the technological transformation of the economy and ensure productivity growth. The primary goal of using EU funds should be stimulating investments that ensure sustainable long-term economic growth.

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DEVELOPMENT OF THE BALTIC COUNTRIES' EXPORT NETWORK

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Abstract

The paper combines the theories of gravity modelling and the economics of networks and empirically analyzes the development of the export network of the three Baltic countries after the collapse of the Soviet Union. We investigate which factors influenced the spread of the export networks of the Baltic countries and if the influence of any of these factors differed for Lithuania, Latvia and Estonia. We find that the network effects are important for the development of the extensive trade margin. The most important factors are the history of exporting, the distance, the ability to understand each other and the stock of migrants between the countries. Results suggest that there were no major differences between any of the countries analyzed.

Keywords: trade, international trade, trade networks, network formation, extensive trade margin

JEL classification: F14, D85

Introduction

When the Soviet Union collapsed, Lithuania, Latvia and Estonia once again entered the international trade market. Before their independence, these three countries had centrally planned economies, very limited cultural and economic relations with the outside world and strictly prohibitive trade restrictions. After the drop of the iron curtain, they re-entered the international trade market and started to form their own trade networks.

The paper builds on this natural experiment and examines how the export of Lithuania, Latvia and Estonia developed after the independence from the Soviet Union. We combine the gravity and networks theories and focus on the extensive trade margin (see Alborno et al. (2012), Conconi (2022), Helpman et al. (2008), Felbermayr & Kohler (2006)) to analyze how different direct and network factors influenced the formation of the export networks of Lithuania, Latvia and Estonia. We seek to determine the most important factors forming their export networks and to examine if the influence of these factors was the same for each of these countries.

We aim to answer the following research questions:

- Which factors influenced the spread of the export networks of each of the Baltic countries?
- How different was the influence of these factors for each of the Baltic countries?

This paper aims to empirically examine the importance of a wide range of network effects for the development of the extensive trade margin of the Baltic countries. The novelty of the research lies in including many network effects to the gravity model, and in comparing the influence of the network effects among the countries. Another novelty of the paper is that it focuses on developing markets and examines how the emerging economies form their export network. Current empirical research (e.g. Chaney, 2014; Rauch & Trindade, 2002; Felbermayr & Kohler, 2006; etc.) is based mainly on the matured markets, engaged in the international trade for several decades or even centuries (e.g. the USA, France, etc.).

The setup of the paper is as follows: in the literature review section we analyze the latest research and its relevance to our study, in the methodological section we discuss the methodology and describe the data, results section presents the general model for all three Baltic countries and compares the results for Lithuania, Latvia and Estonia, finally, we conclude, address the limitations of the study and provide recommendations for future research.

Literature review

This research contributes to the literature on international trade networks and empirical gravity modelling. Since Tinbergen (1962) primary trade determinants have been demand, supply, and the trade costs, whereas the most common proxy of trade costs is the distance between the countries (e.g. Tinbergen, 1962; Anderson, 1979; Anderson & Van Wincoop, 2003; Anderson, 2011; Felbermayr & Kohler, 2006). Other authors elaborated the concept of the trade costs, including such trade determining factors as language skills (Ginsburgh & Weber, 2020; Egger & Toubal, 2018; Rindler, 2021), belonging to the currency union (Berthou & Fontagne, 2008; Baldwin & Di Nino, 2006), openness of political regimes (Kim et al., 2019; Alborno et al., 2012), migration networks (Parsons & Vézina, 2018; Baiardi & Ammon, 2022; Zhang, 2020), social connectedness (Bailey et al., 2021), religious beliefs (Lo Turco & Maggioni, 2018) and search costs (Allen, 2014).

Helpman et al. (2008), Chaney (2014), Chaney (2016), Chaney (2018), Morales et al. (2019), Defever et al. (2015), Fernandes & Tang (2014), Wang & Zhao (2013), Lawles (2013) and other authors started to include experience of exporting and to apply economics of networks in trade modelling. Chaney (2014), Defever et al. (2015) and Morales et al. (2019) claim that new export relations tend to be created from the places where export relations have already been created (they called it the ‘network effects’, ‘extended gravity’ factor group or ‘spatial exporters’). Similar results were obtained by Berthou & Ehrhart (2017) and Chen & Sun (2021). Morales et al. (2019) argued that it is less costly to enter a new market which is similar to the market where the firm has already exported.

We build our analysis on the models developed by Chaney (2014), Defever et al. (2015), Chaney (2018) and Morales et al. (2019). We follow the assumption that the export network of a country develops stage-by-stage. In the first stage, the country of origin finds several export destinations directly. In the second and further stages, the country of origin finds more export destinations in two ways: directly from the origin, and indirectly – from its current export destinations which have already been found in the previous stages. We shall refer to the factors affecting this indirect search procedure (i.e. the factors influencing country’s ability to find new export destination not directly from the origin, but from the current export destinations of a country), as the ‘network effects’, ‘indirect effects’ and/or

‘friends-of-friends’ effects.

Methodology

The model

Following Chaney (2014), we assume that the spread of the export markets depends on the trade costs and the import growth between the origin and the destination, and between the current destination of the origin and its new destination. As proxies of the trade costs we include the direct and indirect versions of common spoken languages, free trade agreements, belonging to the same economic and political unions and the stock of migrants. We attempt to test which direct and indirect effects were the most important for the development of the extensive margin of international trade in Lithuania, Latvia and Estonia and if their influence differed for the three Baltic countries.

In order to examine the factors that are important for the export network formation, the following dynamic gravity-type model was estimated:

$$1[Export_{i,c,t+1}^s > 0] = \alpha Markets_{i,t}^s + \beta_1 \underset{(direct)}{X_{i,c,t}^s} + \beta_2 \underset{(fof)}{X_{i,c,t}^s} + \delta 1[Export_{i,c,t}^s > 0] + \underset{Controls_{c,t}^s}{Controls_{c,t}^s} + \varepsilon_{i,c,t}^s + u_{i,c}^s \quad (1)$$

Here, $1[.]$ is an identity function indicating if product i from the country of origin s was exported to country c at time t . $Markets_{i,t}^s$ shows the number of country s export markets of product i at time t . Vectors X stand for all the factors influencing the direct search procedure (these are the factors which condition expanding the country’s export network directly from the country of origin, e. g. the number of emigrants from the country of origin to country c) and all the factors influencing the indirect search procedure (these are the factors which condition expanding the country’s export network from the current export partners of the country of origin, e. g. the average number of emigrants from the current export partners of the country of origin to country c). The controls stand for any additional controls needed (i.e. the size of a destination country, the industry dummy, etc.). Finally, ε is an error term and u is the individual effect.

Exogenous variables are as follows:

- Nominal GDP (in logs) of the destination country in millions USD
- Previous exporting shows if product i was exported from the country of origin to the country of destination in year t
- The number of export markets give the number of product’s i export markets that country of origin had in previous year
- Import growth shows this year’s growth of the total import to destination country
- Import growth f-o-f gives this year’s total growth of import of the destination country from all the countries in which the country of origin exported product i , as of

$$impgrow\_fof_{i,c,t} = \ln(\sum_{c'} Export_{i,c',t}^s * Import_{c,t}^{c'}) - \ln(\sum_{c'} Export_{i,c',t-1}^s * Import_{c,t-1}^{c'}) \quad (2)$$

- Distance from the origin is calculated as the log of the distance between the country of origin and the destination country

- Distance f-o-f indicates the mean of the distances between any destination country c and all the other countries to which the origin exported product i

$$dist_{fof_{i,c,t}} = \frac{\sum_{c'} (distance_{c,c'} * Export_{i,c',t}^S)}{\sum_{c'} Export_{i,c',t}^S} \quad (3)$$

- Soviet bloc membership is a dummy variable and stands for cultural and historical similarities. It can be either '1' (both countries belonged to the Soviet bloc before 1990) or '0' otherwise. The Soviet bloc membership is marked if a country is considered to belong to the Soviet bloc before the 1990s. The countries included in the Soviet bloc in the analysis are: Lithuania, Latvia, Estonia, Moldova, Ukraine, Belarus, Hungary, Poland, Romania, Slovakia, the Czech Republic, Bulgaria, Russia, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Afghanistan, Vietnam, Mongolia, Laos, Mozambique, Yemen, Ethiopia, Cuba, North Korea, Benin, Angola and the Republic of Congo.
- Soviet bloc f-o-f membership is another dummy variable and indicates the indirect effect of belonging to the Soviet bloc

$$sb_{fof_{i,c,t}} = \frac{\sum_{c'} (sb_{c,c'} * Export_{i,c',t}^S)}{\sum_{c'} Export_{i,c',t}^S} \quad (4)$$

- EU membership can be either '1' if both countries belong to the European Union and it equals '0' otherwise. The EU membership is accounted for each year
- EU f-o-f membership indicates the indirect effect of belonging to the EU and is calculated as follows

$$eu_{fof_{i,c,t+1}} = \frac{\sum_{c'} (eu_{c,c',t+1} * Export_{i,c',t}^S)}{\sum_{c'} Export_{i,c',t}^S} \quad (5)$$

- Free trade agreements (FTA) are accounted for each year and amounts to '1' if both countries had a free trade agreement at the time, otherwise it is '0'
- FTA f-o-f shows the average of free trade agreements between the export partners of the origin and the other countries:

$$fta_{fof_{i,c,t+1}} = \frac{\sum_{c'} (fta_{c,c',t+1} * Export_{i,c',t}^S)}{\sum_{c'} Export_{i,c',t}^S} \quad (6)$$

- Language is a measure, showing the abilities of two countries to communicate with each other
- Language f-o-f shows the average of the indirect ability of countries to communicate

$$lang_{fof_{i,c,t}} = \frac{\sum_{c'} (lang_{c,c'} * Export_{i,c',t}^S)}{\sum_{c'} Export_{i,c',t}^S} \quad (7)$$

- Migration is the log of the migration stock from the country of origin to the destination country in 1990.
- Migration f-o-f is the log of the average indirect migration calculated for the destination country

$$migr\_fof_{i,c,t} = \frac{\sum_{c'} (migr_{c,c',1990} * Export_{i,c',t}^s)}{\sum_{c'} Export_{i,c',t}^s} \quad (8)$$

As this paper deals with an extensive margin of international trade, we are interested only in the fact whether a country of origin exported product i to the destination country, or not. The exact volume of such export is irrelevant for this analysis.

We estimate each model applying the Linear Probability (OLS) method. According to the common practice (Shepherd, 2012), the general model was estimated including the pairs of combined country-year fixed effects. The robustness check was made by estimating the models with combined destination-product as well as combined year-product fixed effects. Separate country-by-country models were estimated including combined year-product fixed effects. To have better predictions and to reduce autocorrelation and endogeneity problems by catching some of the omitted variables, we also include the lagged export (it shows the persistence of export) to the regression (Hinz et al., 2020). To minimize the risk of other potential discrepancies, we also apply clustering and robust standard errors.

The data

The main product level bilateral trade data comes from the BACI world trade database (Mayer & Zignago, 2011) and covers the period between 1995 and 2015. The year 1995 was chosen because it is the first year when trade statistics for the Baltic countries started to be collected. The year 2015 was the final analyzed period because in this paper we are mostly interested in the beginning of the formation of the countries' export network. The data accounts export only if its value is at least 1,000 USD per year.

The model we are using is mostly designed for the firm-level data, however, we were unable to get a micro-level data. Therefore, based on Baldwin & Di Nino (2006), we are using the most detailed sector-level dataset. Trade is classified according to HS-92 6-digits classification which is the lowest possible aggregation distinguishing about 5000 commodities (Gaulier & Zignago, 2010).

The aggregated bilateral import data by country is taken from Feenstra et al. (2005). The nominal GDP and migration data comes from the World Bank's database. The migration data is represented by the immigrant stock in the destination country by each country of origin as of the year 1990. We do not have any later migration data, however, based on Baiardi & Ammon (2022) and Bailey et al. (2021), the effects of migrants on trade do not fade even in the long run. Finally, the data for the weighted average distances between countries, the measure of common spoken languages between a pair of countries as of the year around 2012, and free trade agreements (FTA) between different countries (based on the information provided by the WTO) are retrieved from CEPII (Mayer & Zignago, 2011).

In total we have 3 countries of origin (Lithuania, Latvia and Estonia), 184 countries of destination, 20 time periods and 2472 distinct products exported by any of the 3 Baltic countries. As not all the products were exported to all the countries in all time periods, together these 4 dimensions give us around 19 million observations.

Descriptive statistics

Table 1 gives descriptive statistics of all the variables before normalization. Both exporting

variables are endogenous and can be either ‘0’ or ‘1’. They show if the country of origin exported product i to the destination country. The direct variables of the Soviet bloc membership, the EU membership and the free trade agreements are dummy variables. The indirect variables of the Soviet bloc membership, the EU membership, the free trade agreements and the common spoken languages are calculated as the averages, hence, they can take any value between ‘0’ and ‘1’.

Table 1: Descriptive statistics

Variable	Mean	St. dev.	Min	Max
Exporting _{t+1}	0.056	0.231	0.000	1.000
Exporting _t	0.053	0.225	0.000	1.000
Markets _t	9.825	8.806	0.000	114.000
GDP (ln)	9.851	2.492	2.512	16.674
Import growth	0.080	0.271	-3.365	4.063
Distance (origin)	8.472	0.876	4.691	9.754
Soviet bloc	0.163	0.369	0.000	1.000
EU membership	0.078	0.267	0.000	1.000
FTA	0.219	0.414	0.000	1.000
Language	0.161	0.203	0.000	0.961
Migrants (ln)	2.046	2.974	0.000	11.785
Imp. growth f-o-f	0.082	0.771	-14.819	16.332
Distance f-o-f	8.531	0.741	2.134	9.886
Sov. bloc f-o-f	0.087	0.223	0.000	1.000
EU membership f-o-f	0.057	0.179	0.000	1.000
FTA f-o-f	0.185	0.296	0.000	1.000
Language f-o-f	0.158	0.178	0.000	1.000
Migrants (ln) f-o-f	5.342	3.772	0.000	15.466

Due to a large number of variables, there is a high possibility of multicollinearity problems. Many direct variables are correlated with the corresponding indirect variables. It is especially true for the Soviet bloc, the EU, FTA and language variables. The direct migration variable is also correlated with the direct language variable. The distance from the origin is correlated with direct migration as well as the indirect EU and FTA variables. We addressed the possible problem by estimating separate models for the direct and indirect variables and comparing their results.

The results

The general Baltic countries model

First, we estimate a general OLS model for all three countries. Following the literature, we estimate fixed effects regressions taking three types of individual effects. The first regression is estimated with year and product fixed effects, the second one with year and destination fixed effects and the third one with a pair of combined fixed effects year-destination and year-origin.

The results of the three models are given in Table 2. Almost all the factors are reported to be highly significant. As expected, the GDP, the number of markets, the previous exporting, the EU membership, the common spoken languages and the number of migrants affect the

future exporting positively, while the effect of the distance from the origin is negative. The effect of the growth of import is not significant. However, some of the network factors tend to change signs by the specification. The reason for that could be that although the influence of the direct factors is the same, however the influence of the network factors is different for all three Baltic countries.

Table 2: Results of the model for all three Baltic countries

Variables, normalized	All 3 Baltic countries		
Dependent variable	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}
GDP	0.006*** (0.000)	0.005*** (0.000)	-
Distance (origin)	-0.018*** (0.000)	-0.012*** (0.000)	-0.037*** (0.000)
Exporting _t	0.133*** (0.000)	0.121*** (0.000)	0.120*** (0.000)
Markets _t	0.015*** (0.000)	0.017*** (0.000)	0.022*** (0.000)
Import growth	0.000*** (0.000)	0.000*** (0.000)	-
Soviet bloc	-0.008*** (0.000)		-
EU membership	0.007*** (0.000)	0.010*** (0.000)	0.061*** (0.000)
FTA	-0.001*** (0.000)	-0.002*** (0.000)	-
Languages	0.026*** (0.000)	0.053*** (0.000)	0.046*** (0.000)
Migrants	0.016*** (0.000)	0.039*** (0.000)	0.028*** (0.000)
Distance f-o-f			0.035*** (0.000)
Imp. growth f-o-f	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)
Sov. bloc f-o-f	0.003*** (0.000)	-0.001*** (0.000)	0.004*** (0.000)
EU f-o-f	0.003*** (0.000)	0.000*** (0.000)	0.006*** (0.000)
FTA f-o-f	-0.002*** (0.000)	0.005*** (0.000)	0.014*** (0.000)
Language f-o-f	-0.008*** (0.000)	0.006*** (0.000)	0.007*** (0.000)
Migrants f-o-f	0.000*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Constant	yes	yes	yes
Fixed effects	year, product	destination, product	year-dest, year-origin
Sector controls	no	no	no
R-squared	0.519	0.537	0.542
Observations	19,123,120	19,123,120	19,123,120

* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Comparisons of the results for Lithuania, Latvia and Estonia

Next, we investigate the differences between the three Baltic countries. Table 3 includes three types of OLS regressions with fixed effects of year and product for each country separately. The first three columns show the results of the regressions for Lithuania, Latvia and Estonia including all the factors. To check if the results are affected by multicollinearity, we also introduced separate models, taking only direct (the second three columns) and only indirect (the last three columns) variables. As all three models give very similar results which are in line with the expectations, we may conclude that the multicollinearity problem does not have any significant impact on the results.

The results of country-by-country regressions show very similar results to the general regression: the effects of the GDP, the previous exporting, the number of markets the EU membership, the common spoken languages, the stock of migrants, indirect factor of belonging to the Soviet bloc and the EU and indirect migration are stable, significant and influence extensive margin of export positively, while both direct and indirect distance, belonging to the Soviet bloc and both direct and indirect free trade agreements have negative effects for the spread of the export markets. Import growth does not seem to have any significant influence on the formation of the export network of any of the three countries.

The negative effect of the belonging to the Soviet bloc could be explained by the increasing orientation of Lithuania, Latvia and Estonia to the EU markets. While the negative sign for the free trade agreements and changing signs for the indirect languages could be related to their correlation with the other variables.

A graphic comparison of the general regression results for Lithuania, Latvia and Estonia is presented in Figure 1. Coefficients are comparable, because the data has been normalized. The results are displayed starting from the highest and finishing with the lowest value.

Table 3: Results of country-by-country models

	General regressions			Direct regressions			Indirect regressions		
Variables, normalized	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia
Dependent variable	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}
GDP	0.010*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.010*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.014*** (0.000)	0.010*** (0.000)	0.011*** (0.000)
Distance (origin)	-0.014*** (0.000)	-0.018*** (0.000)	-0.018*** (0.000)	-0.016*** (0.000)	-0.017*** (0.000)	-0.019*** (0.000)			
Exporting _t	0.139*** (0.000)	0.128*** (0.000)	0.128*** (0.000)	0.140*** (0.000)	0.128*** (0.000)	0.130*** (0.000)	0.150*** (0.000)	0.137*** (0.000)	0.139*** (0.000)
Markets _t	0.012*** (0.000)	0.010*** (0.000)	0.010*** (0.000)	0.011*** (0.000)	0.010*** (0.000)	0.008*** (0.000)	0.009*** (0.000)	0.009*** (0.000)	0.007*** (0.000)
Import growth	0.001*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.001*** (0.000)	0.000*** (0.000)	0.001*** (0.000)			
Soviet bloc	-0.007*** (0.000)	-0.007*** (0.000)	-0.007*** (0.000)	-0.002*** (0.000)	-0.004*** (0.000)	-0.006*** (0.000)			
EU membership	0.005*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.010*** (0.000)	0.010*** (0.000)	0.007*** (0.000)			
FTA	-0.004*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.002*** (0.000)	-0.003*** (0.000)	-0.003*** (0.000)			
Languages	0.035*** (0.000)	0.024*** (0.000)	0.024*** (0.000)	0.026*** (0.000)	0.017*** (0.000)	0.013*** (0.000)			
Migrants	0.012*** (0.000)	0.014*** (0.000)	0.014*** (0.000)	0.014*** (0.000)	0.015*** (0.000)	0.018*** (0.000)			
Distance f-o-f							-0.012*** (0.000)	-0.012*** (0.000)	-0.015*** (0.000)
Imp. growth f-o-f	0.000** (0.000)	0.000 (0.000)	0.000*** (0.000)				0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Sov. bloc f-o-f	0.004*** (0.000)	0.003*** (0.000)	0.003*** (0.000)				0.009*** (0.000)	0.006*** (0.000)	0.003*** (0.000)

	General regressions			Direct regressions			Indirect regressions		
Variables, normalized	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia
Dependent variable	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}	Exp _{t+1}
EU f-o-f	0.008*** (0.000)	0.002*** (0.000)	0.002*** (0.000)				0.011*** (0.000)	0.009*** (0.000)	0.007*** (0.000)
FTA f-o-f	0.002*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)				-0.000*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)
Language f-o-f	-0.010*** (0.000)	-0.007*** (0.000)	-0.007*** (0.000)				0.016*** (0.000)	0.014*** (0.000)	0.012*** (0.000)
Migrants f-o-f	0.000 (0.000)	0.001*** (0.000)	0.001*** (0.000)				0.003*** (0.000)	0.004*** (0.000)	0.003*** (0.000)
Constant	0.063***	yes	yes	yes	yes	yes	yes	yes	yes
Ind. effects (prod, year)	fixed	fixed	fixed	fixed	fixed	fixed	fixed	fixed	fixed
Sector controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
R-squared	0.531	0.51	0.523	0.529	0.506	0.518	0.517	0.495	0.506
Observations	7,338,104	5,174,080	6,610,936	7,338,104	5,174,080	6,610,936	7,338,104	5,174,080	6,610,936

* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Comparison of the general regression coefficients for the three Baltic countries

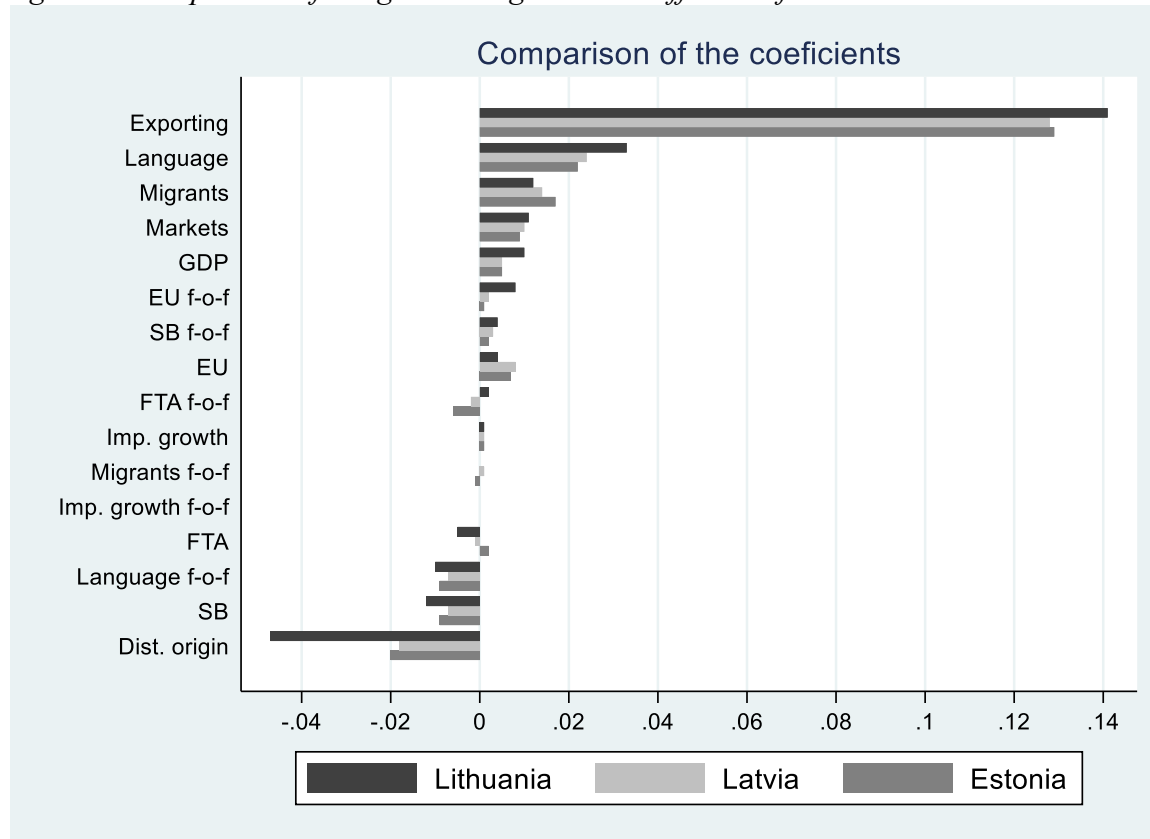


Figure 1 shows that the factors that influenced the formation of export networks of the three Baltic countries were similar. The most influential positive factors for all the countries were the previous exporting, the direct language, the direct stock of migrants, the number of current export markets and the GDP. The most influential negative factors for the three countries were the distance from the origin, the indirect language factor and the direct belonging to the Soviet bloc.

Among the major differences was comparably higher influence of previous export, distance from the origin and direct common spoken languages for the formation of the export network of Lithuania. For the build-up of the Estonia's export network the indirect belonging to the free trade agreements had comparably higher negative influence.

Conclusions

This paper employs theories of gravity modelling and network economics and empirically investigates the factors influencing the formation of the export network of the three Baltic countries during the years 1995-2014.

Our findings confirm the results of Morales et al. (2019), Chaney (2014) and Alborno et al. (2012), who found out that the network variables are important for the spread of countries' export networks. We claim that the factors that influenced the growth of the export networks of Lithuania, Latvia and Estonia were previous exporting, common spoken languages, the stock of migrants in other countries, the number of export markets, the GDP of the origin, both direct and indirect belonging to the EU (all positively), distance from the origin, common spoken

languages between the current export markets of the origin and the other countries and belonging to the Soviet bloc (all negatively). We didn't find any significant differences between the three countries. The importance of the factors that influenced the development of their export network was very similar.

Our empirical findings help us to understand the factors that are influential for the development of a country's export network. The model could be used for researchers when constructing their own trade models and our results could indicate policy makers were to divert resources and which areas of the countries' economies should be strengthened.

While this study is limited to only 3 exporting countries and extensive trade margin, expanding the analysis to include more trading pairs, investigating the intensive trade margin, modelling product diversity, and incorporating potential intermediaries could provide valuable new perspectives and deeper insights into the topic.

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REGIONAL CONVERGENCE OF INNOVATION ECOSYSTEMS: CASE OF CENTRAL AND EASTERN EUROPEAN COUNTRIES

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Abstract

Increasing global tensions have led to the strengthening of de-globalization trends, the disintegration of economic alliances, and the rise of regionalization. This fragmented world has highlighted the diminishing influence of once technologically strong countries and regions. EU countries have emerged as losers in this new global order, which has also affected intra-member relations and contributed to the growing trend of Euroscepticism. These trends have also impacted the CEE region, slowing down economic convergence towards the more developed EU members while accelerating regional convergence. However, given the era of rapid digitalization and informatization, as well as the fast flow of knowledge, the question arises as to whether de-globalization and regionalization have also left a mark on the slowdown of convergence towards the EU's innovation ecosystem. To answer this question, the participation of scientists from CEE countries in the innovation ecosystem of other EU countries will be examined. Specifically, the focus will be on collaboration in joint academic projects and shared patent activity between scientists from CEE countries and other EU members. To illustrate the network and concentration of collaboration, VOSviewer will be used.

Keywords: CEE, innovation, globalization, convergence, de-globalization

JEL classification: O32, O33, O34, O14, P21

Introduction

Innovation and technological progress are fundamental drivers of a country's economic growth. Therefore, investments in research and development (R&D) represent a significant component of political and strategic programs in every country. Regardless of whether these investments are directed towards basic, applied, or experimental research, it is generally believed that any form of R&D investment will eventually yield positive economic results (Coccia, 2009). Technological development is often discussed in the context of globalization processes, and extensive academic literature has been dedicated to the interdependence of these two concepts (Matyushok et al., 2021; Sachs, 2019; Grossman & Helpman, 2015; Shahzad et al., 2022). Globalization is frequently seen as the foundation of innovation, providing an essential backdrop for innovation processes. Global trends, both physical and virtual, have facilitated the international flow of knowledge, an indispensable element of technological advancement. International research collaboration has bridged the issues of knowledge asymmetry and resource scarcity on a global scale. Another stream of research views innovation as a driver of globalization (Korinek & Stiglitz, 2021). The processes of integration and overcoming physical and cultural divides, require technological advancements, positioning innovation as the backbone of globalization. The relationship between globalization and innovation has always

been bidirectional, making it an exceptionally complex and intriguing subject in academic discourse.

Geopolitical tensions, trade wars, and the global pandemic have caused tectonic shifts in innovation trends. Over the past decade, the world has witnessed an intensification of de-globalization, a phenomenon that significantly challenges the trends that have shaped the modern world (James, 2018). This process, which runs counter to the globalization-driven growth of past decades, is present across all spheres of global affairs. The disintegration of global political and economic alliances highlights the emergence of de-globalization, isolation, and the strengthening of regional alliances. Just as globalization has influenced innovation trends, de-globalization is also leaving a significant mark on their formation. The disintegration of international alliances has had both direct and indirect effects on innovation trends and the pace of technological progress. Reduced trade flows and weakened political alliances have limited knowledge exchange, fostering a trend toward self-sufficiency and severely disrupting existing global value chains. While these developments have impacted almost all countries, some have managed to adapt to the newly formed conditions. Others, however, have fallen out of key value chains and become less significant players. The trend of slowing convergence and the strengthening of regionalization is also evident within the EU (Podkaminer, 2016). Economic recessions, migration crises, and trade wars have contributed to growing Euroscepticism, affecting both old and new EU member states and hindering economic convergence.

CEE (Central and Eastern European) countries were among the last to join the EU, and due to their similar historical backgrounds, they have been converging more rapidly with each other than with the rest of the EU. Diverging from the development path of “old” members, lead to a growing inequality in EU. Catching-up of more developed countries is complicated due to a lack of industrial and innovation capacity resulted from deindustrialization that took place during the transition period (Stojčić & Aralica, 2017). Knowledge characteristics, such as speed of transfer, short innovation cycles, and digital literacy, suggest that convergence on the path of developed EU members, CEE should look through integration into EU innovation ecosystem. Innovation activity is the most successful engine of economic growth (Maradana et al, 2017). It was expected that introducing new technologies and shifting technological frontier in “technologically scarce” CEE might lead toward growth of productivity. However, significant changes were not recorded. Introducing new technologies didn’t improve efficiency in resources allocation - lead to stronger growth of productivity. New technologies did leave some impact, however, low level of absorptive capacity, dismantled industry, discourage foreign investors from significant investment in higher value-added production facilities and prevented CEE countries from giant leap forward.

This study will analyze CEE countries and their integration trends within the EU innovation ecosystem over the past two decades. Paper seeks to answer the following research question: Have CEE countries, despite their economic lag, successfully integrated into the innovation ecosystem of the more developed EU member states, or they stayed trapped in innovation ecosystem of CEE countries? Determining their position within the EU innovation ecosystem is crucial not only for CEE countries but also for other EU members. By examining both the current position and historical trends, policymakers in CEE countries can better shape the intensity and direction of their innovation policies. On the other hand, the findings may encourage EU policymakers to invest additional efforts into integrating new member states. Addressing disparities in innovation capacity among EU member states is essential, as such imbalances could further weaken the EU’s already precarious position in the global innovation

race. To assess the integration of CEE countries into the EU innovation ecosystem, this study will analyze international research collaboration between scientists from CEE and other EU member states. The study will use VOSviewer to visualize collaboration networks between CEE countries and the rest of the EU.

The following sections of the paper will present a literature review and the development of the research question. This will be followed by the methodology and research findings. The paper will conclude with a discussion and final remarks.

Literature review

Globalization is a relatively new concept, yet it has long been a reality (James, 2018). For centuries, globalization has been the primary driver of economic development. The unrestricted movement of people and capital, as well as the dissemination of knowledge and technology, have gradually erased economic and cultural boundaries, transforming the world into a "global village" (Ghosh & Ortiz, 1997). Liberalization has facilitated the transmission of technological innovations and fostered political and economic convergence among nations (Skare & Soriano, 2021). Developing countries are slowly catching up with the technological frontier continuously set and expanded by developed nations. According to Kijek & Matras-Bolibok (2020), productivity disparities are diminishing, thereby mitigating the negative effects of spatial inequality. This suggests that the least efficient economies have the greatest potential for rapid productivity growth. Numerous examples support the positive impact of globalization, with China serving as a textbook case. In the 1980s, China's economic reforms and integration into the global market brought revolutionary changes across almost all industrial sectors. While globalization has facilitated the flow of information and technology, its positive effects are not guaranteed for all countries (Archibugi & Pietrobelli, 2003). The impact of spatial effect has not been entirely eliminated, as neighboring regions have exhibited similar behavioral patterns sometimes diverging from expected convergence trajectories (Fingleton, 2003).

The origins of regionalization can also be linked to American hegemony and the effort to maintain a globalization model dominated by the United States (Matyushok et al., 2021). Dissatisfied with the existing globalization model, emerging economic powers—primarily China—have been determined to challenge U.S. dominance. The clash of these economic forces has led to various political and economic trends pointing to an increasingly evident process of de-globalization. The first significant signs of de-globalization appeared in response to the 2008 financial crisis (James, 2018). Warburton (2017) identifies the rollback of free trade agreements, the decline in foreign direct investment, the rise of tariffs, and other protectionist trade measures as clear indicators of de-globalization. Political movements such as "Self-Reliant India" in India, the "Five Star Movement" in Italy, "Podemos" in Spain, and the rise of the nationalist "Syriza" party in Greece are among the many anti-globalization trends that have emerged in recent years. Economic drivers of de-globalization have been closely followed by political developments, which have left an even more profound impact. The European migration crisis led to a resurgence of nationalism. In the UK, nearly 52% of voters opted to leave the European Union following a campaign that framed immigration as a threat (Zhang, 2018). According to Cieřlik & Wciřlik (2020), de-globalization is accompanied by the strengthening of regional alliances, particularly among nations with shared interests and a long history of political and economic ties. Developing economies, which have not yet achieved full institutional convergence, are also experiencing the effects of de-globalization. Research indicates that the absence of institutional convergence could significantly hinder economic

growth (Romer, 1994; Rodrik, 2006). Dollar & Kraay (2004) argue that globalization had a positive effect on economic growth in developing countries towards the end of the 20th century. The expansion of multinational corporations and improvements in digital literacy have been crucial in driving economic convergence (Audi et al., 2022).

It was widely believed that globalization and technological progress shared an exclusively positive relationship. However, globalization's effects are not uniform across all countries. Advanced technological progress is not always equally accessible worldwide (Korinek & Stiglitz, 2021). New technologies tend to be labor-saving and resource-efficient, creating a "winner-takes-all" dynamic that favors developed nations. Thus, the impact of globalization on technological progress is largely dictated by global hegemonies (Witt, 2019). When global powers recognize the risks that globalization poses to their dominance, they swiftly adopt techno-nationalist policies. Techno-nationalism highlights the limitations of globalization, particularly in intellectual property rights. The inability to control intellectual property spillovers has prompted techno-nationalists to advocate for protectionist measures in key industries. Their primary goal is to safeguard domestic industries and reduce dependence on foreign technologies. Furthermore, techno-nationalists argue that protectionist policies can intensify technological competition, leading to further advancements (Moore, 2019). Behera (2021) suggests that de-globalization may provide marginalized economies with an opportunity to progress in the technological race through enhanced regional cooperation. Dissatisfied with American hegemony, China has reshaped its foreign and economic strategy, demonstrating in a short time that de-globalization can positively influence technological progress. Instead of pursuing global integration, China prioritized regional integration. One example is signed the Regional Comprehensive Economic Partnership (RCEP). By forming a regional alliance with some of the world's most advanced economies, such as Japan and South Korea (Johannessen, 2023), China has successfully established a regional innovation ecosystem. Rapid middle-class expansion, urbanization, a highly educated workforce, a focus on STEM disciplines, and state-supported technology companies all contribute to China's growing influence in innovation. Political and economic convergence has been a core objective of the European Union. In an effort to strengthen its economic and geopolitical position, the EU has expanded over time, gradually increasing its number of member states. This expansion represents a unique experiment that has allowed researchers and policymakers to continuously monitor the adaptation and convergence of newly admitted countries with the established EU members.

Research question

In the latest EU enlargement wave, CEE (Central and Eastern European) countries joined the Union. Despite nearly two decades of EU membership (18 years for Bulgaria and Romania, 11 years for Croatia), these countries have struggled to fully integrate. Cavallaro & Villani (2021) argue that older EU member states and CEE countries are not on the same convergence trajectory. Their conclusion is supported by evidence of clustering in aggregate and sectoral productivity growth. Sala-i-Martin & Barro (1995) describe this phenomenon as "Club Convergence." The transformation efforts undertaken by CEE countries during their transition period were substantial. However, institutional and social legacies remained deeply rooted, hindering more profound systemic changes. Outdated infrastructure allowed for some technological catch-up, but also limited long-term progress (Gorynia et al., 2019). Privatization, instead of accelerating technological advancement, contributed to rapid deindustrialization (Stojčić & Aralica, 2017). At the beginning of the transition period, high expectations were placed on the CEE countries' education systems. However, their heavily concentrated

technological focus discouraged foreign investors (Dominguez Lacasa & Giebler, 2014; Lacasa et al., 2017). Additionally, a lack of experience in innovation commercialization further deterred foreign innovators. Instead of recognizing the potential of CEE countries, early transition phases were marked by investments in low-value-added production (Kriaucioniene & Ragauskas, 2008), which still dominates the region today. The lack of investment in advanced technologies has hindered the development of absorptive capacity, increasing the risk of these countries being trapped in a cycle of low-value-added production. The 2008 financial crisis posed additional challenges to innovation capacity development. While innovation activities worldwide were affected, the repercussions were far more prolonged in developing economies, including CEE countries. Reduced investment activity, particularly in the private sector, slowed the development of innovation capacity, raising concerns about the speed of innovation ecosystem convergence.

Nevertheless, isolating an innovation ecosystem in today's world is nearly impossible. The speed of innovation development, the unstoppable flow of knowledge, and high digital literacy levels ensure that CEE countries remain engaged in the global innovation race (Audi et al., 2022). Strong foundations in basic research and significantly lower labor costs present opportunities for investment in early-stage research institutions (Goldberg et al., 2011). This enables the transfer of high-quality technology, helping CEE countries remain on a convergence trajectory with more developed EU members. With nearly 20% of the EU population residing in CEE countries, their political and economic convergence is a priority for the EU. Over the past decade, efforts have intensified as Europe struggles to keep pace in innovation and technology with global leaders like the U.S. and China. Addressing disparities in innovation capacity within EU member states is critical, as failure to do so could further weaken the EU's global standing (Wieser et al, 2024). Consequently, substantial EU initiatives and funds (e.g., Horizon Europe, European Structural and Investment Funds, Digital Europe Programme) have been allocated to accelerate convergence. Thus, this paper seeks to answer this research question:

Have CEE countries, despite their economic lag, successfully integrated into the innovation ecosystem of more developed EU member states, or they stay trapped in innovation ecosystem of CEE countries?

Methodology

To assess the success of integration, this study analyzes international scientific collaboration of CEE countries (Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Bulgaria, Croatia, Romania, Estonia, and the Czech Republic). This paper will closely observe and compare how CEE countries cooperate with other EU members and how they collaborate among themselves. Since the focus of this study is on the convergence of innovation ecosystems within the EU, the analysis exclusively considers collaboration among the 27 EU member states, excluding any partnerships between CEE countries and non-EU countries. Two indicators were used to determine the degree of integration into the EU innovation ecosystem. First is international academic collaboration, measured by the number of joint scientific publications each CEE country has produced with the remaining 26 EU member states. Second is international patent collaboration, measured by the number of joint patent applications of inventors from each CEE country and the remaining 26 EU member states filed at the European Patent Office (EPO). According to the numerous literature (Manual, 2009; Griliches, 1990; Dominguez Lacasa & Giebler, 2014; Evangelista et al, 2001; Kou et al, 2016; Wolszczak-Derlacz, 2017, etc), these

two indicators present two most important intermediary output of R&D process which presents output of basic, applied or experimental research. Perfect measure for assessing overall innovation activity does not exist, however, these two measures combined presents a good proxy for overall innovation activities. Thus, international patent and S&T papers collaboration should present good proxy for overall inventive collaboration (OECD, 2009). For additional exploration of innovation ecosystem regionalization, comparison of dominant technological fields within CEE countries was done. Comparison was done on OECD standardized technological fields (Biotechnology, Nanotechnology, Medical Technology, ICT, AI Technology, Pharmaceuticals) in a period from 2000 to 2020. The data sources for this study were extracted from the OECD database. The OECD indicator for international academic collaboration provides data from 2008 to 2022. Due to practical constraints and space limitations, the analysis presents results for three key years: 2008, 2015, and 2022. The OECD indicator for patent collaboration provides data from 2001 to 2020. Given the length of the patenting cycle (3–5 years) and space constraints, the analysis focuses on five key years: 2001, 2005, 2010, 2015, and 2020. To analyze and visualize international collaboration networks, the VOSviewer software was used.

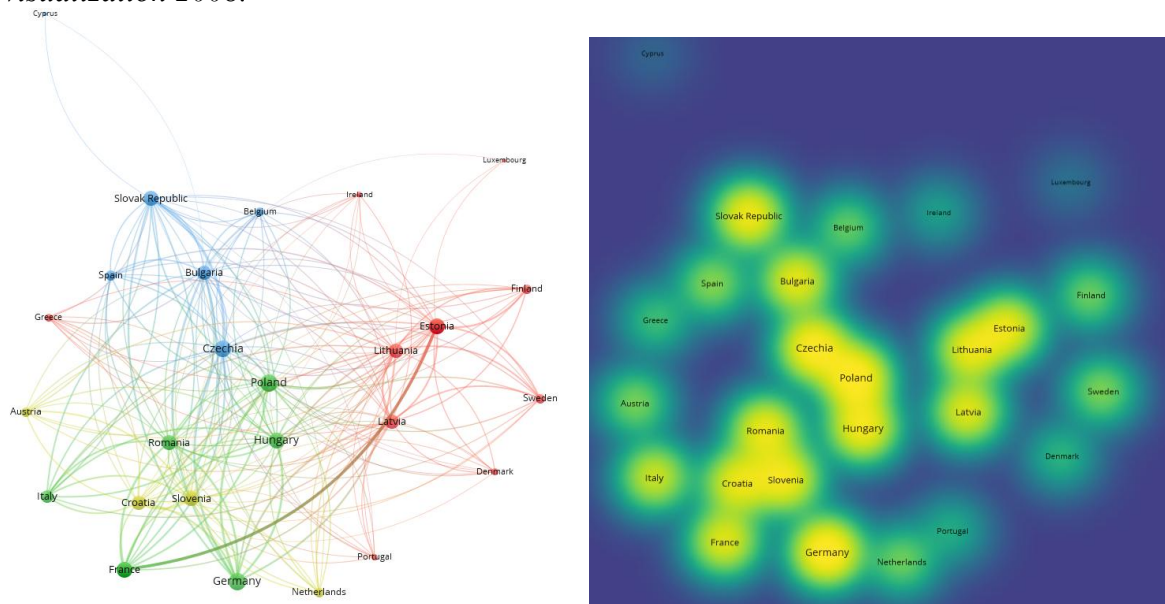
Analysis of results - Academic Collaboration

The results of the bibliometric analysis are presented below. The analysis of international academic collaboration in 2008 indicates that CEE countries were divided into four clusters, each representing a small innovation ecosystem with strong internal collaboration and shared preferences for partnerships with other EU countries.

Estonia, Latvia, and Lithuania formed the first cluster, primarily collaborating with Denmark, Finland, Greece, Ireland, Luxembourg, Portugal, and Sweden while maintaining cooperation with other countries. Hungary, Poland, and Romania constituted the second cluster, focusing on academic ties with France, Germany, and Italy alongside their internal collaborations. The third cluster included Bulgaria, the Czech Republic, and Slovakia, which showed a preference for working with Belgium, Cyprus, and Spain. Finally, Croatia and Slovenia made up the fourth cluster, with their academic collaboration primarily directed toward Austria and the Netherlands. These divisions suggest that, while CEE countries engaged in broader EU collaborations, they maintained distinct regional research networks. The analysis of international academic collaboration in 2015 also identified four clusters, though some shifts in groupings were observed. Bulgaria, Croatia, Estonia, and Lithuania formed the first cluster, primarily collaborating with Belgium, Cyprus, Finland, Greece, Ireland, Portugal, and Sweden while maintaining broader academic connections. Hungary, Poland, and Romania remained in the second cluster, continuing their established partnerships with France, Germany, and Italy. The third cluster consisted of the Czech Republic, Slovakia, and Slovenia, which favored collaboration with Austria, the Netherlands, and Spain. Meanwhile, Latvia emerged as a separate entity in the fourth cluster, demonstrating a distinctive collaboration pattern with Denmark, Luxembourg, and Malta. These changes suggest a gradual evolution in the research networks of CEE countries while still maintaining regional academic ties. By 2022, the analysis once again identified four clusters, reflecting a continued evolution of academic partnerships among CEE countries. Bulgaria, Croatia, Latvia, and Lithuania formed the first cluster, primarily collaborating with Cyprus, Denmark, Greece, Ireland, Malta, and Portugal while maintaining connections with other EU partners. Hungary, Poland, and Romania remained in the second cluster, preserving their strong academic ties with France, Germany, Italy, and Spain. The third cluster included the Czech Republic, Slovakia, and Slovenia, which focused on partnerships with Austria, the Netherlands, and Luxembourg. Estonia emerged as a distinct

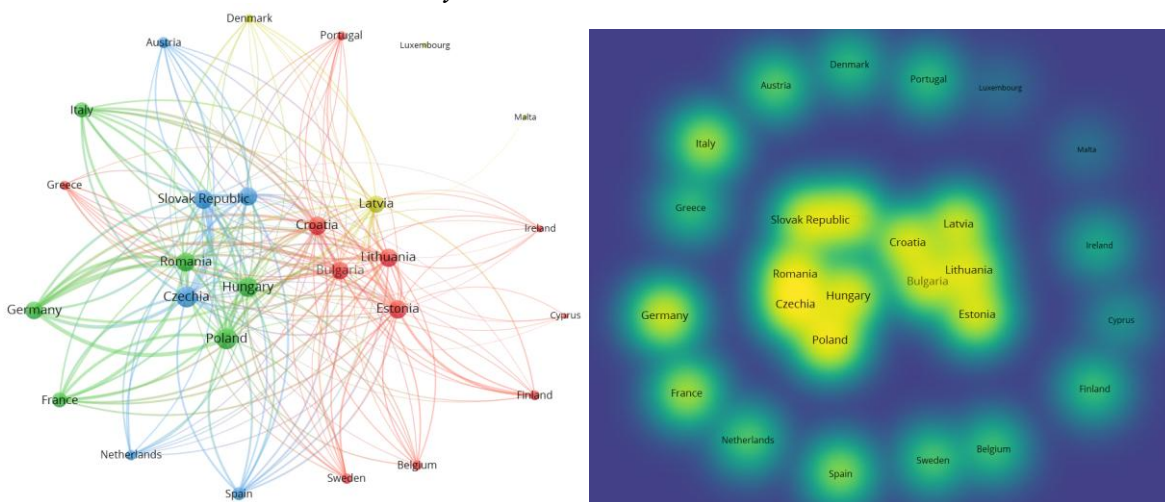
entity in the fourth cluster, demonstrating its strongest collaboration with Belgium, Finland, and Sweden. These findings suggest a dynamic but persistent pattern of regional academic ecosystems within the broader EU research network.

Figure 1: CEE countries international academic collaboration - network and density visualization 2008.



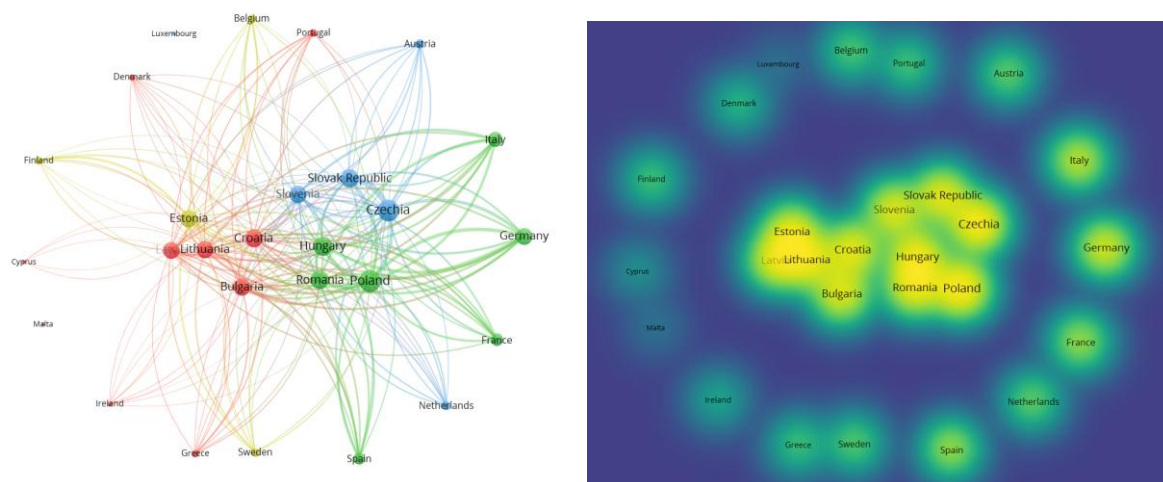
Source: Authors work, VOSView

Figure 2: CEE countries international academic collaboration - network and density visualization - network and density visualization 2015



Source: Authors work, VOSView

Figure 3: CEE countries international academic collaboration - network and density visualization 2022



Source: Authors work, VOSView

Analysis of result - Patent Collaboration

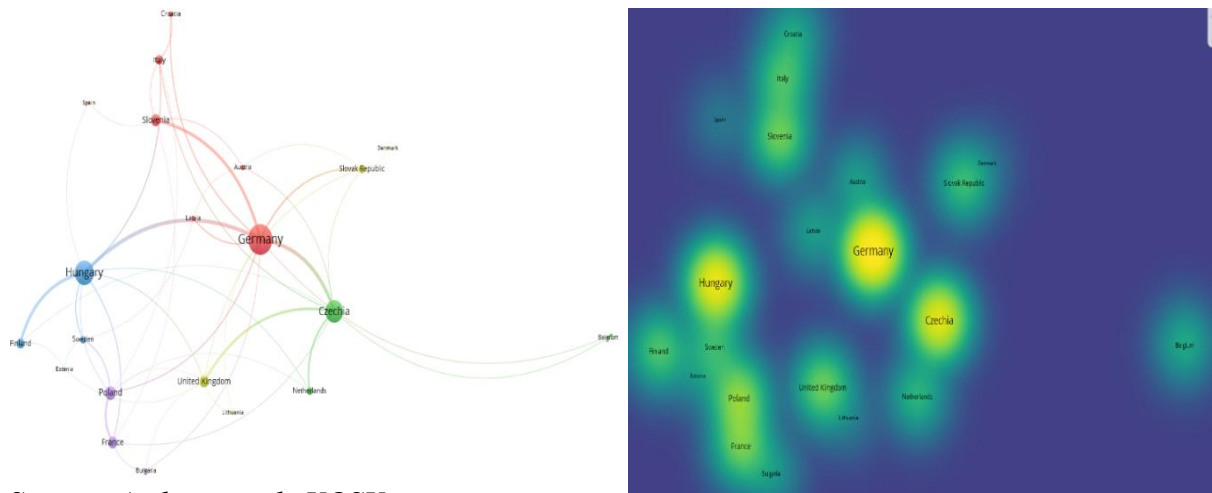
The analysis of patent collaboration highlights the evolving trends in international innovation partnerships within the CEE region over the past two decades. In 2001 (Figure 4), patent activity in CEE countries was relatively low, and collaboration with foreign innovators was an even rarer occurrence. The number of patent partnerships within the CEE region and with other EU countries remained in single digits.

Almost all CEE countries, except Slovakia and Poland, had no recorded collaboration with other CEE nations, as their international patent activity was primarily linked to other EU member states, particularly Germany, France, and the United Kingdom). The most active patent locations in the region were Hungary and the Czech Republic, with Germany being the dominant international collaboration partner for all CEE countries. By 2005 (Figure 5), international patent collaboration among CEE countries showed a noticeable shift. While still relatively low, all CEE countries, except Romania, had established at least one collaboration within the region. However, international patenting activity remained strongly tied to major EU member states, particularly Germany, France, and the UK. The most patent-active locations were Hungary, the Czech Republic, and Poland, with Germany continuing to be the most important partner for international collaboration across the region. The year 2010 (Figure 6) marked a significant increase in Poland's international patent activity. Collaboration between CEE countries continued to grow, while Germany remained the leading partner for all regional innovators. New cross-border partnerships also emerged, such as those between Estonia and Sweden, Poland and Denmark, Hungary and France, and Poland and the UK, reflecting the gradual expansion of CEE innovation networks beyond Germany. In 2015 (Figure 7), international patent activity among CEE innovators continued to rise, although no drastic changes in numbers were observed. The most patent-active CEE countries were Poland, the Czech Republic, and Hungary. Poland maintained Germany as its primary innovation partner, while also strengthening ties with France. The Czech Republic's international collaborations included Germany, France, Slovakia, and Austria, while Hungary expanded its partnerships with Germany and the UK. Despite these developments, Germany remained the most significant partner for all CEE innovators. By 2020 (Figure 8), Poland had emerged as the leader in international patent collaboration within the CEE region. Polish innovators recorded the

highest number of partnerships, with Germany remaining their top collaborator, followed by France, Finland, Sweden, and the UK. The Czech Republic also played a key role in international patent activity, primarily partnering with Germany and Slovakia. Hungary ranked third in terms of international collaboration, forming strong patent partnerships with Germany, Sweden, and Austria. Despite the diversification of innovation networks, Germany continued to be the dominant patent partner for all CEE countries.

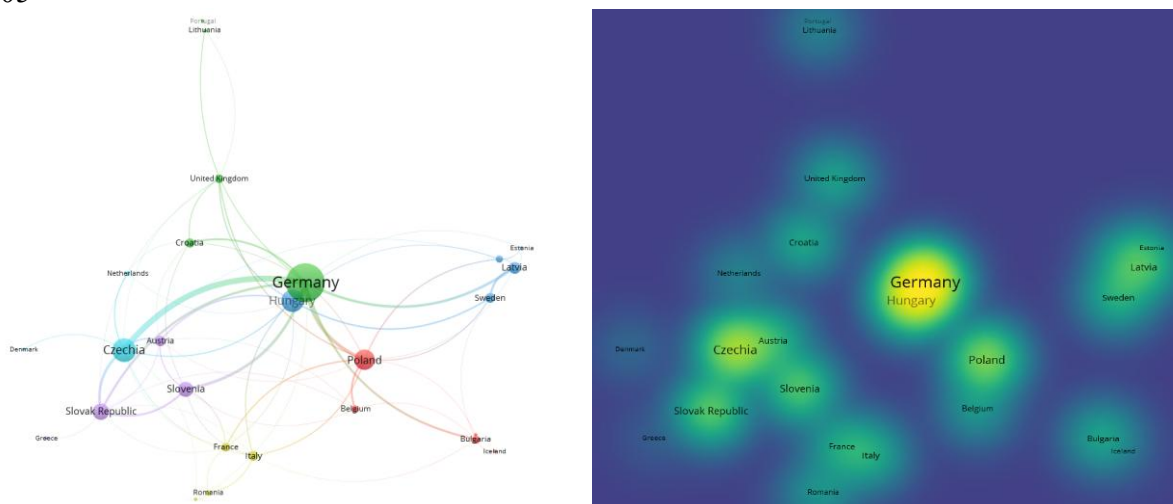
The analysis indicates a gradual but ongoing process of innovation ecosystem integration within the European Union, with Poland, the Czech Republic, and Hungary leading the way in patent activity.

Figure 4: CEE countries international patent collaboration - network and density visualisation 2001



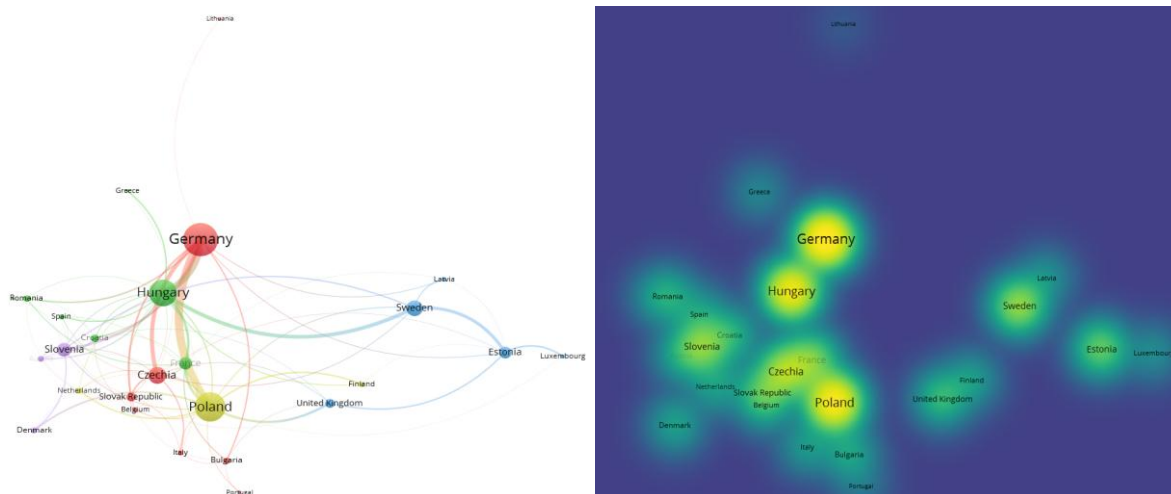
Source: Authors work, VOSView

Figure 5: CEE countries international patent collaboration - network and density visualisation 2005



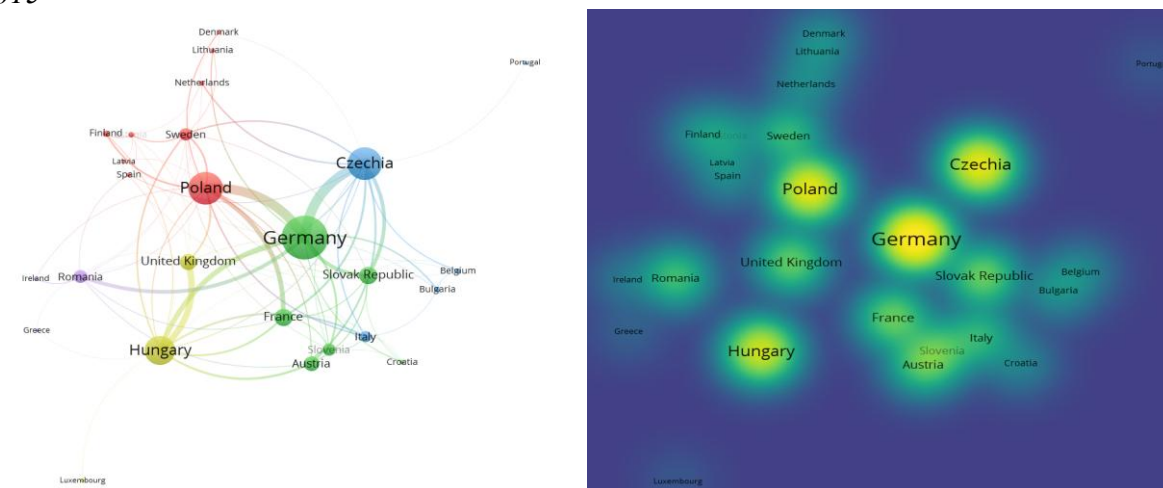
Source: Authors work, VOSView

Figure 6: CEE countries international patent collaboration - network and density visualisation 2010



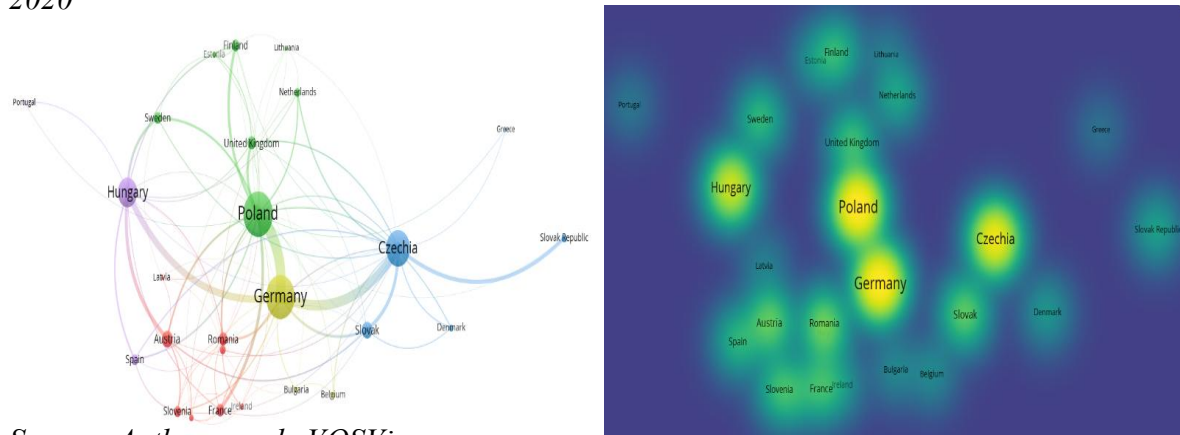
Source: Authors work, VOSView

Figure 7: CEE countries international patent collaboration - network and density visualisation 2015



Source: Authors work, VOSView

Figure 8: CEE countries international patent collaboration - network and density visualisation 2020



Source: Authors work, VOSView

Analysis of results – technological specialization

To assess innovation ecosystem convergence, we examined the specialization of CEE countries in various technological fields. The findings are presented in Figure 9. This figure shows stacked bar charts for countries of CEE region, each illustrating the share of patents in different technology fields (Biotechnology, Nanotechnology, Medical Technology, ICT, AI Technology, Pharmaceuticals) from 2000 to 2020. Technological fields are created according to OECD standard. Each bar sums to 100%, so the relative heights of the colored segments show how each technology field's proportion changes over time within each country. Overall, the figure provides a quick comparative view of how technology specialization in these CEE countries has evolved over two decades.

ICT dominates Czechia's technology mix across most years, with only minor fluctuations in the mid-2010s. Biotechnology and pharmaceuticals maintain smaller shares, highlighting a continued focus on digital and information-based sectors. Hungary shows a steady prominence of ICT and pharmaceuticals, with smaller but noticeable shares of other fields. AI technology appears to expand slightly in the later period, suggesting a gradual shift toward advanced digital research. Estonia exhibits a strong and growing ICT segment throughout, consistent with its reputation for digital innovation. Biotechnology and medical technology remain comparatively small, underscoring a less pronounced emphasis on life-science sectors. Latvia's chart indicates a gradual rise in ICT, though less steep than Estonia's. Pharmaceuticals and biotechnology keep relatively modest shares, hinting at a moderately diverse but not heavily life-science-oriented portfolio. Lithuania sees an increasing ICT share from the mid-2000s onward, coupled with moderate levels of other fields such as biotechnology. Overall, no single sector fully dominates by 2020, pointing to a somewhat balanced technology specialization. Poland's distribution is fairly balanced, with ICT clearly taking the largest slice in most years. Pharmaceuticals and AI technology make gradual gains in the latter half, broadening the country's innovation landscape. Slovakia's ICT segment grows notably later in the timeline, while other advanced technologies like nanotech or AI appear in smaller proportions. Biotechnology and pharmaceuticals remain limited, indicating a stronger tilt toward digital and engineering-focused fields. Slovenia maintains a significant ICT share, with occasional fluctuations in AI and other technology areas over time. Biotechnology remains comparatively smaller, suggesting a lesser focus on life-science research relative to digital innovation. Bulgaria shows increasing emphasis on ICT over the years, while AI and pharmaceuticals are present but at lower levels. Biotechnology and medical technology comprise smaller fractions, underscoring a continued lean toward information-based specializations. Croatia's reliance on ICT becomes more pronounced from around 2005 onward, though earlier years feature a broader mix of technologies. Pharmaceuticals and AI technology hold modest but steady shares, reflecting some diversification without eclipsing ICT. Romania sees a marked uptick in ICT and AI technology in the later years, surpassing the smaller biotech and pharmaceutical segments. This trend indicates a shift toward digital fields as a key pillar of the country's evolving tech specialization.

Figure 9: CEE technology specialization



Source: Authors work, OECD database (<https://data-explorer.oecd.org/>)

Discussion

The presented results provide insights into the research question, indicating that integration into the EU innovation ecosystem is significantly stronger than integration within the regional innovation ecosystem of other CEE countries. Both academic and patent collaborations demonstrate that CEE countries more frequently choose partners from the more developed EU nations rather than forming a closely-knit regional network. This confirms Dobbins & Kwiek (2017) finding. According to them, scientists collaborate internationally when it enhances their academic prestige, scientific recognition, and access to research funding. Above criteria are still not reachable in CEE countries, thus, they turn more toward developed EU countries. Illusion about formation of regional innovation ecosystem were additionally scattered with findings on technological specialization among CEE countries. The observed data indicate no common pattern of technological specialization, suggesting that each country has pursued an independent strategy over time. Instead of aligning toward a unified regional innovation framework, CEE countries have developed their own distinct technological priorities, reflecting national-level innovation policies rather than a collective regional approach. This suggests that regional economic integration has not been accompanied by innovation ecosystem integration.

Innovation, by nature, transcends borders. The rapid advancement of information technology has facilitated global knowledge exchange, ensuring that countries are not limited to collaborating only with their immediate neighbors (Cuervo-Cazurra et al., 2020). During the era of centrally planned economies, CEE countries primarily engaged in international business and innovation activities within other planned economies. Innovation activities were centrally directed and designed to serve domestic markets and those of partner countries within the system (Radošević & Yoruk, 2018). These historical ties are still visible today, with around 30% of international academic collaboration in CEE countries occurring within the region according to OECD database. Significant deviation from this average was observed in the case of the Slovak Republic. Over a fifteen-year period, international academic collaboration with CEE countries has grown, reaching 48% in 2022. The majority goes toward collaboration with the Czech Republic. This confirms findings of Kwiek (2021). According to him, this is logical sequences, given that they share a common history, a similar language and culture, and the Czech Republic is significantly more advanced. However, with political constraints lifted, CEE countries are now free to choose research and innovation partners from around the world. Aware of their inherited lack of experience, competitiveness, and distance from technological frontier, they prioritize collaboration with partners from advanced economies. Additionally, they sought out partnerships with countries possessing sizable markets, aiming to elevate their position on the global innovation stage. Research indicates that there were signs of regionalization, initially stronger at the start of the transition, but these have weakened over time. This goes in line with Wozniak-Jechorek, B. (2024) historical overview of transition process. This is most evident in the case of the Baltic countries, which tend to work closely together. However, unlike the clusters formed under the centralized decision-making system, contemporary clusters appear to have freed themselves from special influences and political heritage, and are now shaped by economic and strategic factors. In the case of the Baltic nations (Estonia, Latvia, and Lithuania), they identified their most natural partnerships with Sweden, Finland, and Denmark. This is supported with findings of Chasovsky (2020). In his research Baltic CEE countries still reflect “neighborhood effect”, however, this time they lean toward collaboration with geographically close “old EU members”.

Academic and industrial partnerships are two primary pathways that facilitate international scientific collaboration. Industrial scientific collaboration is usually measured with patent collaboration. Due to an outdated infrastructure, lack of product development and commercialization experience, competitiveness and limited R&D capacity, patent activity in CEE countries heavily relies on foreign capital, multinational companies (Radošević 2002). The most developed EU countries, such as Germany, Austria, Italy, and the Netherlands, UK, have been the biggest investors in CEE economies (Eurostat, 2025). They were the first to strengthen R&D capacities in CEE countries. Their multinational corporations (MNCs) provide a platform for local researchers to integrate into global scientific networks. They offer the only access to cutting-edge technologies and knowledge (Holm et al, 2019). The second pathway is academic collaboration. In CEE nations, public ownership dominates the academic sector. This implies that most of the progress in academic research hinges on government funding and EU programs (Peng & Heath, 1996). According to Zhou-Lv (2015), national policies focus on expanding and improving quality of academic output, and visibility through cooperation with researchers from countries that have higher levels of development. The limited representation of CEE academic institutions in top-ranked universities hinders the region’s ability to develop stronger academic collaboration internally. The European Union is likewise pivotal in promoting research partnerships between CEE scholars and more advanced member nations. To balance innovation capacities across the EU, the European Commission has prioritized supporting the development of innovation ecosystems in less developed member states. This is

evident in the numerous EU funding programs and initiatives, such as Horizon Europe, the European Structural and Investment Funds, and the Digital Europe Programme, which are designed to accelerate convergence and reduce disparities within the EU innovation landscape. This goes in line with findings of Wieser et al (2024) who emphasizes the need to strengthen Central and Eastern Europe in order to strengthen Europe.

Conclusion

Investments in R&D have always been considered a key factor in enhancing an economy's competitiveness. Since the mid-20th century, the growing trend of globalization has underscored the importance of participating in the global innovation race and keeping pace with the latest developments. In this way, globalization has taken center stage and proven essential for spurring innovation revolutions. However, the strong global polarization of political and economic power has left many stakeholders dissatisfied. Over the past two decades, dissatisfaction with hegemonic power has spread, leading many countries to view disintegration or regionalization as a means of maintaining competitiveness. The CEE countries joined the market economy relatively late and, in the midst of rapid globalization, quickly began to experience de-globalizing trends as well. They faced these confusing signals when entering the EU. As a result, CEE countries never fully integrated, instead experiencing a slight divergence from other, more developed member states. A shared historical heritage has led to greater regional closeness; however, economic, social, and political convergence has not necessarily been accompanied by convergence in innovation ecosystems. This reflects the specific nature of innovation processes—namely, informatization, digitalization, intangibility, rapid innovation cycles, and dependence on human capital—all of which enable smaller players to participate in the global market. The findings of this research indicate that, despite their evident economic lag, CEE countries have not formed a distinct regional innovation ecosystem. Instead, they have effectively integrated into the innovation ecosystem of the more developed EU member states.

Determining their position within the EU innovation ecosystem is crucial not only for CEE countries but for other EU members as well. By examining both current positions and historical trends, CEE policymakers can more precisely shape the intensity and direction of their innovation policies. At the same time, these findings may encourage EU policymakers to devote additional effort to integrating newer member states. Addressing disparities in innovation capacity among EU member states is vital, as such imbalances could further weaken the EU's already precarious standing in the global innovation race. The main shortcoming of the work is manifested in the lack of data for international academic collaboration. Unfortunately, the database used contains only data from 2008 onwards, whereas the available data for patent collaboration date from 2001. This prevents us from comparing these two indicators in the period from 2001 to 2008 and detecting any potential deviations from the trends in the subsequent period. Furthermore, despite international patent and academic collaboration being good proxy for overall international innovation activity, we must be aware of the imperfections of this indicator. Future research might explore further avenues for integrating CEE countries into the global innovation ecosystem. In addition, identifying alliances with specific countries could yield the greatest benefits for CEE countries.

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EXPLORING HEATFLATION: HOW CLIMATE CHANGE CONTRIBUTES TO INFLATIONARY PRESSURES

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Abstract

Purpose of the research is to explore the concept of heatflation; rising food prices caused by extreme heat. The paper's unique contribution is in the use of quantile regression analysis to estimate the impact of temperature change on inflation while accounting for latitude and the income level of the country. This research initially employs random effects, fixed effects, and pooled OLS models to estimate the main determinants of inflation. After that, stationarity testing is used to verify the validity of the data, Granger causality to investigate the directional relationship between temperature and inflation and impulse response functions to observe the dynamic effects of temperature shocks on inflation. Finally, the models of quantile regression are estimated to investigate the effects of temperature changes on inflation at various distributional levels. Research findings indicate that there is an adverse effects of temperature change on inflation worldwide, with low-income countries closer to equator having greater negative consequences of global climate change, particularly in the last two decades. The findings suggest that adaptive policies, including investments in climate-resilient infrastructure and renewable energy, are necessary to mitigate these effects. Future research should explore sector-specific impacts and long-term consequences.

Keywords: climate change, heatflation, panel data, quantile regression

JEL classification: C21, C23, E31.

Introduction

The past few decades have seen one of the fastest periods of global warming in recorded history, with global temperatures rising at an unprecedented rate. Unquestionably, human activity has caused global warming, with the global surface temperature rising by 1.1°C between 2011 and 2020, mostly due to greenhouse gas emissions, IPCC (2023). Climate change has a major impact on social and economic development worldwide and presents several issues outside of the environmental sphere, Kishan (2024). A comprehensive approach that emphasizes the dangers to long-term growth and the ways in which climate influences various industries and areas is necessary to comprehend the future economic effects of climate change. Without further climate action, simulations indicate that global GDP might drop by 1% to 3.3% by 2060, and

by 2100, it could drop by 2% to 10%, particularly in vulnerable countries like Asia and Africa where climate impacts could be especially severe, OECD (2015).

The growing consequences of climate change have attracted a lot of attention, especially in relation to how they affect inflation, a key macroeconomic variable that affects central banks' monetary policy and the state of a country's economy. More and more academics are aware of how temperature variations brought on by climate shocks impact inflation rates, which in turn have an impact on the well-being and living standards of society. According to Cottarelli et al. (1998) major monetary determinants of inflation are fiscal deficits, relative price changes, central bank independence, the exchange rate regime and the degree of price liberalization.

This paper examines the phenomenon known as "heatflation," which is the result of rising global temperatures brought on by climate change and the ensuing influence on food prices from natural disasters like floods and droughts. The paper aims to investigate the ways in which global inflationary pressures are exacerbated by climate change. The observed period spans from 1960 to 2023, and all countries and dependent territories worldwide will be included if data is available. Inflation, measured using the Consumer Price Index (CPI), is the dependent variable in the model, while other variables serve as independent variables. Initially 12 macroeconomic variables, based on a comprehensive literature review, were chosen in the model as explanatory variables. Those are broad money, electric power consumption, energy use, official exchange rate, GDP per capita, central government debt, imports of goods and services, latitude, geopolitical risk index, surface temperature change, unemployment and urban population. Some variables in the analysis were expressed in levels while others in percentages.

The preliminary analysis revealed significant data issues related to missing data problem which represented a major limitation of the analysis. As a result, this led to a significant number of non-significant variables in the regression models. Therefore, variables included in the analysis are inflation (INF), annual surface temperature change (TEMP), GDP per capita, PPP, (GDPPP) and countries' latitude (LATITUDE), where GDP per capita, temperature change and latitude are explanatory variables in the model. Hypothesis of the paper states the following:

H1... Low-income countries, located at lower latitudes, are experiencing higher levels of inflation due to global warming

The hypothesis of the paper brings into connection changes in temperatures, due to global warming, with changes in inflation rates, primarily from rises in food prices and costs of energy, with low-income countries, settled on lower latitudes. Temperature increases have unequal macroeconomic impacts, disproportionately impacting hotter countries, especially those with lower incomes. According to Acevedo et al. (2018), rising temperatures in these regions have a short- and medium-term detrimental effect on per capita output by lowering agricultural yields, labour productivity, investment, and public health. This paper's contribution is the use of quantile regression analysis to estimate how temperature changes affect inflation while accounting for latitude and the income level of the country. Methods used in the research are POLS, FE, RE and quantile regression models. It is expected that the results will show the adverse negative impact of rising temperatures, particularly in low-income, hotter nations nearer the equator.

Paper is structured into following chapters: introduction, literature review, data and methodology section, analysis and discussion part and conclusions. The introduction highlights the paper's primary objective and contributions. Data sources and the methodology are

described in detail in the data and methodology section. Main limitations of the analysis are also explained in this section. The paper's analysis and discussion chapter presents and expands on its key findings. Final chapter concludes.

Literature review

In order to examine how climate-related natural disasters affect inflation and economic growth in a wide range of countries, in the period between 1970 and 2020, Cevik & Jalles (2023) used the local projection approach. The findings point out to strong, albeit distinct, responses from GDP growth and inflation to different kinds of climate shocks, with considerable differences between advanced and developing nations, according to fiscal capacity and income levels. Using monthly data from 186 countries over a 23-year period, Chadwick & Saygili (2024) examined the relationship between weather factors including temperature and precipitation and the food price inflation. The findings indicate that while precipitation exhibits a positive correlation with inflation, temperature tends to have a negative immediate effect. The cumulative inflationary impact of a 1°C increase in temperature can reach up to 0.6 percentage points, depending on the inflation quantile and methodological approach. By integrating monthly production growth and inflation data with high-frequency weather data, Ciccarelli et al. (2023) use Bayesian Vector Autoregressions to investigate how weather shocks affect inflation components in the four biggest economies in the euro area. The results show notable seasonal variations and country-specific asymmetries in inflation responses, with higher temperature variability aggravating inflation rates beyond changes in average temperatures and temperature increases driving inflation in summer and fall, especially in warmer countries.

Using monthly time series data and an ARDL model, Jackson et al. (2023) examine the factors that influence inflation in Sierra Leone between 2010 and 2021. The findings reveal that while all variables except real GDP and exchange rate have substantial effects in the short term, the exchange rate, real GDP, fiscal balance, currency in circulation and loan rate have a significant impact on inflation in the long term. Khan et al. (2007) use an econometric technique with data from 1972-73 to 2005-06 period to investigate the main causes of inflation in Pakistan. The results showed that growing import prices, private sector lending and adaptive expectations were the main causes of inflation, with fiscal policy having a negligible impact. Erdogan et al. use data from 2008 to 2020 and non-linear, quantile-based approach to investigate how climate change affects food prices in Nigeria. Indicating the "heatflation" phenomenon, in which rising temperatures and agricultural difficulties fuel food price inflation, the results show a strong time and frequency-based dependence between food prices and temperature. With rising temperatures consistently driving higher food prices and general inflation across income levels, especially in low-latitude locations and during high-latitude summers, climate change poses a threat to price stability. Global food and headline inflation might increase by 0.92 to 3.23 percentage points per year by 2035, according to projections. Extreme occurrences like the summer heat in Europe in 2022 are predicted to make these effects worse by 30–50%, Kotz et al. (2024).

Using a VAR model, Kousar et al. (2022) investigate the factors that contributed to energy inflation in Pakistan between 1972 and 2021, with particular attention to the effects of the twin deficit, urbanization, climatic change, energy output, and exchange rates. According to the findings, energy inflation is largely driven by the twin deficit and exchange rate, with the deficit having a greater effect on oil prices than electricity. In the long term, urbanization, climate change, and the production of oil and gas have a significant impact on electricity prices,

highlighting the need for targeted policies to reduce energy inflation. Kunawotor et al. (2022) examine how inflation is affected by climate change, particularly extreme weather events, and how this affects monetary policy in Africa between 1990 and 2017. The findings show that major weather-related events, like droughts and floods, significantly contribute to the inflation of food prices, mainly by affecting agricultural output. This emphasizes the necessity for monetary policymakers to include supply shocks from climate events in their plans. Using data from 1995 to 2021, Li et al. (2023) examine how temperature changes affect inflation and discovers a steady positive correlation between rising temperatures and inflation. With GDP per capita modulating the link in a nonlinear approach and exposing differences in inflationary impulses depending on economic conditions, the study identifies energy consumption as a major factor driving this effect. While oil prices and imported inflation drive overall inflation, supply shocks, notably rainfall unpredictability and imported food price inflation, have a significant impact on food inflation in Eastern and Southern African nations. The region's susceptibility to severe weather, despite of current climate policy, emphasizes the necessity of implementing renewable energy sources and better irrigation techniques to lessen these effects, Odongo et al. (2022). Policy implications are drastically changed when temperature impacts on GDP growth rather than levels are modeled. Variations in consumption are contingent on future temperature change and impact uncertainties, Pindyck (2011). According to Yen & Siok (2015), while money supply, imports, and GDP growth are important in the short term, GDP growth and imports have a considerable long-term impact on inflation in low-inflation nations. Money supply, national spending, and GDP growth are the main drivers of long-term inflation in high-inflation nations; however, short-term inflation is not greatly impacted by any of these factors.

Data and methods

The primary variable in this study is inflation, measured as the average annual percentage change in consumer prices. Specifically, inflation is calculated using the Consumer Price Index (CPI), which reflects the annual percentage change in the cost to the average consumer of acquiring a standardized basket of goods and services. The Laspeyres index method was used to calculate the value of this basket (World Bank, 2024). Inflation data was collected for all countries and dependencies worldwide from 1960 to 2023. However, data availability varied across countries and years. In the analysis both terms countries and countries and dependencies will be used interchangeably. In 1960, inflation data was available for 63 countries. By 1970, this number had increased to 92 countries, and by 1980, it had reached 106 countries. In 1990, inflation data was available for 131 countries, increasing to 163 countries in 2000 and 188 countries in 2010. The maximum coverage was achieved in 2011, with inflation data available for 192 countries. Since 2011, the number of countries with available inflation data has steadily declined. In 2020 and 2021, data was available for 171 countries, dropping to 169 countries in 2022 and 154 countries in 2023. Additionally, no inflation data is available for 24 countries throughout the entire study period, suggesting that missing data issues are likely to arise in the analysis. The study includes a set of 12 explanatory variables in addition to inflation, each with specific definitions and time periods of coverage. These variables provide a comprehensive dataset to analyse the relationship between inflation and various economic, environmental, and demographic factors across countries and time periods. The complete list of variables is provided in Table 1.

Table 1: Complete list of observed variables

Code	Description	Period	Source
INF	Inflation, consumer prices, annual %	1960-2023	World Bank (2024g)
BMONEY	Broad money, % of GDP	1960-2023	World Bank (2024a)
ELECTRIC	Electric power consumption, kWh per capita	1960-2019	World Bank (2024c)
ENERGY	Energy use, kg of oil equivalent per capita	1960-2015	World Bank (2024d)
EXCHRATE	Official exchange rate, LCU per US\$, period average	1960-2023	World Bank (2024h)
GDPPP	GDP per capita, PPP, current international \$	1990-2023	World Bank (2024e)
GOVDEBT	Central government debt, total, % of GDP	1989-2022	World Bank (2024b)
IMPORTS	Imports of goods and services, % of GDP	1960-2023	World Bank (2024f)
LATITUDE	Latitude	2024	Ferlet (2024)
RISKIND	Geopolitical risk index	2011-2022	Geopolitical Risk Index (2024)
TEMP	Surface temperature change, degree Celsius	1961-2023	International Monetary Fund (2024)
UNEMP	Unemployment, total, % of total labor force, modeled ILO estimate	1991-2023	World Bank (2024i)
URPOP	Urban population (% of total population)	1960-2023	World Bank (2024j)

The variable Broad money (BMONEY) represents the sum of various financial assets, including currency outside banks, demand deposits, time deposits, savings, and foreign currency deposits. This variable is expressed as a percentage of GDP. The variable Electric power consumption (ELECTRIC) reflects the average electricity consumption per person in kilowatt-hours, accounting for production losses during transmission and distribution. Similarly, the variable Energy use (ENERGY) measures the total primary energy consumption per capita in kilograms of oil equivalent. The variable Official exchange rate (EXCHRATE) indicates the average exchange rate of local currency units (LCU) relative to the U.S. dollar, calculated annually. The variable Gross domestic product (GDP) per Capita (GDPPP) is expressed in current international dollars, using the purchasing power parity (PPP) conversion factor. The variable Central government debt (GOVDEBT) is represented as a percentage of GDP and reflects the total stock of government liabilities, including both domestic and foreign obligations. The variable Imports of goods and services (IMPORTS) measures the value of all imported goods and services as a percentage of GDP. The variable Latitude (LATITUDE) represents the geographical positioning of countries in absolute terms from the equator. It is assumed that the current positioning in 2024 is consistent with previous years. The variable Geopolitical Risk Index (RISKIND) captures the level of geopolitical uncertainty and its potential impact on economic stability. The variable Surface temperature change (TEMP) measures the annual change in surface temperature, expressed in degrees Celsius, relative to a baseline climatology from 1951 to 1980. The variable Unemployment (UNEMP) represents the percentage of the total labor force that is unemployed but actively seeking work. Finally, the variable Urban Population (URPOP) reflects the percentage of the total population living in urban areas.

Despite the careful selection of variables based on a comprehensive literature review and their potential to explain variations in inflation, the preliminary analysis revealed significant data challenges. Table 1 illustrates that data availability differs across time periods for each variable. However, what Table 1 does not capture is the inconsistent and fluctuating levels of missing data across countries over different years. This poses a major limitation to the analysis and underscores the need for further research on the determinants of “heatflation” (a term that combines heat and inflation).

Due to significant issues with missing data, it has been decided that, for the purposes of this analysis, only the variables INF, TEMP, GDPPP, and LATITUDE will be used. The primary focus will be on examining the relationship between INF and TEMP. Initially, a graphical exploration of the time series development of the variables INF and TEMP will be conducted to observe trends, patterns, and potential anomalies. Following this, the correlation between the variables will be analyzed to assess the strength and direction of their linear relationship. Once these preliminary analyses are complete, the focus will shift to estimating quantile regression models. In these models, the variable INF will serve as the dependent variable, while the variables TEMP, GDPPP, and LATITUDE will be included as independent variables. The quantile regression model to be estimated can be expressed in the following formal form:

$$\begin{aligned} Q_{\tau}(INF_i | TEMP_i, GDPPP_i, LATITUDE_i) \\ = \beta_0(\tau) + \beta_1(\tau) \cdot TEMP_i + \beta_2(\tau) \cdot GDPPP_i + \beta_3(\tau) \cdot LATITUDE_i \\ + \epsilon_i(\tau) \end{aligned} \quad (1)$$

where $Q_{\tau}(INF_i | \cdot)$ represents the conditional quantile of INF at quantile τ , given the independent variables; $\beta_0(\tau)$, $\beta_1(\tau)$, $\beta_2(\tau)$, and $\beta_3(\tau)$ are the quantile-specific coefficients for the independent variables TEMP, GDPPP, and LATITUDE, respectively; $\epsilon_i(\tau)$ is the error term at quantile τ . Quantile regression estimates the mean effect of the independent variables at different quantiles (τ) of the dependent variable's distribution. By estimating the quantile regression model across different quantiles, the analysis will provide a more comprehensive understanding of how temperature impacts inflation, highlighting its differential effects on low- and high-inflation countries.

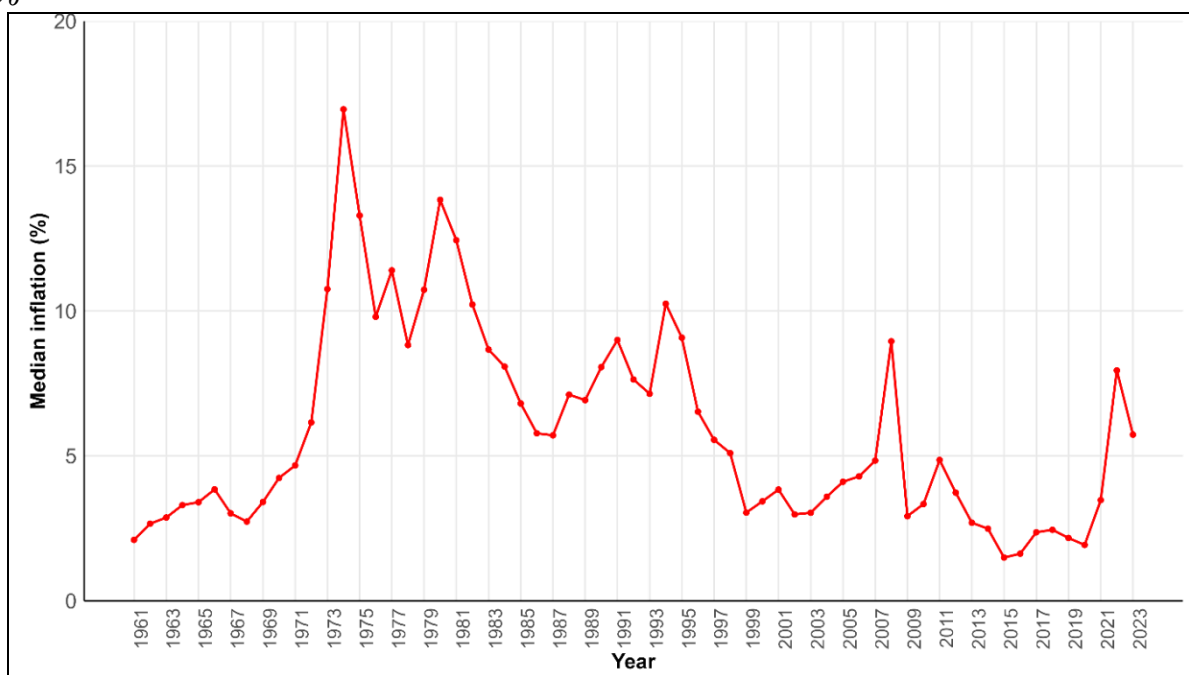
Analysis and discussion

Due to the fact that the main aim of the paper is to investigate the impact of temperature change on inflation in countries and dependencies worldwide, the analysis will focus on the variables INF and TEMP. Firstly, these variables will be described using descriptive methods.

The average inflation rate across all observed countries and dependencies for the period from 1961 to 2023 was analyzed. It is important to note that, although inflation data were available from 1960, the analysis begins in 1961 to maintain consistency with temperature change data, which were only available from that year. The findings indicate that average inflation levels were significantly lower from 1961 to the mid-1980s and from the mid-1990s to 2023 compared to the period between the mid-1980s and the mid-1990s. The highest average inflation rate was recorded in 1994, reaching 271.97% ($n = 151$ countries, standard deviation = 10.25).

Due to this spike and the pronounced inflation surges, particularly between 1984 and 1994, Figure 1 presents median inflation values for the observed countries over the period from 1961 to 2023. According to Figure 1, the general trend of median inflation has been downward since 1973, although notable spikes occurred in 1980, 1993, 2008, and 2022.

Figure 1: Median inflation in the observed countries and dependencies from 1961 to 2023, in %



Source: World Bank (2024g)

Table 2 highlights the countries with significantly higher inflation than the other countries in certain years. The listed countries had inflation values more than 3 standard deviations above the average inflation for the observed year. It should be noted that these outliers appear in the period before 1998. Therefore, it was decided to conduct the further analysis twice, based on two different time periods. The first analysis will cover the entire period for which data for the variables INF and TEMP are available, from 1961 to 2023. To eliminate the possible impact of outliers on the results, the same analysis will be conducted using data from 1998 to 2023, a period during which no outliers related to the variable INF were detected.

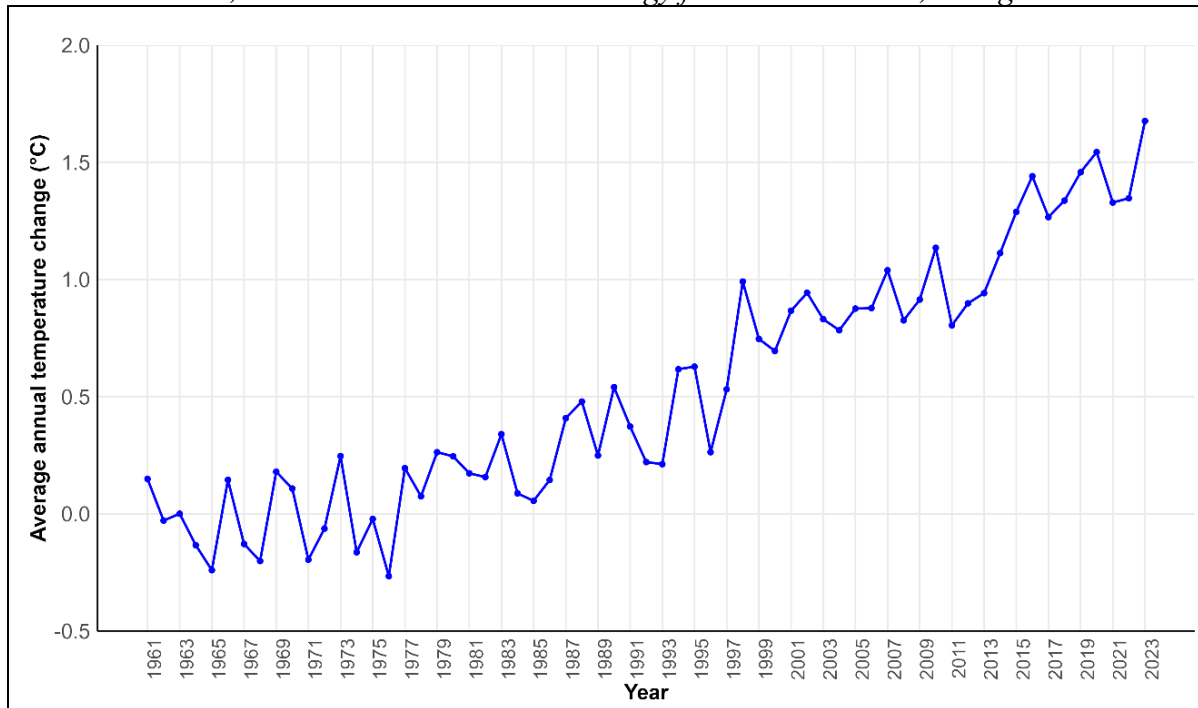
Table 2: List of countries with significantly higher inflation from 1961 to 2023

Year	Countries
1966	Indonesia (3.41)
1984	Bolivia (3.86)
1985	Bolivia (35.98)
1989	Brazil (4.32), Croatia (4.22), Peru (10.36), Slovenia (3.86)
1990	Brazil (8.97), Peru (22.88)
1991	Congo, Dem. Rep. (6.54)
1992	Congo, Dem. Rep. (12.60), Lithuania (3.06), Moldova (3.08)
1993	Angola (4.16), Azerbaijan (3.39), Belarus (3.58), Brazil (5.84), Congo (Dem. Rep.) (6.02), Croatia (4.53), Moldova (4.88), Ukraine (14.45)
1994	Armenia (10.28), Azerbaijan (5.03), Belarus (6.74), Brazil (6.30), Congo (Dem. Rep.) (72.86), Kazakhstan (5.69)
1995	Angola (8.11)
1996	Angola (12.65)
1997	Bulgaria (3.18)

Note: Standardized values of inflation are given in brackets.

Figure 2 shows the average annual surface temperature change in the observed countries from 1961 to 2023. It should be emphasized that the annual temperature change is observed relative to a baseline climatology from 1951 to 1980. Therefore, the results represent the difference between the observed year and the reference period. As a result, it was expected that there would be no significant change from 1961 until the end of the reference period. However, after 1980, particularly after 1990, a clear linear increase in the average annual temperature change is evident.

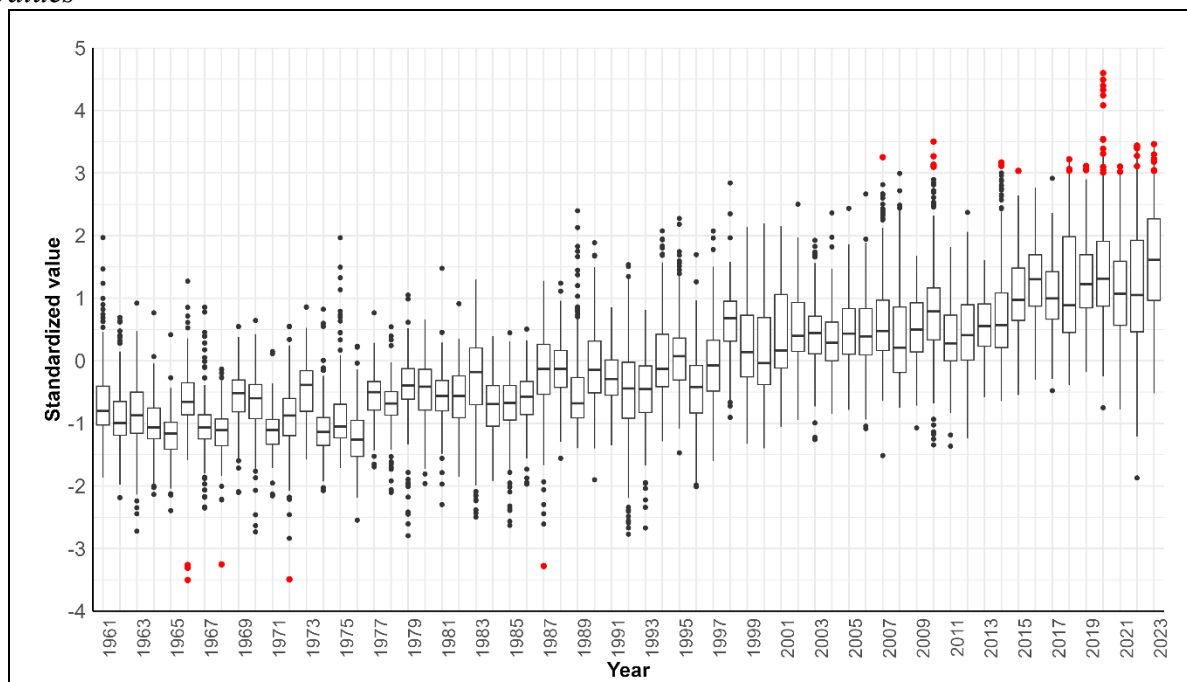
Figure 2: Average annual temperature change in surface temperature in the observed countries from 1961 to 2023, relative to a baseline climatology from 1951 to 1980, in degrees Celsius



Source: International Monetary Fund (2024)

Figure 3 shows box plots of the annual surface temperature change in the observed countries from 1961 to 2023, relative to a baseline climatology from 1951 to 1980, with countries that have significantly higher annual surface temperature changes compared to others in certain years highlighted. These countries are represented by red dots in Figure 3, and their full list is presented in Table 3. While at the beginning of the observed period there were countries with both positive and negative annual temperature changes compared to the reference period, in the last 20 years, only countries with significantly higher positive annual temperature changes are detected.

Figure 3: Box plots of annual temperature change in surface temperature in the observed countries from 1961 to 2023, relative to a baseline climatology from 1951 to 1980, standardized values



Note: Countries with standardized values of annual surface temperature change greater than 3 standard deviations from the mean for each year are highlighted with red dots.

Source: International Monetary Fund (2024)

Table 3: List of countries with significantly higher annual temperature change in surface temperature in the observed countries from 1961 to 2023, relative to a baseline climatology from 1951 to 1980

Year	Countries
1966	Finland (-3.50), Norway (-3.26), Sweden (-3.31)
1968	Finland (-3.25)
1972	Canada (-3.49)
1987	Finland (-3.28)
2007	Mongolia (3.25)
2010	Armenia (3.27), Canada (3.50), Iraq (3.13), Jordan (3.10)
2014	Denmark (3.11), Sweden (3.17)
2015	Finland (3.03)
2018	Armenia (3.22), Czechia (3.06), Turkiye (3.04)
2019	Belarus (3.11), Lithuania (3.05), Poland (3.06)
2020	Belarus (4.33), Denmark (3.05), Estonia (4.49), Finland (4.08), Kazakhstan (3.31), Lithuania (4.24), Luxembourg (3.01), Latvia (4.39), Moldova (3.39), Poland (3.10), Russian Federation (4.60), Sweden (3.53), Ukraine (3.54)
2021	Iraq (3.10), Kuwait (3.02)
2022	Belgium (3.27), Switzerland (3.40), France (3.42), Kazakhstan (3.11), Luxembourg (3.44)
2023	Bulgaria (3.03), Belarus (3.18), Switzerland (3.22), Moldova (3.46), Romania (3.05), Slovenia (3.04), Ukraine (3.30)

Note: Standardized values of annual temperature change are given in brackets.

Source: International Monetary Fund (2024)

Table 4 presents the correlations between the observed variables for the entire period from 1961 to 2023, while Table 5 shows the correlation results calculated based on data from the period 1998 to 2023. When observing the correlation between inflation and temperature change, it can

be concluded that in both cases, the correlation is statistically significant at the 5% level and is negative, though quite low. The Granger causality test and variable stationarity were examined in Table 6, in order to analyze the dynamic response of temperature change to inflation.

Table 4: Correlation matrix of the observed variables across all countries from 1961 to 2023

Variable	Statistics	Variable			
		INF	TEMP	GDPPP	LATITUDE
INF	Correlation	1.0000			
	N	8608			
TEMP	Correlation	-0.0277**	1.0000		
	N	8256	10601		
GDPPP	Correlation	-0.0390***	0.3050***	1.0000	
	N	5660	5960	6233	
LATITUDE	Correlation	-0.0165	0.2039***	0.3588***	1.0000
	N	8608	10601	6233	11844

Note: ***, **, * indicate levels of significance at the 1%, 5% and 10% levels of significance.

Table 5: Correlation matrix of the observed variables across all countries from 1998 to 2023

Variable	Statistics	Variable			
		INF	TEMP	GDPPP	LATITUDE
INF	Correlation	1.0000			
	N	4535			
TEMP	Correlation	-0.0356**	1.0000		
	N	4417	4702		
GDPPP	Correlation	-0.1227***	0.2930***	1.0000	
	N	4490	4634	4793	
LATITUDE	Correlation	-0.0595***	0.3979***	0.3887***	1.0000
	N	4535	4702	4793	4888

Note: ***, **, * indicate levels of significance at the 1%, 5% and 10% levels of significance.

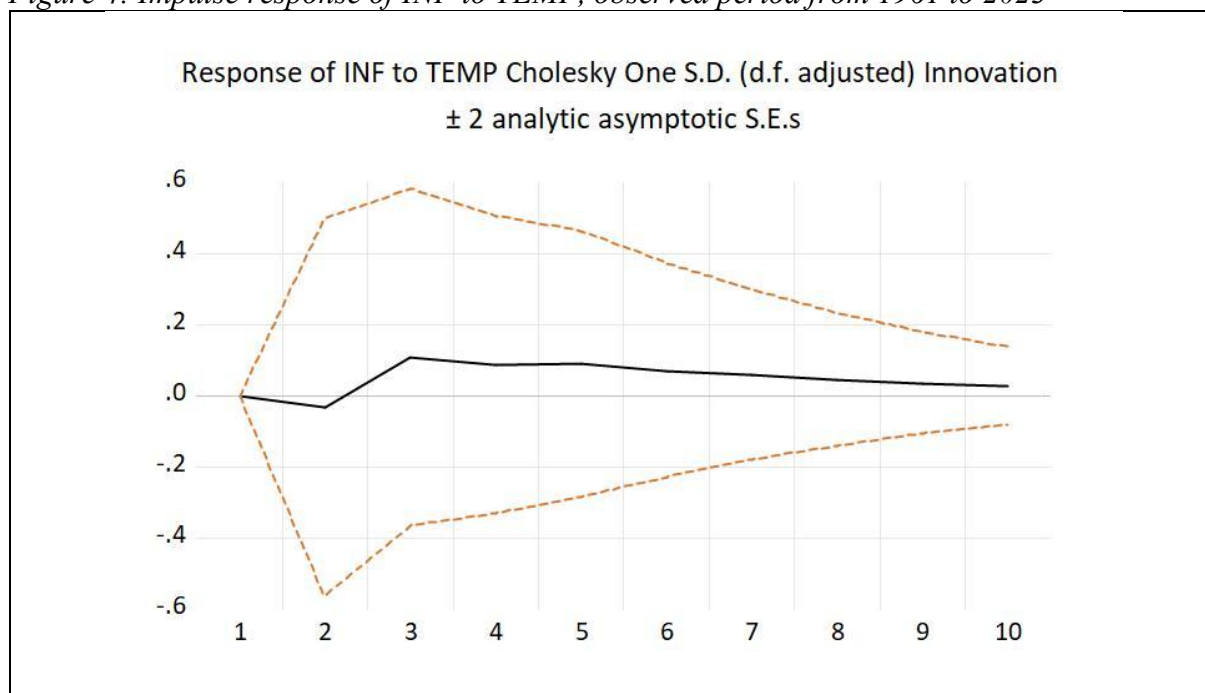
Table 6: Results of stationarity tests and Granger causality test for the variables INF and TEMP, observed period from 1961 to 2023

Stationary test results: variable INF			
Test	N	Statistic	Conclusion
Levin-Lin-Chu	8314	-824.91***	Stationary
Im-Pesaran-Shin	8314	-154.77***	Stationary
Augmented Dickey-Fuller	8314	1786.44***	Stationary
Phillips-Perron	8411	1852.01***	Stationary
Stationary test results: variable TEMP			
Test	N	Statistic	Conclusion
Levin-Lin-Chu	10012	-6.73***	Stationary
Im-Pesaran-Shin	10012	-4.53***	Stationary
Augmented Dickey-Fuller	10012	683.93***	Stationary
Phillips-Perron	10356	1313.54***	Stationary
Granger causality test results			
Test	Relation	F statistic	Conclusion
Granger causality test	TEMP → INF	2.3923*	Granger causality
Granger causality test	INF → TEMP	0.3905	No Granger causality

Note: ***, **, * indicate levels of significance at the 1%, 5% and 10% levels of significance.

All panel unit root tests indicate that both variables are stationary in its levels, meaning that their time-series data do not exhibit trends, have constant statistical properties over time and their values fluctuate around a constant mean and variance. Additionally, results of the Granger causality test indicate that TEMP Granger cause INF meaning that historical values of TEMP contain information that help to predict the future values of INF.

Figure 4: Impulse response of INF to TEMP, observed period from 1961 to 2023



Source: Authors' calculation

The dynamic impact of an abrupt rise in temperature on inflation over a ten-year period is measured by the inflation impulse reaction to temperature change. Immediate disruptions (such as the increase in food prices) cause inflation to soar at first, but it will eventually decline based on changes in policy.

Table 7 presents the results of the quantile regression models, in which the dependent variable is INF and the independent variables are TEMP, GDPPP, and LATITUDE for different quantile levels. To estimate the quantile regression models, data from the entire period from 1961 to 2023 were used.

Table 7: Estimated quantile regression model results (OLS approach), with the dependent variable as INF and independent variables as TEMP, GDPPP, and LATITUDE, for all observed countries from 1961 to 2023, $n = 5486$

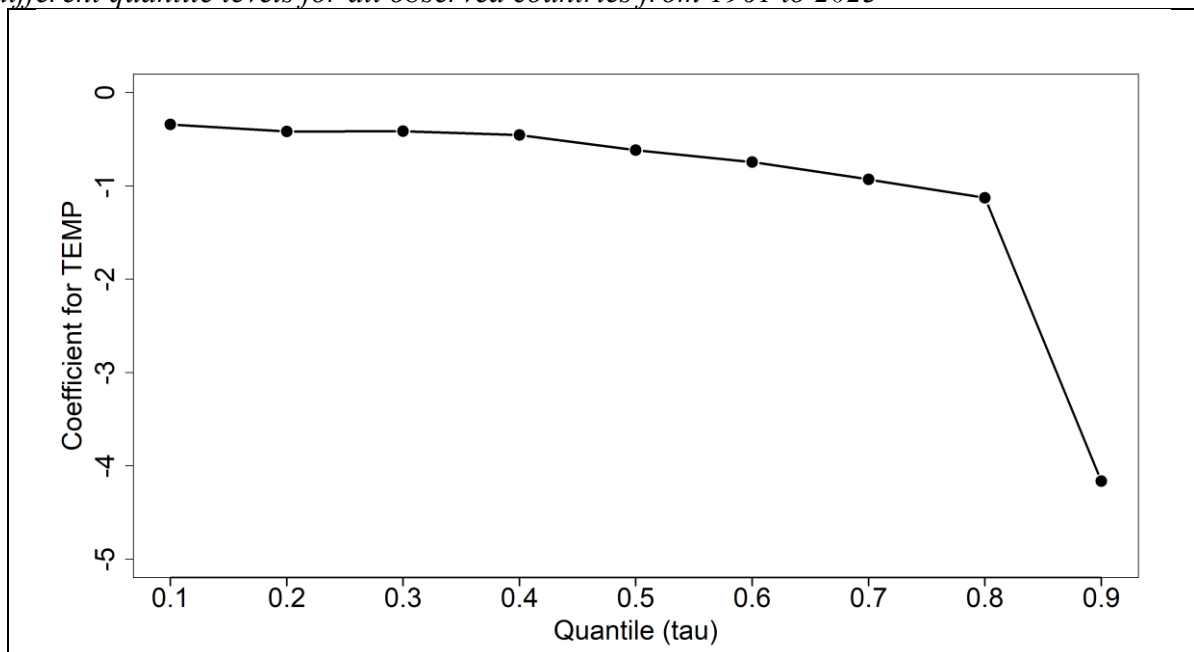
Quantile	Statistics	Quantile regression model			
		Intercept	TEMP	GDPPP	LATITUDE
0.1	Estimate	0.8303***	-0.3421***	0.0000***	0.0176***
	pseudo-R ²	0.1729			
0.2	Estimate	2.0993***	-0.4171***	0.0000***	0.0159***
	pseudo-R ²	0.1733			
0.3	Estimate	3.3800***	-0.4148***	0.0000***	0.0060**
	pseudo-R ²	0.1735			
0.4	Estimate	4.5575***	-0.4555***	-0.0001***	0.0022
	pseudo-R ²	0.1738			
0.5	Estimate	5.9145***	-0.6170***	-0.0001***	0.0024
	pseudo-R ²	0.1741			
0.6	Estimate	7.4642***	-0.7440***	-0.0001***	0.0018
	pseudo-R ²	0.1745			
0.7	Estimate	9.3522***	-0.9304***	-0.0001***	0.0056
	pseudo-R ²	0.1749			

Quantile	Statistics	Quantile regression model			
		Intercept	TEMP	GDPPP	LATITUDE
0.8	Estimate	11.9935***	-1.1279***	-0.0001***	0.0218
	pseudo-R ²	0.1754			
0.9	Estimate	21.9180***	-4.1636***	-0.0001***	0.0809**
	pseudo-R ²	0.1769			

Note: ***, **, * indicate levels of significance at the 1%, 5% and 10% levels of significance.

Figure 5 shows the estimated coefficients for the variable TEMP at different quantile levels. According to the results, across all quantiles (from tau = 0.1 to tau = 0.9), the coefficient for TEMP is consistently negative, suggesting that higher temperature changes are associated with lower inflation, regardless of the inflation quantile. This pattern holds across the entire distribution of inflation, although the magnitude of the impact increases with higher inflation quantiles.

Figure 5: Quantile regression estimated coefficients (OLS approach) for the variable TEMP at different quantile levels for all observed countries from 1961 to 2023



Source: Authors' calculation

In all the estimated quantile regression models, the independent variable TEMP was highly statistically significant. The results of the estimated quantile regression model based on the reduced period from 1998 to 2023 are presented in Table 8, while Figure 6 highlights the estimated coefficients from the quantile regression.

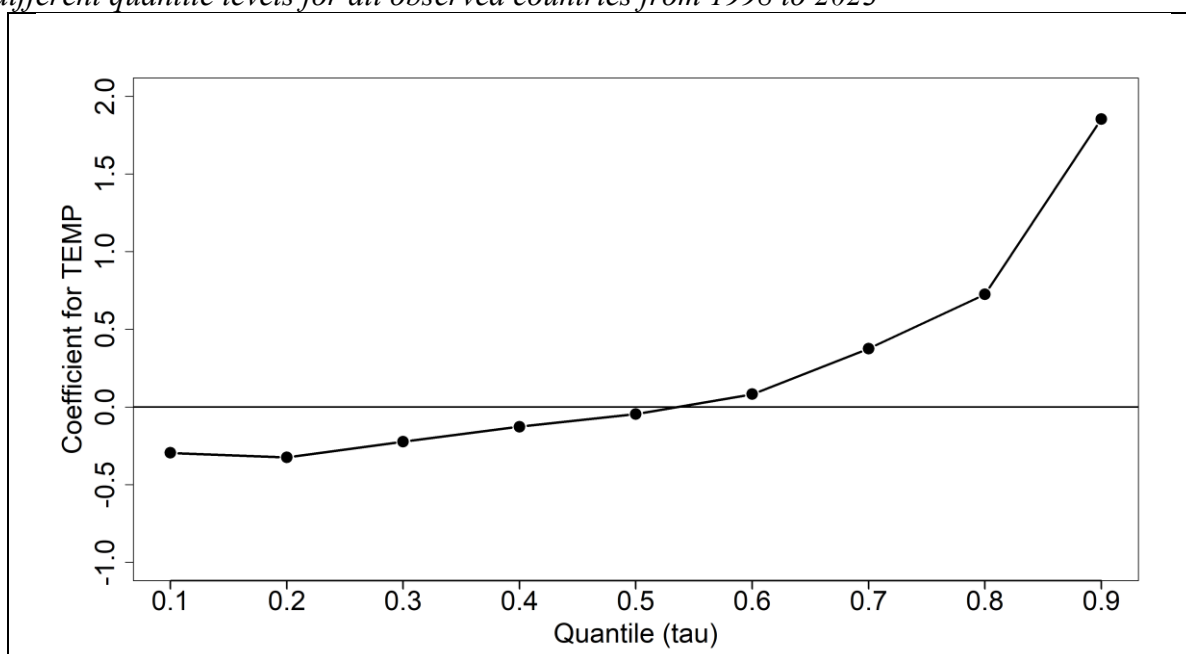
Table 8: Estimated quantile regression model results (OLS approach), with the dependent variable as INF and independent variables as TEMP, GDPPP, and LATITUDE, for all observed countries from 1998 to 2023, $n = 4374$

Quantile	Statistics	Quantile regression model			
		Intercept	TEMP	GDPPP	LATITUDE
0.1	Estimate	0.7158***	-0.2959***	-0.0000***	0.0132***
	pseudo-R ²	0.0839			
0.2	Estimate	1.8591***	-0.3244***	-0.0000***	0.0108***
	pseudo-R ²	0.1088			
0.3	Estimate	2.9010***	-0.2232***	-0.0000***	0.0057**

Quantile	Statistics	Quantile regression model			
		Intercept	TEMP	GDPPP	LATITUDE
	pseudo-R ²	0.1283			
0.4	Estimate	3.9210***	-0.1272	-0.0000***	-0.0025
	pseudo-R ²	0.1435			
0.5	Estimate	4.8314***	-0.0458	-0.0001***	-0.0060*
	pseudo-R ²	0.1554			
0.6	Estimate	5.9098***	0.0820	-0.0001***	-0.0081*
	pseudo-R ²	0.1667			
0.7	Estimate	7.1625***	0.3762*	-0.0001***	-0.0094
	pseudo-R ²	0.1749			
0.8	Estimate	9.2502***	0.7258**	-0.0001***	-0.0214**
	pseudo-R ²	0.1720			
0.9	Estimate	12.9367***	1.8547***	-0.0001***	-0.0475***
	pseudo-R ²	0.1130			

Note: ***, **, * indicate levels of significance at the 1%, 5% and 10% levels of significance.

Figure 6: Quantile regression estimated coefficients (OLS approach) for the variable TEMP at different quantile levels for all observed countries from 1998 to 2023



Source: Authors' calculation

In contrast to the results from the quantile regression models based on data from the period from 1961 to 2023, the value of the estimated coefficient for the variable TEMP increases with the rise in quantiles. At lower quantiles (from $\tau = 0.1$ to $\tau = 0.3$), the coefficient for TEMP is negative and statistically significant, indicating that higher temperature changes are associated with lower inflation at the lower end of the inflation distribution. However, at higher quantiles (from $\tau = 0.7$ to $\tau = 0.9$), the coefficient for TEMP becomes positive and statistically significant, suggesting that higher temperature changes are associated with higher inflation at the upper end of the inflation distribution. The values of estimated coefficients for GDPP and LATITUDE variable are both negative at higher quantiles, meaning that lower GDP per capita values as well as lower latitudes (closer to equator) are related to higher inflation at the upper end of inflation distribution. These findings point out for validating the hypothesis of the paper that low-income countries, located at lower latitudes, are experiencing higher levels of inflation due to global warming.

The results of this analysis are comparable to the previous investigation in this field of research. Low-income nations, who can least afford it, will bear the brunt of the negative effects of rising temperatures, and their effects will not be uniform everywhere, Acevedo et al. (2018). According to Li et al. (2023) there is a steady positive correlation between rising temperatures and inflation with GDP per capita modulating the link in a nonlinear approach and exposing differences in inflationary reactions depending on economic conditions. Similar results were obtained by Kunawotor et al. (2022). Their findings show that major weather-related events, like droughts and floods, significantly contribute to the inflation of food prices, mainly by affecting agricultural output in Africa.

Conclusion

Main findings the paper indicate that there is an adverse effects of temperature change on inflation worldwide. Low-income countries, closer to equator, affect greater negative consequences of global climate change, which is particularly pronounced in the last two decades. It was found that low-income countries, laying on lower latitudes, are more fragile to temperature shocks validating the hypothesis of paper. Limitations of the paper are related to missing data for main determinants of inflation, leading to a significant number of non-significant variables in the regression models. Future research directions for exploring the relationship between temperature change and inflation could include regional analysis between developed and developing countries, sector-specific effects, short-term vs. long-term effects, monetary policy responses and technological adaptation. Investing in climate-resilient infrastructure, improving agricultural technologies, and supporting renewable energy sources are examples of adaptive policies that governments should put into place to lessen the inflationary effects of climate change.

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ECONOMICS

TRACK 2: Public Policy, Governance, And Sustainability

PREFACE

ECONOMICS – TRACK 2: PUBLIC POLICY, GOVERNANCE, AND SUSTAINABILITY

This track explores how public finance, economic policy, and sustainability initiatives intersect to drive economic development and address multifaceted societal challenges. It investigates the efficacy of government revenue collection, the strategic integration of environmental and social governance (ESG) principles within institutions, the design of fiscal instruments aimed at fostering a greener and more resilient economy, and the crucial role of consumer behavior in achieving sustainability goals. The papers in this section collectively highlight the indispensable role of policy and institutional frameworks, alongside behavioral insights, in guiding economic growth towards more equitable and sustainable outcomes. The papers in this section collectively focus on governmental and institutional strategies to foster economic stability, manage public resources, and promote sustainability, often through the lens of policy effectiveness and behavioral responses to societal challenges.

Galetić and Walter conduct a comparative analysis of tax collection efficiency in Croatia, identifying key areas for improvement in personal income tax collection and proposing policy recommendations for effective public finance. Ivanišević Hernaus focuses on corporate sustainability policies, providing a state-of-the-art overview and future research directions on the ESG maturity of large European financial institutions, mapping existing models and empirical maturity levels. Finally, Pernici and Stancu offer a statistical breakdown into the EU-27 environmental taxation, profiling regional specificities and illustrating the time dynamics of green fiscal policies over the last decade. Platz and Péter explore consumer attitudes towards food waste in a sociodemographic approach, revealing how education and environmental awareness among households can inform targeted policy measures and social campaigns for greater sustainability in Hungary.

TAX COLLECTION EFFICIENCY IN CROATIA: A COMPARATIVE ANALYSIS

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Abstract

Tax collection efficiency is a critical component of a well-functioning tax system, influencing government revenue, economic stability, and taxpayer compliance. This paper examines the efficiency of tax collection in Croatia, with a particular focus on personal income tax (PIT). While existing research has explored the progressivity and administrative efficiency of taxation in Croatia, this study is the first to conduct an in-depth analysis of tax collection efficiency and compare it to other European Union (EU) countries. By analyzing tax arrears and the effectiveness of tax enforcement mechanisms, the study identifies key areas for improvement. Croatia maintains a relatively low proportion of year-end tax arrears compared to net revenue; however, the share of collectible arrears remains below 10%, signaling inefficiencies in debt recovery. Drawing from international best practices, the paper highlights policy recommendations, including expanding tax withholding to rental income, enhancing digital compliance monitoring, and increasing investment in digital tax solutions such as AI-driven risk assessments and mobile tax applications. Furthermore, strengthening transparency and anti-corruption measures is essential to fostering public trust and improving voluntary tax compliance. The findings provide a foundation for future empirical research on optimizing tax collection strategies in Croatia and improving overall fiscal efficiency.

Keywords: tax collection efficiency, personal income tax, Croatia

JEL classification: H21, H24, H26

Introduction

The efficiency of a tax system is a crucial element of public finance, shaping how effectively a government collects revenue while minimizing economic disruptions and administrative burdens. An ideal tax system not only generates adequate revenue but also upholds fairness, transparency, and practicality in administration. Striking a balance between efficient revenue collection, economic incentives, and taxpayer compliance is essential in achieving high tax efficiency (Nguyen et al., 2020). When discussing tax efficiency, much of the attention is directed toward economic efficiency – ensuring that taxation does not distort economic behavior. Complicated tax regulations and high compliance costs can lead to increased instances of tax avoidance or unintentional errors (Andreoni et al., 1998). In response, many countries have introduced reforms such as simplified tax laws, pre-filled tax returns, and digital filing systems to ease compliance and enhance efficiency.

The challenges of stimulating economic growth and ensuring an equitable distribution of tax burdens underscore the importance of examining the intricacies of personal income tax efficiency. This study undertakes a critical analysis of the prevailing framework of personal income tax in Croatia, with a specific focus on its tax collection efficiency. The personal income tax (PIT) system in Croatia is integral to the formation of the nation's economic landscape and the promotion of social equity. Instituted in response to increasing disparities in income distribution, the PIT employs a progressive tax framework whereby individuals with higher incomes are liable to pay a larger proportion of their earnings. This mechanism facilitates wealth redistribution and underpins the financing of essential public services. The importance of this system is further highlighted by analyses that illustrate how various components, including tax schedules and deductions, contribute to its progressive character, particularly benefiting lower-income taxpayers. In this manner, the PIT fosters a more equitable economic environment (Urban et al., 2006). However, complexities within the tax code can discourage foreign direct investment (FDI), as they contribute to increased compliance costs and uncertainty among potential investors (Mudd et al., 2003). Overall, the effectiveness of personal income tax in Croatia is crucial not only for revenue generation but also for sustaining economic stability and promoting inclusive growth. While several studies have examined the progressivity and efficiency of taxation in Croatia, particularly in terms of minimizing economic disruptions and administrative burdens (Krtalić & Peruško, 2023; Urban, 2023; Urban, 2016; Šimović, 2012) to the best of the authors' knowledge, this is the first study to conduct an in-depth analysis of tax collection efficiency in Croatia. Consequently, this paper contributes to the literature by offering a comprehensive examination of tax collection in Croatia and providing a comparative analysis with other European countries.

The data used in this paper are secondary data from organizations CIAT, IOTA, IMF, OECD, PWC and Trading Economics. The paper is composed of five main chapters. After the introduction, the first chapter gives an overview of the current situation with personal income tax in Croatia. Then the analysis moves to factors that influence tax efficiency and tax collection efficiency. The fourth chapter analyzes tax collection efficiency in Croatia after which there is a discussion on policy implications.

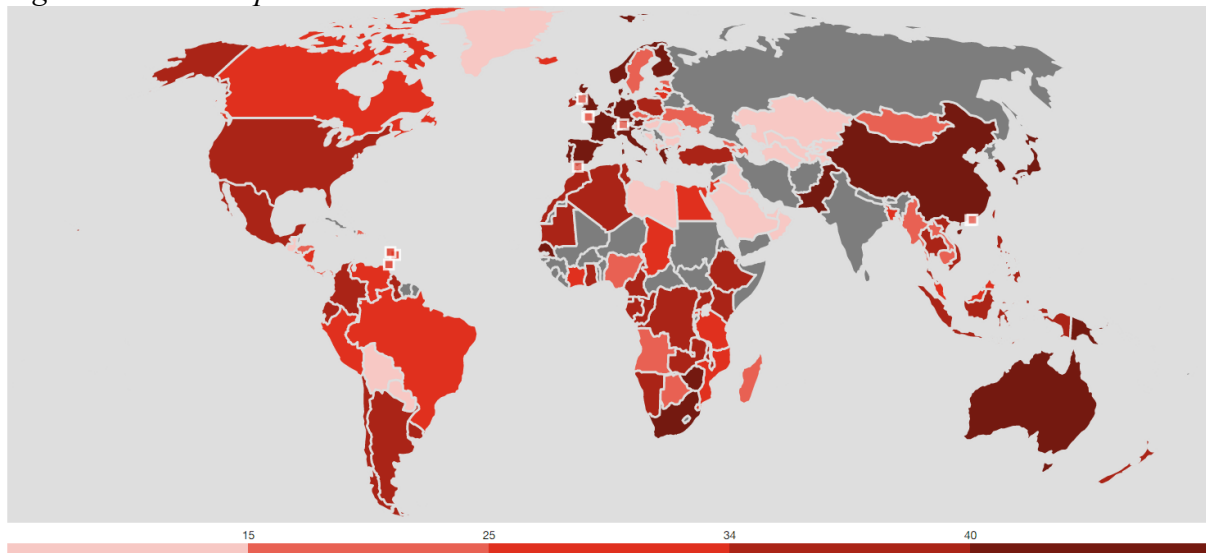
Current structure of personal income tax in Croatia

The present structure of the personal income tax (PIT) system in Croatia is characterized by a progressive rate framework aimed at ensuring equitable distribution of tax burdens among citizens. This framework encompasses a range of elements, such as tax schedules, allowances, deductions, and credits, all of which collectively impact the overall progressivity of the system. Historical analyses, including those conducted in 1997 and 2004, have shed light on the functionality of these components across various income quantiles, demonstrating the system's responsiveness to the needs of lower-income taxpayers (Urban et al., 2006). Nonetheless, despite the implementation of these progressive measures, challenges persist in enhancing tax efficiency. To bolster its economic development prospects, Croatia must address the deficiencies present within its PIT structure by instituting stable macroeconomic policies and effective market-based institutions, as recommended in strategic proposals for long-term growth (Mihaljek et al., 2001). This dual emphasis on structural reform and economic strategy is crucial for optimizing the efficacy of personal income taxation in promoting comprehensive national development.

The analysis of tax brackets and rates in Croatia reveals significant implications for personal income tax efficiency. Croatia employs a progressive tax system that is designed to alleviate the burden on lower-income taxpayers; however, the structure of tax brackets can ultimately complicate this goal. Key insights into this inefficiency stem from studies that highlight the elements of the tax system, including allowances and deductions, which shape the overall progressivity of the tax code (Urban et al., 2006). Furthermore, the introduction of flat taxation systems and their impact on formalizing labor in the economy raise concerns about incentives for compliance among taxpayers. While flat taxes can simplify tax structures, they may also exacerbate issues related to undeclared work, suggesting that simply altering tax rates may not adequately address broader economic challenges (Leibfritz, 2011). Consequently, a comprehensive review of tax brackets and their effectiveness in fostering tax compliance is essential for enhancing overall efficiency.

Comparing Croatia to other European countries could give a better insight into this issue. As countries usual apply many different tax rates, this comparative analysis focuses on the maximal personal income tax rates.

Figure 1: Maximal personal income tax rates in 2024 in the world



Source: <https://taxsummaries.pwc.com/quick-charts/personal-income-tax-pit-rates>

On the world map it can easily be seen that the highest maximal personal income tax rates mostly appear in Europe. There are only few countries outside Europe with maximal personal income tax rate over 40%, such as Australia, South Africa or China. It is also interesting to mention that in North America and in South America none of the countries have maximal personal income tax rate above 40%.

Table 1: Maximal personal income tax rates in 2024 in European countries

<i>Country</i>	<i>Tax rate</i>	<i>Country</i>	<i>Tax rate</i>
Montenegro	9	Malta	35
Bosnia and Herzegovina	10	<i>European Union average</i>	38,7
Bulgaria	10	Norway	39,6
Kosovo	10	Ireland	40
Macedonia	10	Switzerland	40
Romania	10	Turkey	40

<i>Country</i>	<i>Tax rate</i>	<i>Country</i>	<i>Tax rate</i>
Serbia	10	Luxembourg	42
Moldova	12	<i>Euro area average</i>	42,7
Belarus	13	Italy	43
Russia	13	Greece	44
Hungary	15	France	45
Ukraine	18	Germany	45
Estonia	20	United Kingdom	45
Isle of Man	20	Iceland	46,25
Lithuania	20	Spain	47
Liechtenstein	22,4	Portugal	48
Albania	23	Netherlands	49,5
Czech Republic	23	Belgium	50
Slovakia	25	Slovenia	50
Croatia	30	Sweden	52,3
Latvia	31	Austria	55
Poland	32	Denmark	55,9
Cyprus	35	Finland	57

Source: <https://tradingeconomics.com/country-list/personal-income-taxrate?continent=europe>

Table 1 shows the maximal personal income tax rates for European countries in 2024. Countries are sorted from the one with the lowest value towards that with the highest one. Countries marked with light grey fields are members of the European Union, and those with dark grey are members of European Monetary Union. In general, countries in the EU have higher values and countries outside the EU have lower values of maximal personal income tax rates.

The lowest value is in Montenegro (9%) and the highest in Finland (57%). The EU average is 38.7% and the EMU average is 42.7%. This shows that countries in the EMU have higher maximal PIT rates by 3 percentage point on average.

Factors influencing tax efficiency

Tax efficiency is heavily influenced by various factors, such as the complexity of the tax system, administrative capacities, and the prevalence of economic informality. In Croatia, the simplicity of tax regulations is crucial, as a more streamlined process can improve compliance and diminish tax evasion, ultimately leading to increased tax revenues. However, the relationship between tax simplicity and efficiency can pose challenges, since a simpler system does not necessarily guarantee optimal revenue generation. Additionally, the presence of an unofficial economy in Croatia complicates efforts to achieve tax efficiency, as noted in (Bičanić et al., 1997), where researchers examine the underlying causes of tax evasion and its impact on public finances. This phenomenon emphasizes the need to adjust tax policies to enhance revenue generation while also supporting sustainable economic development. The challenge of balancing compliance simplicity with effective economic stimulus illustrates the broader complexities present in tax systems across the region, as discussed in (Hashorva et al., 2025).

The effectiveness of personal income tax systems in Croatia can be analyzed critically by considering compliance rates alongside the administrative costs involved in tax collection. High compliance rates generally indicate a taxpayer's willingness and ability to fulfill their tax obligations, which is vital for maintaining government revenue and supporting economic growth. However, excessive administrative costs can detract from these efforts by diverting resources that could be utilized more effectively in other areas. An examination of these factors in Croatia shows that, while compliance has improved over time, the costs associated with tax collection remain disproportionately high in relation to the revenue generated. This inefficiency not only limits the potential for reinvestment in public services but also poses challenges for smaller businesses and individual taxpayers, ultimately impacting overall tax morale. As highlighted by the Institute of Public Finance, reforms in tax administration practices are essential for enhancing both efficiency and compliance (Ott et al., 1998; Harutyunyan et al., 2006). Another crucial factor, which is also the focus of the remainder of this paper, is the efficiency of the tax authority in recovering outstanding debt. This will be analyzed in two ways. First, by examining the mechanisms and debt recovery strategies that are essential for addressing already accumulated debt. Second, by exploring preventive measures designed to mitigate the risk of debt accumulation.

Tax collection efficiency: mechanisms and debt recovery strategies

Tax collection efficiency hinges on the ability of tax authorities to recover outstanding tax liabilities through both legal enforcement and administrative measures. A successful tax collection system relies on a structured approach that incorporates clear legislative frameworks, effective enforcement tools, and preventative mechanisms that promote compliance before debts escalate. While enforcement plays a crucial role in addressing non-compliance, proactive strategies aimed at preventing tax arrears are often more cost-effective and sustainable in the long term (OECD, 2019).

Tax collection powers

Tax authorities worldwide employ a range of tools to collect overdue taxes. One widely used mechanism is the formulation of structured payment arrangements for taxpayers unable to meet their tax obligations in full. Recognizing that not all tax debts stem from deliberate evasion, tax administrations frequently offer installment plans that allow individuals and businesses to settle their liabilities over time. The OECD's Tax Administration 2024 report highlights how most tax administrations utilize this power, as it facilitates tax debt recovery while reducing the administrative burden associated with enforcement actions (Ebraico & Rua, 2015).

In addition to payment arrangements, many tax authorities grant extensions for tax payments, particularly during economic downturns when taxpayers may face liquidity constraints (Hybka, 2015; Sancak et al., 2010). However, while offering flexibility can improve compliance rates, tax administrations must carefully manage these provisions to avoid excessive delays that could increase the risk of default.

Another measure frequently used by tax administrations is the ability to remit interest and penalties in specific circumstances. Some jurisdictions apply this tool liberally to incentivize compliance, while others use it sparingly to avoid setting a precedent that tax debts can be easily negotiated (Torgler, 2007). Beyond these supportive measures, tax authorities have access to a variety of legal enforcement tools to recover unpaid taxes. One widely employed method is the

offsetting of tax arrears against tax overpayments. In jurisdictions that permit this approach, any tax refunds or government payments due to a taxpayer are automatically redirected toward outstanding liabilities (OECD, 2024). This method streamlines the collection process, ensuring that tax debts are settled with minimal need for direct enforcement.

Another common enforcement mechanism is wage and bank account garnishment, allowing tax authorities to recover unpaid taxes directly from a taxpayer's income or financial assets. While this method is particularly effective for taxpayers with stable incomes, it must be applied judiciously to avoid undue financial hardship, particularly for low-income individuals (OECD, 2024). In cases where tax debts remain unresolved, tax authorities may impose liens on taxpayers' property, restricting the sale or transfer of assets until outstanding debts are settled. As a more drastic measure, authorities may also resort to asset seizures, auctioning confiscated properties or valuables to recover unpaid taxes. However, such measures are typically considered a last resort, used only when other collection efforts have been exhausted (OECD, 2024).

Some jurisdictions extend liability for unpaid tax debts to third parties, such as business partners or corporate directors, to prevent tax avoidance strategies where companies are liquidated to evade liabilities (Torgler, 2007). By holding associated individuals accountable, tax authorities can deter deliberate non-compliance and improve collection rates.

Beyond direct enforcement, tax administrations also use indirect measures to encourage compliance. One common approach is requiring tax clearance certificates for businesses bidding on government contracts (Walsh, 2012). This ensures that companies seeking public sector work are up to date with their tax obligations. Some jurisdictions also withhold government payments to tax debtors, preventing taxpayers from benefiting from public funds while they have outstanding liabilities (OECD, 2024).

A more controversial strategy involves publishing the names of tax debtors as a deterrence measure. While public exposure can incentivize compliance, it may disproportionately affect individuals facing temporary financial hardship rather than habitual tax evaders. Additionally, some countries impose travel restrictions on high-value tax debtors, preventing them from leaving the country until they settle their liabilities. While effective in some cases, this measure is typically reserved for extreme circumstances.

Although enforcement tools are necessary, excessive reliance on coercive measures can lead to administrative inefficiencies and taxpayer resistance. A more effective approach balances enforcement with preventive strategies and incentives that encourage voluntary compliance (Carrillo-Maldonado & Ramírez-Álvarez, 2020).

Preventive approaches to tax collection efficiency

Preventative measures play a crucial role in reducing tax delinquency and fostering voluntary compliance. Many of the most efficient tax administrations focus on preventing tax arrears before they arise, utilizing tools such as real-time transaction monitoring, third-party reporting, and taxpayer engagement programs (Ebraico & Rua, 2015). One of the most successful preventive strategies is the use of pre-filled tax returns, in which tax authorities automatically populate returns based on data from employers, banks, and other institutions. This system, commonly used in Scandinavian countries, reduces filing errors and enhances compliance rates.

Similarly, real-time transaction monitoring, which integrates tax systems with banking and financial networks, enables tax authorities to track taxable transactions as they occur. Estonia and Sweden have implemented such systems with significant success, leading to higher compliance levels (OECD, 2024).

Third-party reporting is another effective approach. By requiring businesses, financial institutions, and employers to report taxable transactions directly to tax authorities, governments can cross-check taxpayer filings for discrepancies and prompt corrective actions before tax debts accumulate (Alqalawi et al., 2023).

Additionally, early intervention measures—such as installment payment plans and negotiation mechanisms—allow tax administrations to recover debts more efficiently while reducing the need for legal action (OECD, 2019).

Other factors influencing tax collection efficiency

A study by Ubago Martinez et al. (2022), which analyzed tax administration efficiency in 28 OECD countries between 2004 and 2017, found that fiscal decentralization plays a significant role in improving tax collection efficiency. Countries that delegate tax collection responsibilities to regional or local authorities tend to perform better, as they can adapt enforcement strategies to specific economic conditions. Decentralization also enhances accountability and reduces inefficiencies associated with bureaucratic centralization, aligning with modern fiscal federalism theories that advocate for localized tax enforcement.

Another critical factor influencing collection efficiency is the structure of the tax system itself. Systems that rely more on indirect taxes, such as VAT and excise duties, tend to be more effective than those that emphasize direct taxes like income and corporate tax. Indirect taxes are embedded in transactions, making them harder to evade, whereas direct taxes involve complex reporting, creating more opportunities for avoidance (Alqalawi et al., 2023). In Croatia, VAT remains the dominant source of tax revenue.

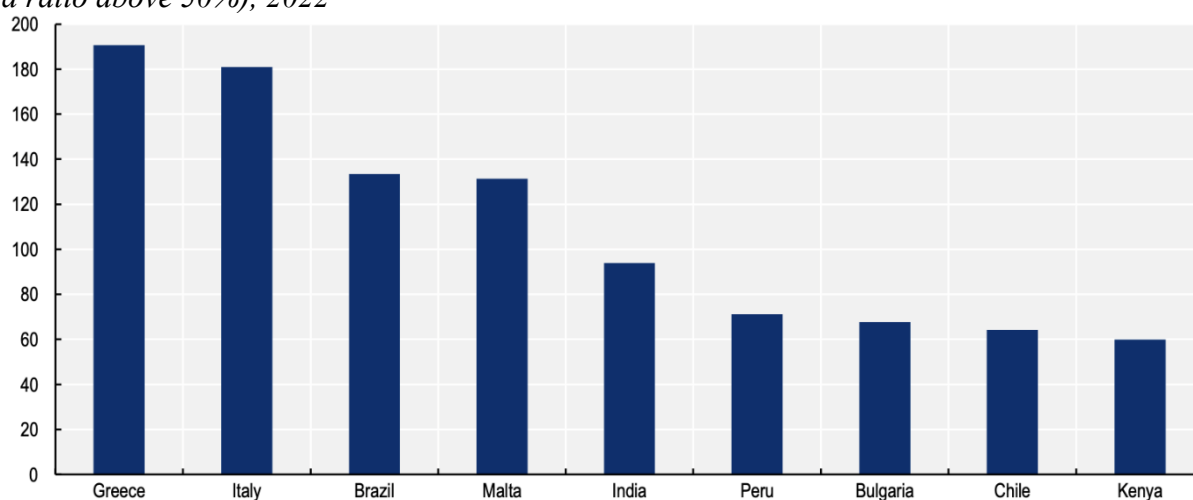
Other important factors include financial literacy and corruption control. Countries with higher levels of financial education tend to experience better tax compliance, highlighting the need for stronger tax education initiatives. Likewise, strong governance and anti-corruption measures are crucial, as corruption weakens enforcement and facilitates tax evasion. Digitalization, transparency, and strict oversight are essential to maintaining a fair and efficient tax system (César Leal Ordóñez, 2014).

Tax collection efficiency in Croatia: a comparative perspective within the EU

This paper primarily focuses on tax collection efficiency in Croatia. One of the key indicators used to evaluate a country's effectiveness in collecting tax debt is the ratio of total year-end arrears to total net revenue. The OECD employs this benchmark to assess tax administrations' success in recovering outstanding tax liabilities. A ratio below 5% is considered a sign of strong performance, while a figure exceeding 20% is indicative of weaker collection efficiency (Ebraico & Rua, 2015). Based on this measure, Croatia ranks among the high-performing countries.

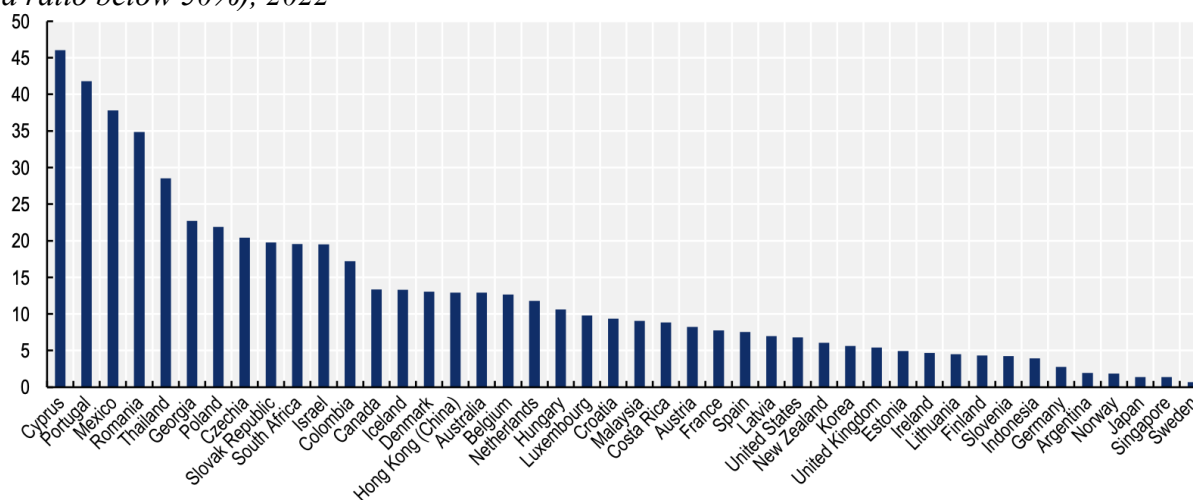
In 2022, the average ratio of total year-end arrears to net revenue collected across EU countries was 29%. However, this number is skewed by a few jurisdictions—most notably Greece, Italy, Malta, and Bulgaria—where arrears exceeded 50%. When these outliers are removed from the equation, the average drops to approximately 13%, positioning Croatia slightly below this revised benchmark (see Figure 1 and Figure 2). That being said, there is still room for improvement when compared to the most efficient EU nations, including Estonia, Ireland, Lithuania, Finland, Slovenia, Germany, and Sweden, all of which report ratios below 5%. According to data from the Croatian Tax Administration (2024), Croatia's tax collection rate is relatively high, with approximately 98% of assessed tax obligations being successfully collected. The remaining 2% represents uncollected liabilities, indicating that the vast majority of due taxes are effectively recovered.

Figure 2: Total year-end arrears as a percentage of total net revenue (for administrations with a ratio above 50%), 2022



Source: CIAT, IOTA, IMF, OECD, International Survey on Revenue Administration, <https://data.rafit.org/regular.aspx?key=74180902> (accessed on 8 February 2025).

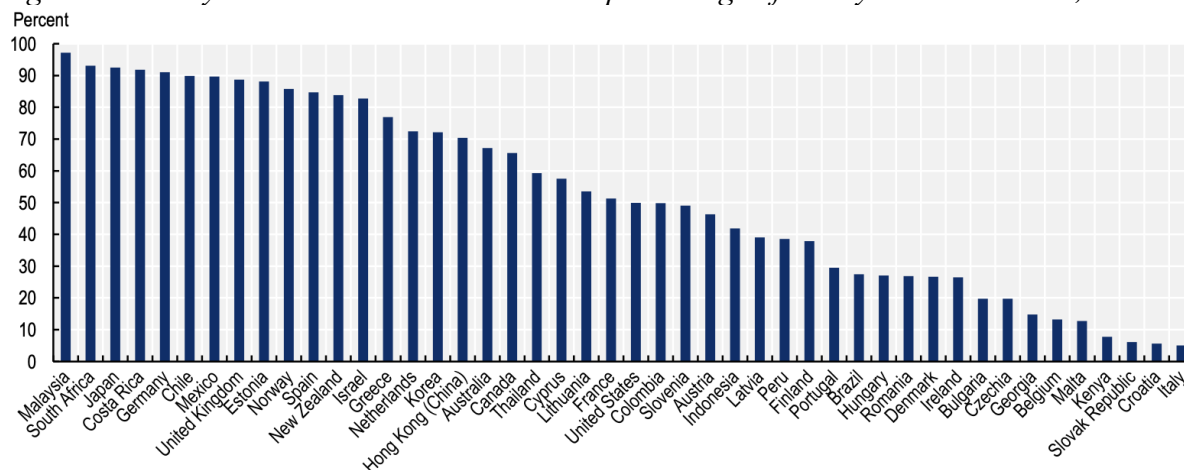
Figure 3: Total year-end arrears as a percentage of total net revenue (for administrations with a ratio below 50%), 2022



Source: CIAT, IOTA, IMF, OECD, International Survey on Revenue Administration, <https://data.rafit.org/regular.aspx?key=74180902> (accessed on 8 February 2025).

According to 2022 data, approximately half of the total arrears were deemed collectable, reflecting a 4% increase from 2018. However, Figure 3 highlights significant disparities between different jurisdictions. While some report that nearly all arrears can be recovered, others categorize the majority as uncollectible. Despite Croatia's relatively low proportion of year-end arrears compared to net revenue, the share of collectible arrears remains below 10%, one of the lowest among the observed countries.

Figure 4: Total year-end collectible arrears as percentage of total year-end arrears, 2022



Source: CIAT, IOTA, IMF, OECD, *International Survey on Revenue Administration*, <https://data.rafit.org/regular.aspx?key=74180902> (accessed on 8 February 2025).

During the first nine months of 2024, Croatia's Ministry of Finance and the Tax Administration implemented 374,742 measures aimed at recovering outstanding tax debts. Of these, 372,728 were administrative enforcement actions undertaken directly by the Tax Administration, covering total arrears of EUR 1.54 billion, out of which EUR 913.9 million was successfully collected. Meanwhile, the State Attorney's Office submitted 2,014 court proposals for securing or enforcing claims on real estate, amounting to a total tax debt of EUR 28.2 million (Croatian Tax Administration, 2024).

Furthermore, once the unified six-year statute of limitations expires, tax debts secured by liens or mortgages can only be collected from the encumbered assets. The Croatian Tax Administration continues to enforce the collection of expired debts and has recovered the following amounts in recent years: EUR 3.78 million in 2021, EUR 5.76 million in 2022, and EUR 5.19 million in 2023. In the first nine months of 2024, an additional EUR 3.78 million was collected. Since 2021, a total of EUR 18.51 million has been recovered from expired tax obligations secured by liens on debtor assets (Croatian Tax Administration, 2024).

The use of collection powers in Croatia

The Ministry of Finance and the Tax Administration oversee tax collection and enforcement procedures in accordance with the Law on the Tax Administration, ensuring the recovery of taxes, contributions, and other public charges.

The extent to which tax authorities utilize their collection powers varies significantly across EU countries. In Croatia, commonly used enforcement measures include (CIAT et al., 2022):

1. Negotiating payment arrangements with taxpayers;
2. Offsetting tax arrears against overpayments in other tax categories;

3. Obtaining liens on taxpayer assets;
4. Requiring businesses to secure tax clearance certificates before bidding for government contracts;
5. Publicly disclosing the names of taxpayers with outstanding debts.

However, certain enforcement tools are used less frequently in Croatia compared to other EU countries, such as (CIAT et al., 2022):

1. Collecting unpaid taxes via third parties;
2. Garnishing wages or other property to recover tax debts;
3. Temporarily closing businesses or withdrawing licenses for tax non-compliance;
4. Withholding government payments from delinquent taxpayers;
5. Restricting access to government services for individuals with outstanding tax liabilities;
6. Initiating bankruptcy or asset liquidation proceedings;
7. Remitting interest and penalties in specific cases.

Unlike some of the most efficient tax administrations, Croatia does not enforce the collection of disputed taxes while a case is still under administrative or judicial review. Implementing this practice could help maintain tax revenue during prolonged legal proceedings, preventing tax debts from accumulating further (CIAT et al., 2022).

One of the more controversial tax collection measures is the publication of tax debtors' names in the media or through official government channels. In Croatia, the Tax Administration has the authority to publicly disclose a list of individuals and businesses with overdue and unpaid tax liabilities, including debts related to VAT, corporate income tax, personal income tax, social security contributions, excise duties, and other levies. While some EU countries also use this approach, it is worth noting that Germany and Sweden—both of which maintain the lowest levels of undisputed tax debt relative to net revenue collection—do not. The effectiveness of public disclosure as a deterrent has been debated, with some questioning whether it truly enhances compliance.

At present, e-filing is mandatory in Croatia for corporate income tax, employer withholdings, and VAT, but it is not available for personal income tax. Additionally, there is no requirement for electronic payment of any tax obligations. In contrast, top-performing EU countries require both e-filing and e-payment for all tax categories (CIAT et al., 2022). This is a preventive strategy whose implementation has the potential to enhance tax collection efficiency.

Several high-performing tax administrations, such as those in Germany and Sweden, leverage advanced technology to enhance tax collection. AI-powered monitoring systems assist in identifying taxpayers at a high risk of evasion, allowing enforcement efforts to be more targeted and efficient. This reduces reliance on widespread audits and streamlines compliance. Furthermore, real-time integration with banking systems enables automatic tax payments, minimizing overdue liabilities and ensuring timely collection.

To improve digital services and make tax management more accessible, the Croatian Tax Administration introduced mPorezna, a mobile application designed to simplify tax-related tasks. This app provides individuals, freelancers, and businesses with real-time updates on tax deadlines and payments, allowing them to submit tax forms digitally, check their tax balance, generate payment barcodes, and review past submissions. The app also includes a QR code scanning feature for verifying invoice authenticity and reporting irregularities directly to the

Tax Administration. By making tax compliance more user-friendly and accessible, mPorezna supports Croatia's broader effort to create a more efficient tax system.

One of the most critical mechanisms for ensuring effective tax collection is tax withholding. In Croatia, withholding tax applies to income types such as wages, salaries, dividends, interest, royalties, and patents, with strict reporting requirements for each transaction. Compared to the highest-performing tax administrations, Croatia's withholding system is well-structured. However, given the substantial role of the tourism sector, introducing withholding tax on rental income could improve compliance and enhance revenue collection (CIAT et al., 2022).

Policy implications

A comparative analysis of tax collection efficiency across different countries highlights significant differences in enforcement effectiveness, debt recovery strategies, and the overall performance of tax administrations. By examining the practices of high-performing tax administrations and contrasting them with those of less efficient systems, we can identify key policy measures that contribute to improved compliance, stronger enforcement, and more effective tax collection.

Several critical factors appear to be closely linked to successful tax debt recovery. Among these are the widespread use of withholding taxes, the implementation of efficient advance payment systems, the broad adoption of electronic payment methods, strong debt collection authority, a well-resourced tax recovery team, above-average investment in IT infrastructure for tax administration, and the extensive use of digital technologies (OECD, 2019).

Conversely, countries with weaker enforcement frameworks—such as Italy and Greece—often struggle with significantly higher levels of tax arrears. In these cases, administrative inefficiencies, prolonged legal proceedings, and limited digital capabilities create major obstacles to effective tax collection, leading to considerable revenue losses. Tax authorities in these jurisdictions frequently face difficulties in recovering outstanding debts, with many cases of unpaid taxes remaining unresolved for years. Addressing these challenges requires a multi-pronged approach that includes greater investment in digital infrastructure, streamlining enforcement procedures, and adopting risk-based compliance strategies to target non-compliance more effectively.

In Croatia's case, tax collection efficiency is relatively strong compared to some EU counterparts. However, there are areas that could be further refined to enhance overall effectiveness. The country benefits from a well-functioning tax withholding system and a high overall collection rate, but certain challenges remain—particularly regarding the low collectability of tax arrears and the absence of mandatory electronic payment for taxes. Additionally, while Croatia's reliance on indirect taxes such as VAT aligns with best practices, the country could benefit from strengthening enforcement mechanisms. Expanding tax withholding to include rental income and improving digital compliance monitoring could significantly enhance tax collection efficiency.

Further investment in digital tax solutions would also contribute to more effective tax administration. Expanding the functionalities of the mPorezna mobile app, integrating AI-driven risk assessments, and linking tax payments directly with banking systems could streamline compliance and help reduce tax arrears. Beyond technological improvements,

enhancing transparency and reinforcing anti-corruption measures would also play a crucial role in fostering public trust and encouraging voluntary tax compliance.

However, the successful implementation of these reforms is likely to encounter several risks and constraints. Political resistance remains a key challenge, as Public Choice Theory points out that policymakers often act in their own self-interest, prioritizing short-term political benefits over long-term institutional improvements. Reforms aimed at improving tax compliance can be politically costly, particularly when they affect powerful interest groups. Furthermore, the concept of fiscal illusion—where the complexity of the tax system conceals the true cost of public spending—can reduce incentives to simplify tax structures and enhance transparency. These considerations underline the need to assess not only the technical soundness of proposed reforms but also the broader political and institutional context in which they must operate.

Conclusion

This paper examines the Croatian tax system with a particular focus on the structure of personal income tax. However, its primary contribution lies in an in-depth analysis of tax collection efficiency in Croatia, providing a comparative perspective with other EU countries. To the best of the authors' knowledge, this is the first study to systematically explore tax collection efficiency in Croatia and offer policy recommendations for its improvement.

While Croatia has a relatively low proportion of year-end tax arrears compared to net revenue, the share of collectible arrears remains below 10%, one of the lowest among the observed EU countries. This indicates that once tax debt arises, the likelihood of recovering it is significantly limited. Although Croatia's reliance on indirect taxes, such as VAT, aligns with best practices, the country could enhance its tax collection efficiency by strengthening enforcement mechanisms. One key policy recommendation is to adopt strategies employed by the most efficient tax administrations in the EU, including expanding withholding tax to cover rental income and improving digital compliance monitoring.

Further investment in digital tax solutions would also contribute to a more effective tax administration system. Enhancing the functionalities of the mPorezna mobile application, integrating AI-driven risk assessments, and linking tax payments directly with banking systems could streamline compliance and help reduce tax arrears. Beyond technological advancements, increasing transparency and strengthening anti-corruption measures are essential steps in fostering public trust and encouraging voluntary tax compliance.

This paper serves as a foundation for future research on tax collection efficiency in Croatia. While extensive empirical research has been conducted on tax progressivity and tax efficiency in minimizing economic distortions, further studies should focus on the empirical evaluation of different tax collection mechanisms and enforcement strategies. By providing an overview of Croatia's current tax collection landscape, this paper offers a framework for future empirical research aimed at identifying and implementing more effective tax collection policies.

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While preparing this paper, the authors used *Grammarly* to check for grammatical errors and enhance the language. Following this, they reviewed and edited the content as necessary and take full responsibility for the final version.

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SUSTAINABILITY AND ESG MATURITY OF LARGE EUROPEAN FINANCIAL INSTITUTIONS: A STATE-OF-THE-ART AND FUTURE RESEARCH DIRECTIONS

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Abstract

An increasing number of organizations, including financial institutions, strategically embed sustainable development goals into their corporate DNA, largely struggling to meet ambitious ESG targets. Most organizations do not follow target-oriented (systematic and structural) roadmaps to guide them toward higher levels of ESG maturity. Sustainability/ESG maturity models are conceptual tools that are helpful in positioning and guiding organizations on their ESG journey. Motivated to offer a comprehensive and practical state-of-the-art overview, the purpose of this study is to systematically examine existing sustainability and ESG maturity models. Eight generic sustainability/ESG maturity models (four consultancy and four academic ones) were selected and content-wise examined. Criteria-based comparisons were done to determine key similarities and differences. Both consultancy and academic maturity models largely follow a consensual three-pillar view of ESG. Most are presented as universal and applicable across organizational sizes, sectors, industries, countries, etc. However, specific differences exist among existing sustainability/ESG maturity models, especially when comparing the number of maturity levels (less), the criteria, and the respective indicators used (more). In addition to the review insights offered, the ESG book dataset has been used to explore empirically the maturity levels of 75 large European financial institutions. Noticeable differences were detected and visualized within and across financial institutions, indicating that a component-based approach to assessing ESG maturity is needed in addition to the widespread composite index approach. The present study is a pioneering attempt to create a bird's-eye view of the ESG maturity landscape. It offers comparative insights, establishes the common ground between academicians and practitioners, and provides future research recommendations.

Keywords: financial institutions, ESG, sustainability, maturity models, ESG maturity

JEL classification: G21, Q56

Introduction

Sustainability – a universal value-adding philosophy, and ESG – Environmental, Social, and Governance as a specific framework used to evaluate and measure sustainability practices, have entered the boardroom (George et al., 2021) and dominate the contemporary strategic agendas (Lichtenthaler, 2023). The European Union has recently taken a global lead in development of the regulatory framework related to sustainable finance (e.g. the *EU Taxonomy Regulation*, *Sustainable Finance Disclosure Regulation – SFDR*, *Climate Benchmark Regulation – CBR*, *Corporate Sustainability Reporting Directive – CSRD*). The regulatory requirements, compliance trends, and stakeholder preferences (Cantero-Saiz et al., 2024) put continuous

pressure on executives to make their organizations ESG-friendly. However, since ESG has become indicative of a company's potential performance (Khamisu et al., 2024), almost 50% of contemporary CEOs and board members go beyond just compliance (KPMG, 2023) to ensure market-granting higher ESG proficiency levels. The ESG imperative is strong within the financial sector since banks, insurance companies, and other financial institutions realize their importance in supporting the ESG ecosystem (Park & Lee, 2023).

Although an increasing number of organizations (including financial institutions) strategically embed sustainable development goals (SDGs) into their corporate DNA (Tyan et al., 2024), they largely struggle to meet ambitious ESG targets (Pirc, 2023). Cross-country evidence recognized the lack of integrated analytical approaches and models as a primary reason for ineffective SDG implementation (Allen et al., 2018). Indeed, most organizations are missing a clear line of sight; they do not follow target-oriented roadmaps to guide them toward higher levels of ESG maturity. To respond to the managerial, institutional, and investors' interest in the materiality of ESG issues, scholars and practitioners (i.e., rating analysts) recently started with the development of descriptive and prescriptive ESG performance assessment tools (Madison & Schiehl, 2021) which make continuous monitoring possible (Terouhid & Ries, 2016), ease comparisons and enable more informative investment decisions (Mandas et al., 2023). With a maturity model, organizational decision-makers may develop an infrastructure for objectively measuring and assessing ESG value (Park & Lee, 2023) and focus on critical success factors for implementing ESG practices (Khamisu et al., 2024).

Motivated to offer a comprehensive and practical state-of-the-art overview, this study systematically examined existing sustainability and ESG maturity models. Specifically, eight generic maturity models were identified and studied. Criteria-based comparisons were made to determine key similarities and differences. In addition, the ESG book dataset has been used to explore the maturity levels of 75 large European financial institutions. The financial sector has been chosen as financial institutions have an important role in supporting the green transition and managing the financial risks of a climate-neutral and sustainable economy (EBA, 2025a). With an estimated 6.6 trillion EUR of ESG assets under management in 2024, the EU is the leading ESG market worldwide (Heflich & Saulnier, 2024). The positive role and significant improvements made by European financial institutions over the last few years regarding the availability and accessibility of ESG data has been recently acknowledged by the European Banking Authority (EBA, 2025b).

The present study offers a twofold contribution. It is a pioneering attempt to create a bird's-eye view of the ESG maturity landscape, with special attention given to the financial sector. This novel and emerging concept has recently been strongly introduced by leading or specialized consultancy firms in the corporate world. Unfortunately, scientific research has not adequately followed and supported it. Therefore, practice-science gaps are identified by systematically mapping recent developments. Moreover, comparative insights are offered, the common ground between academicians and practitioners is established, and future research recommendations are provided.

The ESG maturity concept

Definition and importance of maturity models

Generally, maturity is “when someone or something is completely grown or developed” (Cambridge Learner’s Dictionary, 2025). Within the business context, we apply maturity models as systematic and structural approaches to reaching the ultimate level of proficiency in a particular domain. They represent (self-)assessment tools (Kalender & Žikla, 2024) that may guide the strategy implementation process (Dümler et al., 2022) following typified and logical development paths. Every maturity model consists of several stages and is grounded in several dimensions or criteria (i.e., measurable and independent components that show different aspects of maturity (Gluszek, 2017) that define activities at diverse maturation levels.

Organizational maturity models have been with us since Crosby (1979) set the stage with his Quality Management Maturity Grid. Numerous maturity models have been developed addressing various managerial concerns in various disciplines (Kucinska-Landwojtowicz et al., 2024). Although their primary role is to guide, that is, to enable organizations to realize their strategic goals in a step-wise manner and act as a road map, according to Pöppelbuß and Röglinger (2011), they can also serve for diagnostics (descriptive models), improvement (prescriptive models) or comparing with others (benchmarking models). Determining maturity is crucial for organizational improvement and growth (Kucinska-Landwojtowicz et al., 2024).

Each maturity model or grid is a process-based framework, showing a logical (anticipated or typical) development (evolutionary or gradual) path from the initial to the final stage. These stages indicate distinct levels of organizational proficiency, signaling the strengths and weaknesses of an organization (Cognet et al., 2023). Besides describing main organizational attributes at a particular level, maturity models specify cumulative organizational capabilities/practices and people competencies essential in producing desired outcomes. Moreover, maturity models suggest a demarcation point between stages (Kucinska-Landwojtowicz et al., 2024). As they mature, organizations progressively become more advanced in managing their operations (Terouhid & Ries, 2016). However, they can also regress in their practices, thus ending up at a lower maturity level.

Common maturity model rules

Maturity models share common characteristics or design principles. Each maturity stage is represented by a specific set of criteria indicating different levels of development. However, these criteria (i.e., maturity dimensions) may be of equal (unweighted) or diverse importance (weighted). Upon their accomplishment, an organization can progress to the next level of maturity (Terouhid & Ries, 2016). As maturity levels represent systematic patterns of logically related and chronological steps, they cannot be skipped, although some recent work on sustainability argues the opposite (e.g., Dümler et al., 2022; Ramanauskaite et al., 2024).

There is no consensus regarding the number of different levels across maturity models. Scholars and practitioners usually use three to five levels to measure a continuum from total immaturity (level 1) to full maturity state (level 5). According to Ramanauskaite et al. (2024), maturity models with more levels offer more detailed level descriptions and guidelines. Moreover, key indicators have to be identified at each maturity level to provide performance feedback (Cognet et al., 2023). Irrespective of the number of levels, voluminous research confirmed that increased maturity is positively associated with desired organizational outcomes (Kucinska-Landwojtowicz et al., 2024). The same is valid for ESG; ESG-mature organizations outperformed immature ones by 40% (Pirc, 2023).

ESG pillars and themes

ESG consists of three pillars. The *environmental pillar* (ENV) represents organizational efforts to mitigate environmental costs and risks (Brooks & Oikonomou, 2018). It entails how a business uses renewable energy, handles waste, conserves natural resources, reduces pollution, protects biodiversity, and mitigates climate change (Khamisu et al., 2024). The *social pillar* (SOC) refers to organizational impact on people and society. It indicates whether managers and employees act according to legal requirements, follow moral and ethical standards, promote diversity and inclusion, and build and manage relationships with external stakeholders (Lee et al., 2016). The *governance pillar* (GOV) covers internal systems, policies, rules, and procedures that guide organizational decision-making, accountability, and ethical management practices. It concerns corporate issues such as report quality, politics, corruption, business ethics, and governance structure (Khan et al., 2016).

ESG rating providers use different criteria and activities to define, measure, and assess ESG. For example, Refinitiv (2022) uses over 630 manually processed company-level ESG measures grouped into ten categories (i.e., resource use, emissions, innovation, workforce, human rights, community, product responsibility, management, shareholders, CSR strategy). A similar yet somewhat different approach to ESG assessment is taken by Morningstar (Abercomby et al., 2023). The Morningstar Sustainability Rating considers 17 ESG risk factors (emissions, effluents, and waste; carbon and greenhouse gas costs; resource and energy management; land impact and biodiversity; climate and weather risks; social impact of products and services; human capital and human rights; product governance; data privacy and security; occupational health and safety; community relations; access to basic services; bribery, corruption and political risks; business ethics; corporate/transaction governance; institutional strength, governance, and transparency; peace and security). No different it is across other scholarly or consultancy-derived excellence models and respective ESG criteria. For instance, *Spectrum Innovation Group* highlighted five categories (leadership, strategies and plans, corporate culture, people and skills, and environmental awareness), while Cagnin et al. (2005) mentioned seven (strategy, partnership, motivation, competencies, communication, technology, operation).

Each maturity model or assessment framework examines issues distinctively classified into subdimensions and ESG pillars. In other words, while ESG pillars remain the same across all maturity models, noteworthy differences are present at dimension- and indicator levels. To overcome the biases of individual raters (Reiter-Palmon et al., 2019) and ESG rating disagreements among different providers (Bissoondoyal-Bheenick et al., 2024), Mandas et al. (2023) recently conducted ESG topic modeling. They extensively listed ESG criteria, determined their related words or dictionaries, and examined word frequencies across documents to understand the importance of a particular criterion. The output of their effort was a set of keywords that probabilistically best describe ESG categories and topics.

Sustainability and ESG maturity models

Search strategy

Maturity models often differ in scope and applicability, selected criteria, number of maturity levels, and type of assessment proposed (Cognet et al., 2023). They could be generic or industry-specific (the Process Classification Framework; APQC, 2024) or developed to analyze

the degree of maturity of a specific area, product, or process (Vasquez et al., 2021). Moreover, they may represent high-level self-assessment or in-depth audit tools developed by scholars (i.e., the academic community) or practitioners (i.e., consulting firms).

The search strategy included two separate efforts to acknowledge different source types and remain systematic in our approach. First, a ‘topic’ search in the Web of Science Core Collection citation database was conducted. To optimize search query and avoid broad yet non-relevant search results (Marzi et al., 2025), specific keywords (“ESG maturity” and “sustainability maturity”) were combined with Boolean operator ‘OR’ and yielded 38 documents. A closer manual investigation additionally filtered initial search results, ending with four academic maturity models of sustainability or ESG to be analyzed. Such a selective case study approach is necessary to gain in-depth theoretical insights (Eisenhardt, 2014). Second, maturity models developed by consultancy firms were searched for using the Google search engine. The exact keywords were used as in the database search. Since we hit over 10,000 pages, indicating a current surmounting interest for ESG consultancy, special attention has been given to generic sustainability/ESG maturity models of Big Four global consulting firms (i.e., Deloitte, KPMG, PwC, and Ernst & Young). Overall, eight sustainability/ESG maturity models were selected and content-wise examined.

Consultancy maturity models

Universal ESG maturity models have been increasingly developed in recent years, primarily by practitioners, while academicians are still lagging. In what follows, a few generic (multi-industry) sustainability or ESG maturity models developed by leading practitioners are briefly described.

KPMG (2023) designed the KPMG ESG Assurance Maturity Index to offer its corporate clients a roadmap and guidelines and help them to measure progress in the following ESG areas: governance, skills, data management, digital technology, and value chain. It is a weighted index that classifies organizations into three ranks: *beginners* (the bottom 25th percentile), *advancers* (the next 50th percentile), and *leaders* (the top 25th percentile). A large-scale follow-up global executive survey revealed that most organizations are at the beginning of the ESG journey (KPMG, 2023).

Deloitte has strongly addressed the maturity perspective by introducing several sustainability/ESG assessment tools. Among others (e.g., the Sustainable Investor Framework, The Sustainability Accelerator Tool, the Workforce Sustainability Maturity Model, and the ESG portfolio management maturity model), it launched the ESG SelfAssess. This free and easy-to-use tool advises organizations on identifying and focusing on the following areas of importance: governance, materiality assessment, ESG strategy, climate (GHG, climate risks and opportunity), people/social, data, processes, and controls, reporting and disclosure, and technology and platforms to enable ESG governance and reporting (Deloitte, 2025). Moreover, the self-assessment output recommends which steps must be taken to meet the evolving requirements of the ESG landscape.

PwC (2025) suggested four different ESG maturity profiles. *Minimalists* are organizations at the beginning of their ESG journey. They approach ESG reporting and disclosure as an act of compliance and primarily focus on environmental issues (e.g., energy transition, net zero). *Pragmatists* are organizations oriented to ESG risk rather than opportunities. C-level managers are not responsible for ESG, and science-based targets are missing. Instead, ESG activities and

reporting are segregated across different organizational units. *Strategists* are organizations with mature ESG disclosure and reporting. Moreover, they offer ESG-differentiated products or services. Their executives feel responsible for ESG, see opportunities and risks in ESG, and introduce science-based targets. Finally, *trailblazers* are purpose-led organizations with ESG embedded into their strategy, operations, and products/services. CEO is responsible for ESG, while their financial and non-financial reporting is integrated and aligned to ESG metrics.

Ernst & Young (2025) has developed an ESG maturity model to help organizations align and close the gap between financial and non-financial performance. Their inclusive scoring methodology covers 16 ESG themes (environmental pillar: air quality, nature impacts, climate change, GHG emission, Waste management and circular economy, water and wastewater management; social pillar: diversity and inclusion; Employee health, safety and wellbeing; Employment and working conditions; Human rights in supply chain; Societal value and license to operate; governance pillar: Board diversity and independence; Business ethics; Data privacy; Product quality and safety; Transparency and disclosure) and recognizes 94 key performance indicators (Ernst & Young, 2022).

Table 1: Big 4's sustainability/ESG maturity models

Consultancy	Model name	Maturity levels	ESG themes covered
KPMG	ESG Assurance Maturity Index	three (beginners, advancers, leaders)	governance, skills, data management, digital technology, value chain
Deloitte	ESG SelfAssess	-	governance, materiality assessment, ESG strategy, climate, people/social, data, processes, and controls, reporting and disclosure, and technology and platforms to enable ESG governance and reporting
PwC	ESG maturity profiles	four (minimalists, pragmatists, strategists, trailblazers)	-
Ernst & Young	-	-	Air quality, Nature impacts, Climate change, GHG emission, Waste management and circular economy, Water and wastewater management, Diversity and inclusion; Employee health, Safety and well-being; Employment and working conditions; Human rights in supply chain; Societal value and license to operate; Board diversity and independence; Business ethics; Data privacy; Product quality and safety; Transparency and disclosure

Source: Author

Academic maturity models

The academic literature has a history of maturity model development. Within the domain of present research, corporate social responsibility (CSR) models may be qualified as precursors of contemporary sustainability and ESG maturity models. For instance, Zadek (2007) developed his CSR development maturity model two decades ago, suggesting that organizations to 'become good citizens' have to follow a long 5-stage development process (i.e., defensive, compliant, managerial, strategic, and civil).

Baumgartner and Ebner (2010) published a highly cited four-level maturity grid to address sustainability in organizations. A *rudimentary level* characterizes an initial consideration of the sustainability agenda mainly focused on compliance with the regulatory framework. An

elementary integration (Level 2) additionally addresses compliance with sustainability-related laws, followed by a *satisfying consideration* stage (Level 3) where an organization targets the specific sustainability aspect. Finally, *sophisticated maturity* is defined by Level 4, representing an outstanding corporate effort towards sustainability (Baumgartner & Ebner, 2010). The levels of corporate sustainability were assessed for each ESG pillar separately.

Furthermore, Khamisu et al. (2024) conducted a thorough and rigorous multi-stakeholder field study to identify and classify critical success factors (CSFs) for ESG implementation. The resulting framework clustered 14 statistically significant CSFs into four groups: *autonomous* (have low driving power and weak dependency, e.g., ESG reporting guidelines, ESG materiality, Board independence), *dependent* (exhibit substantial dependence and weak driving power, e.g., Disclosure costs, Presence of CSR/ESG committee), *linkage* (high dependence and driving power; e.g., Third-party ratings), and *independent* (high driving power and little dependence, e.g., Earnings quality, Environmental performance dependence).

Finally, Vasquez et al. (2021) introduced a four-level Sustainability Maturity Model for micro, small, and medium enterprises (SMMM) using 42 factor-describing characteristics grouped within three dimensions (i.e., environmental knowledge management, strategies, good environmental practices, and environmental management systems). Level 1 represented companies with *insufficient sustainability maturity* where environmental issues are irrelevant in internal activities. Level 2 companies have *basic sustainability maturity* and give importance to environmental management issues (e.g., environmental policy is in place). Level 3 companies have *developed sustainability maturity*; environmental management systems have been defined, and employees are trained to implement environmental strategies and invited to suggest innovative ideas. Finally, Level 4 companies reached *consolidated sustainability maturity*; Environmental sustainability drives their strategic agenda, and resources are assured for implementing company-wide environmental practice programs (Vasquez et al., 2021).

Table 2: Academic sustainability/ESG maturity models

Author(s)	Model name	Maturity levels	ESG themes covered
Baumgartner & Ebner (2010)	-	four (rudimentary, elementary, satisfying consideration, sophisticated)	economic (innovation and technology, collaboration, knowledge management, processes, purchase, sustainability reporting), ecological (energy and material resources including recycling, emissions into the air, emissions into the water, emissions into the ground, waste, and hazardous waste, biodiversity, environmental issues of the product, social (corporate governance, motivation and incentives, health and safety, human capital development, ethical behavior, and human rights, no controversial activities, no corruption and cartel, corporate citizenship)
Khamisu et al. (2024)	-	four (autonomous, dependent, linkage, independent)	14 critical success factors (e.g., ESG materiality, presence of CSR/ESG committee, third-party ratings, earnings quality)
Vasquez et al. (2021)	SMMM	four (insufficient, basic, developed, consolidated)	environmental knowledge management, strategies, good environmental practices, and environmental management systems

Source: Author

The ESG maturity of large European financial institutions

Numerous ESG data providers and rating agencies exist (e.g., Refinitiv, Morningstar, Bloomberg, S&P Global, Sustainalytics). The ESG rating agencies cover multiple sectors (including finance) and the extensive number of companies (including banks and other financial institutions) (Tsang et al., 2024). Comparative empirical evidence continuously showed the divergence of prominent ESG ratings (Berg et al., 2022; Bissoondoyal-Bheenick et al., 2024). Therefore, transparent and comparable yet less investigated data from the ESG Book platform (<https://www.esgbook.com>) was used. This novel ESG rating agency continuously assess sustainability performance of 9,000 publicly listed entities across the globe using 450+ indicators. Their ESG Performance point-in-time score (0-100 scale) contains pillar- (i.e., the environmental, social, and governance) and dimension-level (i.e., business model & innovation, environment, human capital, leadership & governance, and social capital) assessments. It shows the sustainability performance of companies based on publicly available (company reported) data. Scores are derived using a transparent aggregation methodology – with flexible outputs to accommodate different use cases. Specifically, a relative scoring approach is used to express company performance relative to other companies in a universe (ESG Book, 2023). Moreover, the Total score is calculated from the 26 Category scores using a systematic weighting approach (ESG Book, 2023).

The study sample comprised 75 large market-cap European financial institutions covering 18 countries. The United Kingdom (14), Sweden (9), Switzerland (7), the Netherlands (7), and Germany (7) were the most represented countries. Besides major national or regional banks (36), other institution types were also represented, such as multi-line insurance companies (8), investment banks/brokers/managers (8), or financial conglomerates (5).

The average ESG performance score was 59.23 ($SD = 8.44$). The governance pillar was better rated ($M = 64.07$, $SD = 9.70$) than the environmental ($M = 61.49$, $SD = 13.14$), and the social pillar lagged substantially ($M = 54.64$, $SD = 9.49$). At the ESG-dimension level, it has been determined that large European financial institutions primarily excel in Human capital ($M = 68.14$, $SD = 14.29$) and Leadership & Governance ($M = 64.48$, $SD = 10.08$), while other ESG dimensions, such as social capital ($M = 51.18$, $SD = 10.20$) remain less developed.

Since there is no consensus regarding the maturity level thresholds, sampled organizations were categorized into the following five maturity levels: Level 1 (up to 40 points), Level 2 (40 to 50 points), Level 3 (50 to 60 points), Level 4 (60 to 70 points), and Level 5 (70 points and more). Following Baumgartner & Ebner (2010), total, pillar-based, and dimension-based ESG scores were used for multiple maturity-level assessments. Overall, most sampled financial institutions were at Level 3 (41.3%) and Level 4 (41.3%) maturity; only four (5.3%) reached the highest maturity level. However, in-depth assessments indicated distinguished within-organization practices across pillars and dimensions. Specifically, more than two-thirds of the sampled organizations achieved Level 4 or Level 5 maturity in their governance (68.9%) and environmental (64.8%) practices, compared to only 25.7% of organizations meeting high maturity levels of their social practices.

Table 3: Maturity levels of large European financial institutions

OrgID	Total ESG	ESG pillar			ESG dimension				
		Environmental	Governance	Social	Business model & innovation	Environment	Human capital	Leadership & governance	Social capital
FinOrg1	5	5	5	-	-	4	-	5	5
FinOrg2	3	4	4	2	4	2	4	4	3
FinOrg3	3	3	3	3	1	3	4	4	3
FinOrg4	3	3	4	3	4	3	2	4	3
FinOrg5	3	4	4	2	4	3	4	4	3
FinOrg6	3	4	4	2	4	4	3	5	3
FinOrg7	3	4	3	2	5	3	5	3	3
FinOrg8	1	1	3	1	1	1	2	3	1
FinOrg9	3	4	4	3	4	3	5	4	3
FinOrg10	3	3	4	2	3	3	2	4	3
FinOrg11	4	4	5	4	4	3	-	5	4
FinOrg12	4	5	4	3	-	3	5	3	4
FinOrg13	4	2	5	4	1	4	4	5	4
FinOrg14	3	4	2	2	4	4	3	1	3
FinOrg15	2	1	3	2	1	2	4	3	2
FinOrg16	5	-	-	2	-	4	5	-	5
FinOrg17	5	-	5	5	-	5	5	5	5
FinOrg18	4	5	3	3	-	3	4	3	4
FinOrg19	2	1	2	2	1	1	2	2	2
FinOrg20	3	3	5	3	3	3	4	-	3
FinOrg21	4	3	5	5	2	4	5	5	4
FinOrg22	4	-	5	4	-	5	-	5	4
FinOrg23	2	2	1	1	3	2	1	1	2
FinOrg24	4	5	5	4	5	5	-	5	4
FinOrg25	4	5	5	3	-	4	5	4	4
FinOrg26	3	4	3	3	4	3	4	3	3
FinOrg27	3	4	4	3	4	2	3	4	3
FinOrg28	3	3	4	3	3	3	5	4	3
FinOrg29	3	3	3	2	2	3	2	4	3
FinOrg30	3	1	4	4	1	2	4	4	3
FinOrg31	3	4	4	2	4	3	4	4	3
FinOrg32	3	4	3	3	4	3	5	3	3

OrgID	Total ESG	ESG pillar			ESG dimension				
		Environmental	Governance	Social	Business model & innovation	Environment	Human capital	Leadership & governance	Social capital
FinOrg33	4	5	4	3	-	3	-	4	4
FinOrg34	2	2	2	1	1	2	1	2	2
FinOrg35	4	5	5	2	-	3	5	5	4
FinOrg36	3	5	4	2	4	5	5	4	3
FinOrg37	4	4	5	3	4	3	-	5	4
FinOrg38	3	4	4	3	4	3	4	4	3
FinOrg39	3	2	4	3	1	3	5	5	3
FinOrg40	4	4	5	4	4	4	5	5	4
FinOrg41	4	4	5	4	4	4	5	5	4
FinOrg42	4	3	5	3	2	4	-	5	4
FinOrg43	1	1	1	1	1	1	1	1	1
FinOrg44	5	5	5	4	-	3	-	4	5
FinOrg45	3	4	3	2	4	2	3	3	3
FinOrg46	3	3	5	2	3	4	-	5	3
FinOrg47	4	4	5	3	4	3	5	5	4
FinOrg48	3	4	4	3	4	3	4	4	3
FinOrg49	4	4	5	4	5	3	-	5	4
FinOrg50	3	4	3	3	4	3	5	3	3
FinOrg51	3	4	3	3	4	3	4	3	3
FinOrg52	4	5	4	4	-	4	5	4	4
FinOrg53	3	2	4	3	2	2	5	4	3
FinOrg54	4	4	5	4	4	3	5	5	4
FinOrg55	4	5	5	3	5	5	-	5	4
FinOrg56	4	5	4	3	-	4	3	4	4
FinOrg57	3	1	3	3	1	2	4	3	3
FinOrg58	4	4	4	3	5	4	-	4	4
FinOrg59	4	4	4	3	4	4	3	4	4
FinOrg60	4	4	5	4	5	4	5	5	4
FinOrg61	4	4	5	4	4	4	-	5	4
FinOrg62	4	4	5	3	5	3	-	5	4
FinOrg63	4	4	5	2	4	3	5	5	4
FinOrg64	3	2	4	2	3	2	3	4	3
FinOrg65	4	5	4	3	-	3	4	4	4

OrgID	Total ESG	ESG pillar			ESG dimension				
		Environmental	Governance	Social	Business model & innovation	Environment	Human capital	Leadership & governance	Social capital
FinOrg66	4	4	3	4	4	3	4	3	4
FinOrg67	3	4	4	3	5	3	5	4	3
FinOrg68	3	4	3	3	4	3	5	3	3
FinOrg69	4	-	4	4	-	5	5	4	4
FinOrg70	2	2	3	2	3	2	5	3	2
FinOrg71	4	4	4	4	4	4	5	4	4
FinOrg72	3	3	3	3	3	3	3	3	3
FinOrg73	2	1	2	3	2	1	1	2	2
FinOrg74	4	4	4	4	4	4	5	3	4
FinOrg75	2	2	2	2	2	2	2	2	2

Source: Author

Note: ESG Performance Score points were transformed into maturity levels using the following calculus: Level 1 (up to 40 points), Level 2 (40 to 50 points), Level 3 (50 to 60 points), Level 4 (60 to 70 points), and Level 5 (70 points and more).

Discussion and conclusion

The present study systematically reviewed existing sustainability and ESG maturity models. Although consultancy firms excelled in providing ESG services and might leave an impression of being forerunners, scholars' efforts to map and support the ESG journey do not lag substantially. Both consultancy and academic maturity models largely follow a consensual three-pillar view of ESG. Most are presented as universal and applicable across organizational sizes, sectors, industries, countries, etc. However, we should favor more industry-specific solutions (KPMG, 2023) since rating agencies primarily assess corporate ESGs by applying a sectoral perspective (Mandas et al., 2023). The industry-level approach is well-received in other disciplines (e.g., business process management; APQC, 2024). Moreover, function-specific frameworks (e.g., Deloitte's maturity model for ESG portfolio management; Dümmler et al., 2022) might also be helpful and are welcome.

Specific differences exist among existing sustainability/ESG maturity models, especially when comparing the number of maturity levels (less), the criteria, and the respective indicators used (more). A modal number of maturity levels is four, and most authors recommended conducting an overall assessment, although a few suggested a pillar-based approach (e.g., Frantz et al., 2023). As expected, academic maturity models are usually more rigorous and transparent than practitioner-developed ones. The ESG maturity software framework developed by a Portuguese consultancy firm, C-More Sustainability, is an exception. Their questionnaire-based framework (more than 350-450 metrics used) helps organizations calculate their ESG maturity index and provides relevant initiatives, strategies, and action plans (Cruz & Matos, 2023). Nevertheless, future maturity model development attempts might use a Delphi method (e.g., Liou et al., 2023) or similar techniques to build consensual evidence on ESG.

Another distinguishable feature across maturity models is the relative weights of the assumed sustainability/ESG aspects. The building blocks of ESG maturity can be of (un)equal importance (Cognet et al., 2023). For example, environmental pillar issues have a marginal weight in the financial sector, while social pillar topics are equally important across sectors (Mandas et al., 2023). Similar logic can be used at the level of ESG themes and activities. To gain a better understanding of sufficient (i.e., nice-to-have) versus necessary conditions (i.e., must-have) of ESG maturity, a necessary condition analysis (Dul, 2016) is recommended. This advice is aligned with the critical success factor theory (Kannan, 2018), supporting the view that the limited number of ESG components is indispensable for achieving higher maturity levels.

The approach in the present study of large European financial institutions envisioned five maturity levels. The secondary data (i.e., ESG performance scores) was weighted by the data provider (i.e., the ESG Book). Noticeable differences were detected and visualized within and across financial institutions, indicating that a component-based approach to assessing ESG maturity is needed in addition to the widespread composite index approach. Moreover, the preliminary findings favor the critical success factor theory (Khamisu et al., 2024). Therefore, future ESG maturity research may focus on determining a few industry-specific key performance indicators for achieving each ESG maturity level.

No matter which sustainability/ESG maturity model is chosen and how it has been developed, each has a mission to embed ESG into broader organizational practices and impact business, the economy, and society (George et al., 2021). Unfortunately, although process-based, none of the existing models offered temporal evidence or information on how long each maturity

stage should last. Sustainability and ESG transitions are disruptive and long-term (Ramanauskaite et al., 2024), so knowing “what” and “when” to expect throughout this fundamental corporate transformation effort would be beneficial.

Although integrated models do not exist, a few models (e.g., Roy et al., 2023) combined maturity and competency perspectives. Such an integrative approach is much needed if organizations want to make the ESG transformation happen. Promising examples of competency-driven frameworks (e.g., Combe, 2022) should be paired and aligned with sustainability/ESG maturity models. Managers must realize that ESG—a strategic priority with a substantial impact on corporate financial performance and risk profile (Eccles & Taylor, 2023)—should not be approached as a standalone effort of a few individuals (e.g., Chief Sustainability Officer or sustainability task force). Instead, to become ESG leaders, organizations must create new positions, redesign existing jobs, train employees, and introduce ESG-supportive performance targets to stimulate engaged workforce efforts (KPMG, 2022, 2023).

This study is not without limitations. While it provides a conceptual overview of an emerging topic (i.e., ESG maturity), it lacks an in-depth understanding of the criticality and relative importance of various ESG criteria. Although ESG performance scores of large European financial institutions were analyzed, future research should obtain and use a large-scale empirical dataset to gain generalizable insights. On a related note, we still cannot conclude the universality of existing maturity models. National, sectoral, and organizational characteristics should be analyzed with corporate ESG practices to reveal the role of the context when pursuing ESG maturity within organizations. Next, the study’s attention was primarily given to maturity models developed by leading consultancy firms (e.g., the Big 4), thus neglecting the know-how generated within smaller yet ESG-specialized consultancies. Similarly, future academic research should investigate ESG maturity (and distinguish it from sustainability maturity) using bibliometric data and introduce rigorous content/textual analysis.

In conclusion, sustainability/ESG maturity models are conceptual tools helpful in positioning and guiding organizations on their ESG journey. They help organizations benchmark themselves, identify what they are good or bad, and offer actionable steps to progress. However, a maturity model approach is not without weaknesses (e.g., the baseline of what matters is shifting rapidly; George et al., 2021) and, therefore, should not be treated as a standalone avenue for making ESG a panacea to market power (Bond & Levit, 2025). Maturity frameworks have their practical value and should not be overlooked (nor overemphasized) by academicians and practitioners.

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A STATISTICAL BREAKDOWN INTO THE EU-27 ENVIRONMENTAL TAXATION. PROFILING REGIONALITY SPECIFICITY IN A DECADE OVERVIEW

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Abstract

Environmental taxation has become a recurrent subject on the international agenda, being instrumental for the broader sustainability prioritization, as well as a pillar in the newer, greener economy of the future. Thus, the European Union member states have designed a multitude of practices meant to reduce the negative environmental impact, which broadly translated into energy, pollution, and transport taxes. However, these practices are not homogeneous, with the EU institutional guidelines being implemented differently throughout the Organization. As a consequence, in the current paper, we aim to confirm the heterogeneity hypothesis while also extending the research objective to a regional and evaluative assessment of the taxation discrepancies. The methodology will be based on several statistical instruments, complemented by the adjacent graphical representation. The one-way analysis of variance and the correspondence analysis will be the central points, along with the preliminary statistical tests necessary to illustrate their validity. Finally, in the case of the actual indicators, we will focus on the share of environmental taxes as part of the total taxation revenues, considering it the most relevant for the context at hand. The initial exploration will profile two moments in time, 2014 and 2023, having the potential to illustrate the time dynamics happening over the last decade in the European Union. Lastly, in terms of results, we were able to correlate the nucleic regions of the EU with a correspondent volume of environmental taxes while also confirming the general heterogeneity in the area and the slight downward trend.

Keywords: environment, taxation, EU-27, one-way ANOVA, correspondence analysis.

JEL classification: Q58, H23, C12, C38, R11

Introduction

Environmental taxation has been a dynamic subject over the last decades, taking on multiple roles in terms of implementation. For example, in the European Union area, this instrument has been seen as a corrective measure meant to minimize the negative environmental effects, as a driver that could promote and stimulate the transition towards a newer, greener, and more sustainable economy, and as a steady source of revenue for the fiscal macro-equilibrium of the member states. However, in the current paper, we will focus our attention on the first two valences of the concept, with an immediate effect on both the population's behavior and the global community's safety. From this perspective, taxation's ultimate goal will be to alter the

decision-making process of both individuals and businesses while also stimulating behavioral changes that can impose new societal contexts and facilitate the transformation of the new economy.

The EU will refer to an environmental tax as a tax whose base is a physical unit of something that has a proven, specific negative impact on the environment (Eurostat, n.d.). Thus, this type of taxation will become a centerpiece in the broader objective of pollution control and resource management, being omnipresent on the international socio-economic agenda. As mentioned by the European Environment Agency (2022), environmental taxes are seen as a way to support the transition toward a climate-neutral economy by 2050 while also achieving the objectives of the European Green Deal (European Commission, 2020), the main growth strategy of the current decade. Besides reaching neutrality in the next 25 years, one of the other assumed goals will be the reduction of greenhouse gas emissions by 55% by 2030, with the clock ticking not in our favor.

Therefore, a great deal of emphasis has been put on pushing forward legislative guidelines that not only promote and explain the crucial role of taxation but also drive the implementation. Corroborated with the fact that the point of interest at a macroeconomic level is the production and consumption of goods and services, environmental taxes will closely follow this principle, being designed as a control mechanism of every sub-stage of the productive national processes, starting from resource extraction, energy production, transportation, and consumption-related activities.

As a consequence, the socio-economic reasoning behind environmental taxation in the European Union will be clear, however, we still need to assess the status of implementation from a regional and timing perspective. The current paper aims to provide a response, with its sub-adjacent objectives being represented by: validating whether there are geographic differences when it comes to environmental taxation and exploring the dynamics in a 10-year window of time.

However, before proceeding forward, it's important to point out a procedural limitation of the EU, namely, that the organization cannot impose environmental taxes directly at a national level. Its part is a consultative and partially directive one, shaping the strategies, policies, and action plans across its member states. However, its role should not be minimized since the guidance provided through the many legislative propositions, corroborated with a clear, formal, and nationally endorsed prioritization, can prove to be a successful recipe for an environmentally secure future. This is proven by the European Commission's (2021) revised *EU Energy Taxation Directive* (ETD), a legislation meant to harmonize national legislation to avoid distortion in the internal market (European Court of Auditors, 2022). However, since the energy taxation framework has not been revised since 2003, the synchronization results between countries might be late to appear, therefore validating our initial hypothesis regarding the heterogeneity of environmental taxation across the EU.

Scope and literature review

EU Documentation on the Environmental Taxation

Before going forward in the applicative section of our paper, a necessary step will be to highlight some fundamental principles at the European level in the broad context of

environmental taxation. The first, and maybe the most crucial one, is the fact that green taxation should be perceived as a part of a much broader policy context, involving plenty of pricing instruments, financial flows, investments, and legislative projects. Thus, at the national level, the priority should be personalizing the general EU guidelines through forward communication between multiple stakeholders, which can ultimately generate a unified growth strategy, having green economic principles as a pillar and a strict alignment with climate objectives.

Another important principle is the fact that in order to ensure social fairness, *the effect of green taxation should be felt by the social actors that consume the most* (European Commission, n.d.). In other words, the EU directive states that those who inflict the most environmental damage (such as large corporations, high-emission industries, and private, wealthy individuals) should bear the largest share of the green taxation, protecting the more vulnerable social groups. Finally, the last mentioned, which is not a clear principle but has been pushed forward in the form of a tactical practice, is the transferring of labor taxes towards environmental ones in a fiscal reform meant to sustain the economy in a more inclusive way. Thus, as mentioned by the European Environmental Agency (2022), taxes have shifted from being applied to economic functions called ‘goods’, such as labor (personal income tax), to activities that lead to environmental pollution and climate change. At the same time, as a general concern of the future, European institutions are preoccupied with finding a balance between revenue stability (since around 5% of the taxes come from the environmental dimension) and the new, decarbonized economy, which will rely more on renewable sources of energy, being therefore not so heavily taxed, and potentially leading to a dangerous reduction in the overall fiscal volumes.

Another necessary step in the EU context exploration is to reference the high number of publications that have environmental taxation as a subject, starting from the aforementioned *European Green Deal* and going to the European Council’s (2021) *Fit for 55*. At the same time, all the directives mentioned earlier will be based on a multitude of studies and reports, for example, *The study on energy costs, taxes, and the impact of government interventions on investments* (European Commission, 2020), or *The Energy Prices and Costs Report* (European Commission, 2020).

Furthermore, we need to include in this exploration the specific documentation with a much greater directive power over the national governments, such as the *Carbon Border Adjustment Mechanism* (CBAM). This project has been designed as a way to put a fair price on the volumes of emissions during the production of carbon-intensive goods that are entering the EU (European Commission, 2024), with a definitive regime starting from 2026 and a transitional phase happening as we speak. Another measure is represented by the *Carbon Pricing Schemes*, including the *EU Emission Trading System*, which has been linked to a recently revised energy taxation in a cap-and-trade system (European Commission, 2024). Since its implementation in 2005, the practice aimed to limit the total amount of greenhouse gases (GHGs) and incentivize industries to strictly reduce their emissions in accordance with the climate targets set for each year. The initiative has proven to be successful since, as mentioned by the institutional reports, *the EU ETS has helped bring down emissions from the European power and industry plants by approximately 47%, compared to 2005 levels* (European Commission, n.d.), while also providing considerable flows of revenue over the last 20 years.

Experts related literature

However, relying solely on the EU documentation is not enough to construct a comprehensive understanding of the state of environmental taxation. Therefore, we have explored the experts' literature on the subject, starting from the most general publications, focused on macroeconomic equilibrium (Bovenberg & Goulder, 1996, Bovenberg & Goulder, 2002) or the environmental tax reforms and their impact on revenues, pollution, and economic efficiency (Williams, 2016, Bosquet, 2000). Going next to the applicability in the European Union scene, we have found a multitude of articles that tackle the subject of environmental taxes, either from a general point of view (Stern & Köhlin, 2017), a comparative one, with a focus on a specific country (Hodžić & Bratić, 2015), or with a focus on their general effectiveness (Piciu & Trica, 2012), the emissions reduction impact (Wolde-Rufael & Mulat-Weldemeskel, 2023), the acceleration of renewables transition (Dogan et al., 2023), or encouraging the environmentally-friendly behavior (Vasilyeva et al., 2023).

Furthermore, we have found three papers that proposed objectives similar to the current one, namely the illustration of trends within the EU. The first one has been proposed by Delgado et al. (2022) but with a different methodology, focusing on a club convergence analysis and the broader period of 1995-2016. At the same time, Famulska et al. (2022) have also designed a trend exploration of the area with a similar horizon of time: 2009-2020, while Koziuk et al. (2020) have elaborated an article meant to assess the effectiveness of the environmental tax system in European countries. In terms of results, the latter article showed two groups of states and afferent taxation trends: one downward and one upward. This distinction will be also confirmed through our analysis, along with other common observations, such as the slightly downward trend for the share of environmental tax revenues, or the clusterization of the EU states into different entities based on their taxation volumes, with limited (and unsuccessful) harmonization efforts (Delgado et al., 2022).

Considering all these elements and the creation of a conceptual status quo in the European arena, we can now state our main research hypothesis and objective. As seen before, we are starting from the fact that environmental taxation is not a homogeneous process, being subject to national strategy. Thus, we will first present the distribution of taxes in a decade overview, extracting several insights into the growth or decreasing trends. Further on, we will explore the existence of regional differences from a statistical point of view, concluding with a new profile of the EU-27 scene, composed by linking the regional poles to certain environmental levels and taxation trends.

Finally, regarding the main indicators that we have used, it's important to further split down the broad environmental umbrella. Therefore, from a classification point of view, this type of taxation can be split into three main axes, which correspond to an adjacent revenue flow: energy, transport, and pollution & resources. Starting with the first one, the energy taxes will be applied to energy products such as electricity or other energy resources (gas, coal, fuels). The adjacent sustainability goal will be clear: to encourage an energy efficiency approach that can ultimately reduce greenhouse gas emissions (GHG). Next, transport taxes will be applied on vehicles and transportation activities, with the objective of minimizing the car pollution impact and motivating both the local administrations and communities to switch towards clean transport options. Last but not least, the pollution and resource taxes will be put together since the resource practice will refer to the taxes imposed for the extraction and use of natural resources, with a clear goal of pushing conservation in a sustainable manner. Regarding pollution, these measures will be applied to activities that directly harm the environment, in an

initiative meant to discourage a negative footprint and fund environmental restoration. Therefore, after getting a glimpse at the main indicator, we can now go ahead with the detailing of our datasets, as well as the methodology.

Methodology

Dataset

Tackling now the actual measurement, there will be two ways to study the category of environmental tax revenues. The first one will look at the percentages generated as a share of the gross domestic product (which will be identified further as %GDP), while the second one will measure the volumes as a share of the total revenue flows coming from taxes and social contributions (noted further as %TAX). Both of these can show different sustainability trends, especially when studied at the national and regional levels.

Furthermore, the category can be once again divided into three sub-groups, based on the classification profiled earlier: energy, transport, and pollution & resource taxes. Reiterating the above, each country at the European level has the responsibility and freedom to design its own taxation procedures, so there will be many examples that fall into each category. However, as a general description, we have included a summary in Table 1, with several examples for each subgroup, meant to better profile the type of production processes that are affected by the respective taxations.

After exploring the indicator definition, we can proceed to describe the statistical methods that we will employ in the analytical exploration as part of our response to the research objective proposed.

Table 1: Environmental taxes – classification and examples

ENVIRONMENTAL TAXES	Types of taxes	
	ENERGY TAXES	• Levies on energy products and electricity used for stationery and transport purposes (such as petrol & diesel) • CO2 taxes imposed on energy products • Electricity Consumption taxes
	TRANSPORT TAXES	• Motor vehicle ownership and usage: fuel taxes, vehicle registration taxes, congestion charges, road tolling
	POLLUTION & RESOURCE TAXES	• Taxes on raw material extractions • Taxes on emissions to air and water • Waste disposal taxes, plastic bag taxes, water use taxes • Noise management taxes

Source: authors' own processing based on Eurostat indicators

Statistical analysis

Analysis of variance

Shapiro-Wilk Test

Starting with the analysis of variance, the goal of the method will be to identify the potentially significant differences between several distinct groups. However, a mandatory step before computing the One-way ANOVA will be testing the normal distribution of our data series. This will be done using the *Shapiro-Wilk test*, based on the following hypothesis.

- *Null Hypothesis (H0)*: The data follows a normal distribution;
- *Alternative Hypothesis (H1)*: The data does not follow a normal distribution.

Furthermore, for the hypothesis assessment, we will use the test statistic W , calculated using the (1) formula, where n is the number of observations, $X_{(i)}$ is the i –th ordered statistic, $\bar{X}$ is the mean of the variable, and a_i are the coefficients derived from the expected values of the order statistics in the case of a normal distribution. Thus, when interpreting the results, we will look for a value closer to 1, which can be assessed as a normally distributed conclusion.

$$W = \frac{(\sum_{i=1}^n a_i X_{(i)})^2}{\sum_{i=1}^n (X_i - \bar{X})^2} \quad (1)$$

ANOVA method

Coming back to the ANOVA part, the method will be using an *F-statistic* (2), which will be calculated using two variance indicators. The first one will be the variance between groups (*mean square between* – *MSB*), while the second one will be the variance within groups (*mean square within* – *MSW*).

$$F = \frac{MSB}{MSW} \quad (2)$$

The formulas behind the indicators will be profiled in equations (3) and (4), where n will be the number of observations and k the number of groups.

$$MSB = \frac{SSB}{k-1}, \quad MSW = \frac{SSW}{n-k} \quad (3)$$

$$SSB = \sum_{j=1}^k n_j (\bar{X}_j - \bar{X})^2, \quad SSW = \sum_{j=1}^k \sum_{i=1}^{n_j} (X_{ij} - \bar{X}_j)^2 \quad (4)$$

Lastly, the hypothesis for the One-way ANOVA will give us the desired answer in terms of homogeneity in the European Union, being in a general form, addressed as follows:

- *Null Hypothesis (H0)*: There is no significant difference in the mean value of the variable across the categories;
- *Alternative Hypothesis (H1)*: At least one category mean is significantly different.

Tukey's Honest Significant Difference

Since the analysis of variance will tell us whether there are, or not, significant differences between the groups, but not any other characterization, we might need a complementary method that can better profile those differences. For this, we will use *Tukey's Honest Significant Difference* method, which will be able to generate pairwise comparisons based on the HSD statistic, the lower and upper confidence interval bound, and the p-values. Thus, the test will be computed using the formula in equation (5), where $\bar{X}_i$ and $\bar{X}_j$ are the means for the groups that are compared, MSW is the mean squared within the ANOVA and n is the number of observations.

$$HSD = \frac{|\bar{X}_i - \bar{X}_j|}{\sqrt{\frac{MSW}{n}}} \quad (5)$$

In conclusion, these three statistical instruments will be computed in order to illustrate whether regional differences could be profiled in the European Union, based on a geographical classification we will describe further. However, the second part of our exploration will rely on an analysis of correspondence that can better describe the linkages between regionality and taxation in a qualitative way.

Analysis of Correspondence

Chi-Squared Test

The *Chi-square test*, similar to *Shapiro-Wilksinon*, will be a mandatory statistical test before computing the analysis of correspondence. Its objective will be to determine whether there is a significant association between two categorical variables through the comparison between the observed (O_i) and expected frequencies (E_i) under the following hypothesis:

- *Null Hypothesis (H0)*: The two variables are independent;
- *Alternative Hypothesis (H0)*: The two variables are dependent.

Thus, the formula behind the Chi-Square indicator will be described in equation (6).

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}, \text{ where } E_i = \frac{(R_i \times C_j)}{n} \quad (6)$$

After the computation of the test, the next step in the correspondence analysis will be performing the *Singular Value Decomposition (SVD)*, which can reduce the dimensionality of the contingency table. The mathematical principle behind this will be illustrated in equation (7), with X being the standardized matrix (representing the difference between observed and expected frequencies), U is the matrix of left singular vectors (row associations), Σ is the diagonal matrix of singular values (the importance of each dimension), and V^T is the matrix of right singular vectors (column associations).

$$X = U \times \Sigma \times V^T \quad (7)$$

As a last methodological mention, all of the below computations have been made using R language and environment and will be applied to the indicators described in the previous section.

Results

EU-27 Average picture - 2014 versus 2023

Reaching the results section, the first milestone in our analysis is to provide a broader picture of the European Union before deep-diving into regional and national levels. Therefore, we can start by looking at the EU-27 averages for the three tax indicators in a comparative overview between 2014 and 2023. The EU mean values can be observed in Table 2 in the two forms previously explained. Besides those, we have also included the shares for each of the three sub-categories under the environmental umbrella in an effort to understand whether any internal dynamics have appeared when it comes to the crucial European sustainability agenda.

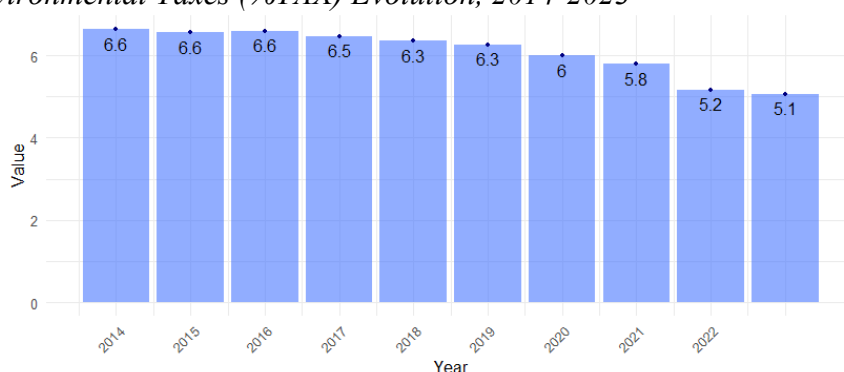
Table 2: European Averages – 2014 versus 2023

TYPE OF TAXES	% GDP		% TAX		% ENVIRONMENTAL TAXES	
	2014	2023	2014	2023	2014	2023
ENERGY	2.17%	1.58%	5.29%	3.94%	79.8%	77.9%
TRANSPORT	0.46%	0.36%	1.12%	0.91%	16.9%	18%
POLLUTION/RESOURCES	0.09%	0.08%	0.22%	0.21%	3.3%	4.2%
ENVIRONMENTAL	2.72%	2.03%	6.63%	5.06%	100%	100%

Source: authors' own processing based on Eurostat data

Therefore, we can observe that the ratio of environmental tax revenues in 2023 has reached the lowest point, the European average being set at around 2% of the gross domestic product, slightly decreasing from the 2.72% average in 2014. At the same time, the share of the total tax revenues shows a decreasing trend as well, from a 6.6% value to 5% in 2023. This can also be seen in Figure 1, where we have plotted the same environmental taxes as an average at the EU level, in the entire 2014-2023 period. This can help with showcasing the constant rhythm throughout 2010s, followed by the clear downward tendency post-pandemic.

Figure 1: Environmental Taxes (%TAX) Evolution, 2014-2023



Source: authors' own processing, based on Eurostat data

Furthermore, when it comes to internal distribution, in 2023, around 78% of the revenues came from energy taxes, 18% were generated by transport, while pollution and resources only accounted for 4%. However, no major transitions could be observed between the two moments of time, other than a slight increase in the percentage of the pollution/resources allocation, to the detriment of the energy one, a fact that could be interpreted as a more climate prevention prioritization.

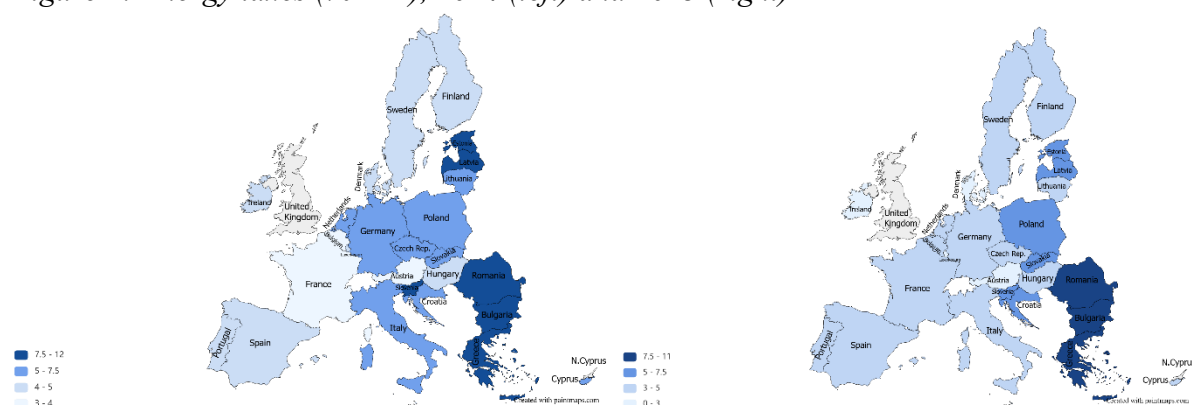
After this initial exploration, we can draw a first conclusion that although the focus has been more and more intense on the environmental agenda, and taxes could be seen as a fundamental implementation instrument, there hasn't been a clear movement in terms of revenue distribution.

EU-27 Regional Picture - 2014 versus 2023

Next, we will now proceed to assess our first research objective, with a focus on the regionality trends and understanding the national distribution in the 27 member states of the European Union. Thus, in the mappings done forward, we have used the shares from the total tax revenues for all three types of environmental indicators, with the amplitude being heterogeneous, starting from 0% and reaching values close to 15%. At the same time, we have placed next to each other the two moments that we selected, namely 2014 and 2023, in a 10-year comparative overview meant to better profile time volatilities and evolutions.

To start with the first indicator, as seen in Figure 2, in terms of energy taxes, the highest levels of energy taxation seem to be registered in the southern part of Europe: Greece, Bulgaria, and Italy are among the countries that show the highest percentages for both the 2014 and 2023 moments. At the same time, we can see some evolutions across the 10-year period, with Romania, Bulgaria, and Greece increasing their taxation level, while Slovakia, Italy, and Latvia decreasing their regulatory practices.

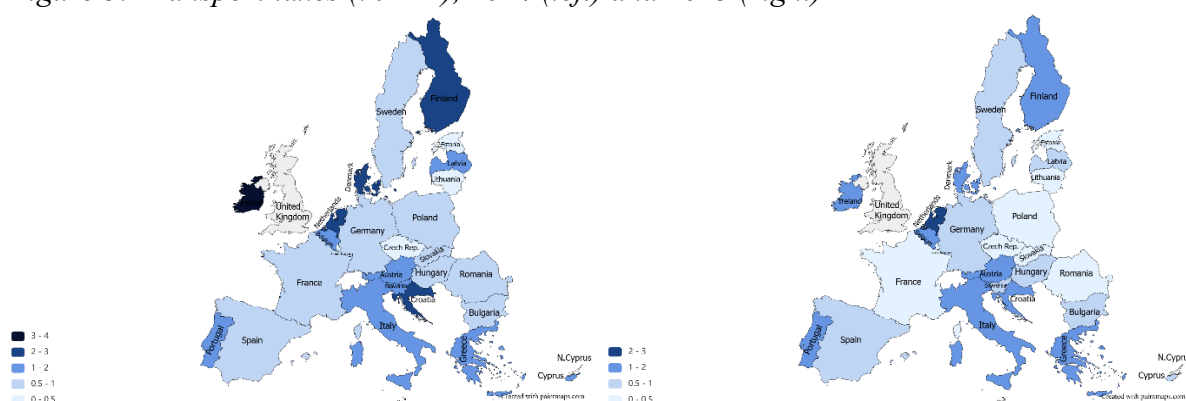
Figure 2: Energy taxes (%TAX), 2014 (left) and 2023 (right)



Source: authors' own processing, based on Eurostat data

Going forward to the second indicator, namely *transport* taxes, we can observe a slightly different distribution (Figure 3), with the Nordic countries being among the ones with a considerable percentage of revenues generated by this axis, especially in 2014: from this category, we can name Finland, Denmark, Netherlands, or Ireland. Reaching 2023, the levels have decreased, and the only state remaining above the 2% threshold is Denmark. Besides those, the vast majority of states are classified in the 0-1% interval, showing overall small taxation applied to vehicles and transport-associated activities.

Figure 3: Transport taxes (%TAX), 2014 (left) and 2023 (right)

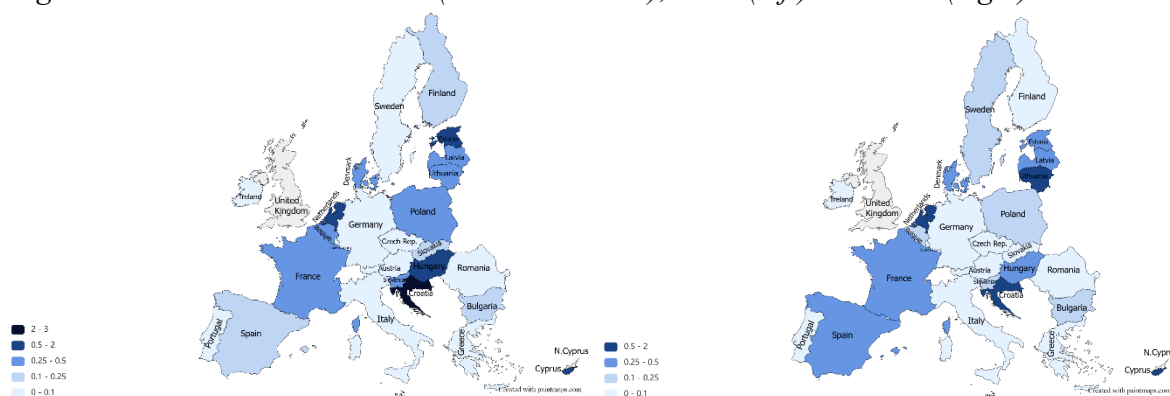


Source: authors' own processing, based on Eurostat data

Last but not least, regarding the *pollution and resources* tax, illustrated in Figure 4, we can see once again a distinct allocation, with the highest percentages being registered for Croatia, Netherlands, and Denmark, while the Baltic countries will also be a part of this high-taxes cluster. The vast majority of states would be framed into the 0-0.25% of the total revenue flows, so a very low share, with few movements throughout the years.

Therefore, we can confirm the conclusion highlighted earlier: the existence of a very small evolution in the last decade and a surprising descending trend in terms of environmental taxation, as opposed to the urgency generated by the climate context. At the same time, no indicator out of the three has shown a clear homogeneous distribution across the European Union, so a further statistical methodology could help assess whether the dissimilarities are indeed significant.

Figure 4: Pollution & Resources (%POLLUTION), 2014 (left) and 2023 (right)



Source: authors' own processing, based on Eurostat data

Regionality Breakdown

As mentioned earlier, we will now proceed to further study the regionality of the European Union by first selecting an optimal classification for the 27 member states. Thus, we have used one of the most frequent regional allocations, starting from the *World Factbook*, and making some changes based on the economic, political, or geographical contexts. The results are shown in Table 3, with the states being described as Nordic, Baltic, Central, Western, and finally arriving at the Southern and South-Eastern groups.

Table 3: Country allocation by region – 2014 versus 2023

Region	Countries
NORDIC	Denmark, Finland, Sweden
BALTIC	Estonia, Latvia, Lithuania
CENTRAL	Austria, Czechia, Germany, Hungary, Poland, Slovakia, Slovenia
WESTERN	Belgium, France, Ireland, Luxembourg, Netherlands
SOUTH-EASTERN	Bulgaria, Romania, Croatia, Greece
SOUTHERN	Italy, Malta, Portugal, Spain, Cyprus

Source: authors' own processing

Before proceeding with any type of statistical analysis, as mentioned in the methodology part, we will first compute the Shapiro-Wilk normality test for the three indicators at focus, as well as for the general one, represented by the total environmental taxes. Since there won't be any major differences between the results obtained for 2014 versus 2023, in Table 4, we have presented them only for the most recent year.

Table 4: Shapiro-Wilk Normality Test, Environment Taxes (%TAX), 2023

TYPE OF TAXES	w	P-value	Conclusion
ENERGY	0.886	$0.0055 < 0.05$	Not normally distributed
POLLUTION	0.74	$0.00001118 < 0.05$	Not normally distributed
TRANSPORT	0.96	$0.3427 > 0.05$	Normally distributed
ENVIRONMENT	0.916	$0.0283 < 0.05$	Not normally distributed
ENVIRONMENT (with outlier exclusion)	0.937	$0.1256 > 0.05$	Normally distributed

Source: authors' own processing

In terms of conclusions, we can see that the transport taxes will be the only indicator that will be characterized by a normal distribution, with the rest of the *p-values* showing a lack of significance. However, through multiple testing of different scenarios, we have observed that Bulgaria will be an outlier for the environment share (verified through box plotting), therefore, we have removed it from the dataset (as seen in Table 4, last row). After repeating the computation, the result has now become positive, with the data series being normalized and adequate for ANOVA.

Therefore, we can proceed with the analysis of variance only for the indicators mentioned, based on the six regions illustrated in Table 3. The results can be observed in Table 5, with the transport variable not generating a valid confirmation, while in the case of the environment, the alternative hypothesis has been confirmed. Thus, when it comes to environmental taxation, we can explore further the existence of differences between the 6 regions selected.

Table 5: Analysis of Variance Results

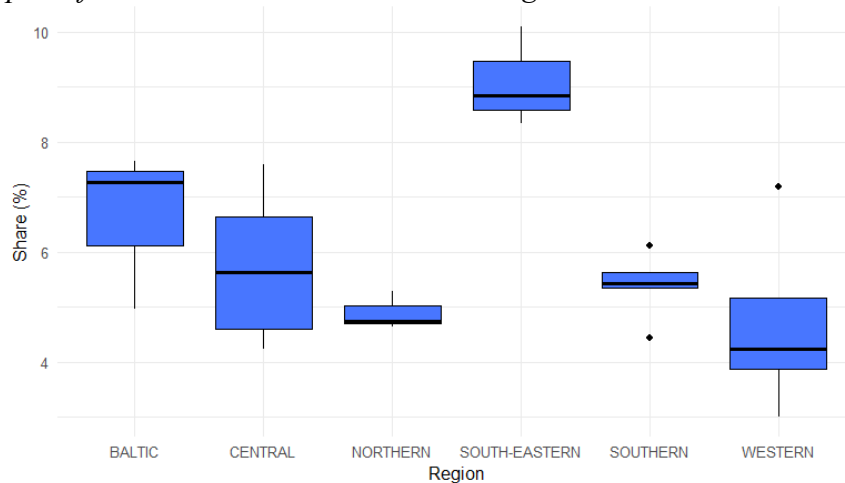
TAXES	ANOVA			
	Sum SQ.	Mean SQ.	F Value	Pr(>F)
TRANSPORT	2.481	0.496	1.281	0.311
ENVIRONMENT (with outlier exclusion)	28.12	8.79	6.25	0.00121 **

Source: authors' own processing

Discussion

Next, in order to depict the discrepancies between the regions, we will now use two graphical representations, starting with a comparative boxplot for each region, illustrated in Figure 5.

Figure 5: Boxplot of environmental taxes in the EU regions

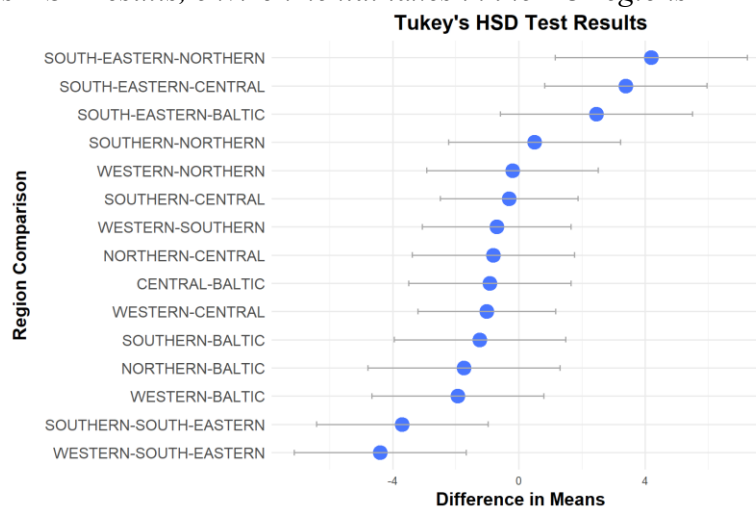


Source: authors' own processing

As an initial overview, we can note that the South-Eastern region is showing the highest share of environmental taxes, while the Western regions will register the lowest one. On the other hand, the Central and Baltic areas will have the most volatile distribution and no outliers. For the Southern region, however, both inferior and superior extreme values could be observed.

The second method we can employ to deep-dive into the differences is the *Tukey HSD*, with the results being graphically illustrated in Figure 6. We can observe several differences between pairs of regions, with the most distinctive ones being represented by the South-Eastern zones, compared to the Northern, Central, and Baltic ones.

Figure 6: Tukey's HSD results, environmental taxes in the EU regions



Source: authors' own processing

Looking also at the actual values, the countries with the highest environmental taxes will also be part of the South-Eastern division, referring now to Bulgaria, Croatia, Greece, or Romania.

However, this should not be necessarily a negative aspect, considering the potential for the aforementioned states to actually inflict sustainability changes and help the EU area converge faster to the proposed climate targets, as opposed to the Western or Nordic countries that have already integrated proactive environmental taxation and policies.

Finally, completing the results section and reinforcing the above conclusion, we have also applied a correspondence analysis meant to highlight the relationship between the region categories and a new classification of states defined using the volume of environmental taxes. The grouping has been made according to the rule available in Table 6, with the averages and the countries being added to the summarization. Thus, we can see that in the *High_Taxes* category, we will have 6 countries included, with an average of 9% of environmental taxes from the total contributions, while the largest number of states will be representative of the *Medium_Taxes*, with values between 5% and 7.5%. Finally, 9 countries will be a part of the last class, profiling environmental taxes of under 5% of the total flows.

Table 6: Taxes classification

Type	Rule	Average ENV TAXES%	Number of countries	Countries
HIGH_TAXES	>7.5%	8.96%	6	Bulgaria, Croatia, Greece, Estonia, Romania, Slovenia
MEDIUM_TAXES	[5%,7.5%]	5.96%	12	Belgium, Cyprus, Finland, Hungary, Italy, Latvia, Malta, Netherlands, Poland, Portugal, Slovakia
SMALL_TAXES	<5%	4.20%	9	Austria, Czechia, France, Germany, Ireland, Lithuania, Luxembourg, Spain, Sweden

Source: authors' own processing

Next, as mentioned in the methodology, a mandatory step before the computation will be calculating the Pearson Chi-Squared test (Table 7), which will assess whether there is a strong relationship between the row and column variables. After the computation, the generated result shows a p-value of 0.02, being placed just under the statistically significant threshold of 0.05, so the correspondence analysis can be applied successfully but prudently.

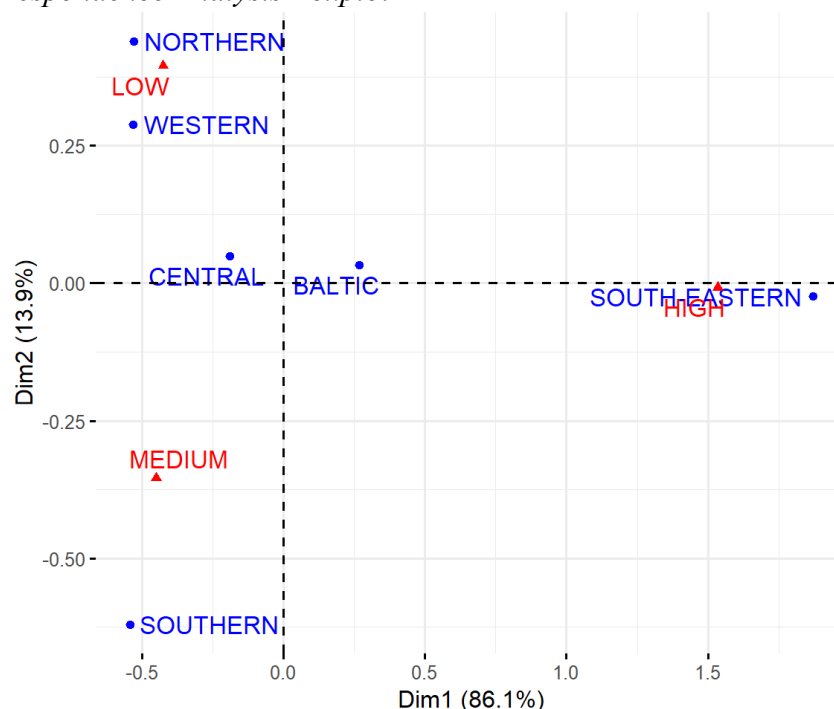
Table 7: Chi-Squared Test

Chi-Squared	21.125
Degrees of Freedom	10
p-value	0.02024

Source: authors' own processing

After the computation of the analysis, the results can be extracted from the biplot represented in Figure 7, with several clear relationships being illustrated.

Figure 7: Correspondence Analysis Boxplot



Source: authors' own processing

First of all, the Western and Northern Europe regions will be mapped closely to the lowest shares of taxes, while the South-Eastern Europe group will have a similar profile to the high shares of taxes in member states. On the other side, the Central and Baltic regions are placed closer to the center, profiling a low-quality representation in the new dimensional space.

Thus, we are finally able to identify the characteristics of each region in terms of environmental taxation volumes, with a semi-indirect linkage between the countries known as poles of macroeconomic performance and demographics, and the implementation of this fiscal instrument at a national level. From an economic perspective, this was to be expected, considering the fiscal capacity and development level that highly influence taxation in general. Moreover, regarding the general heterogeneity, which has now been confirmed, we can highlight once again that although the EU guidelines and strategies have clearly stated taxation as a mandatory best practice, the implementation has been slow, threatening the transition to a greener economy. Providing some examples of this, we can mention the Nordic countries, with an accent on Sweden and Finland, which have introduced carbon taxes to reduce emissions from fossil fuels, Italy and France, or Denmark and Austria, which levy taxes on chemical use and waste disposal to promote sustainability. These taxes aim to incentivize greener practices but have been implemented with varying levels of success and at different pace across countries.

Regarding other points of differentiation between the clusters, we can name several economic and administrative factors. For example, strong institutional frameworks and efficient regulatory bodies are better equipped to enforce environmental taxes, while those with weaker institutions may struggle to implement and monitor these policies effectively. At the same time, the level of political will also varies significantly, as some governments may prioritize environmental sustainability and push for green taxes, while others may face some resistance, minimizing progress. Furthermore, the economic structure of a country, such as heavy

dependence on fossil fuels, agriculture, or industry, can shape the feasibility and effectiveness of environmental tax policies.

Conclusions

In conclusion, throughout this paper, we have analyzed both the regionality and temporal dynamics of environmental taxation. Starting with the split into energy, transport, and pollution/resources taxes, we have illustrated the national performances in a comparative overview between 2014 and 2023. The first conclusion has been the relative lack of differences between the years, with the indicators showing a very moderate decreasing trend. This contrasts with the prioritization of the environmental axis and the importance of taxation as an instrument that can control, adjust, stimulate, and facilitate the overall economic green transition, as stated in the related literature. Another important observation to retain is that the highest share under the environmental taxes will be represented by the energy indicator, while in terms of significant regional differences, the environmental values will be the only valid one, considering both the ANOVA and the correspondence analysis. In terms of actual regional differences, the Nordic and Western countries will be represented by smaller percentages of environmental taxes, while the South-Eastern states will be on the other side of the metric.

Therefore, we find the current approach not only relevant in this context but also valuable in the broader effort to profile the European landscape and the status quo of environmental taxation. As for current limitations, the relatively small sample of countries raised questions about the applicability of certain methods. To address this, future work could extend the framework to include NUTS2-level data or adopt a broader, more comprehensive overview. Also, as a completion of the current work, we recommend expanding the analysis to test alternative classifications within the ANOVA framework. For example, grouping countries based on economic indicators, such as GDP per capita, could help determine whether observed differences are primarily driven by geographic location or underlying socioeconomic factors.

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CONSUMER ATTITUDES TOWARDS FOOD WASTE IN A SOCIODEMOGRAPHIC APPROACH

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Abstract

Food waste is one of the most pressing environmental, economic, and social challenges of our time. In Hungary, a significant portion of food waste originates at the household level, which is why this study aims to explore some of the correlations related to food waste through quantitative research. The primary goal was to examine how respondents perceive sustainability, their food consumption, and waste. The research was conducted using a non-random sampling method, with a sample size of 798, which is not representative, but the authors aimed to approximate a random sampling approach as closely as possible. The results of the study indicated that the extent of food waste is strongly correlated with demographic factors, attitudes, and habits. It was found that education and environmental awareness play a crucial role in reducing waste. The findings of this research can contribute to the development of targeted policy measures and social campaigns aimed at reducing food waste and promoting more sustainable lifestyles in Hungary.

Keywords: food waste, sustainability, environmental awareness, demographic factors

JEL classification: Q18, Q01, D12

Introduction

The study of factors influencing food consumption—such as income, supply and demand, prices, and consumer preferences—has increasingly come to the forefront of scientific research in the last decades of the 20th century and the first decades of the 21st century. At the same time, humanity is increasingly confronted with global issues such as climate change, environmental degradation, and food security. It is becoming increasingly clear that the roots of these problems lie in food production (its shortcomings and inequalities) and changes in our consumption habits. The global food system and production are sources of numerous problems, as they significantly contribute to greenhouse gas emissions, deforestation, water scarcity, and the decline in biodiversity. Obviously, we cannot live without the natural environment, a fact that we often tend to overlook. Closely related to this is the issue of food security. Food security is now one of the most important decision-making criteria, influencing consumer behavior. The traceability of food from producer to consumer provides companies with the opportunity to gain a competitive advantage by offering high-quality, verifiable products. By ensuring traceability—so that consumers know what their food contains and where it comes from—companies gain the most important thing: consumer trust (Huszká, 2019).

Food waste is one of the most serious sustainability challenges of modern societies, with significant environmental, economic, and social consequences. According to UN data, approximately 1.3 billion tons of food are wasted globally each year, while millions around the world struggle with food shortages. Food waste is one of the most urgent issues of our time, with severe impacts both globally and locally, as it represents one of the most significant environmental, economic, and social challenges of modern societies. Globally, about 1.3 billion tons of food are wasted annually. In South Africa, annual food waste is approximately 9.04 million tons (Oelofse & Nahman, 2013), while in Brazil, it is 82.20 million tons per year (Dal'Magro & Talamini, 2019). In the EU, this amounts to nearly 59 million tons annually, equivalent to 131 kg of waste per person. Reducing waste at every stage of the supply chain could reduce losses by up to 50%. This would help improve food supply to meet the future needs of approximately one billion people (Kummu et al., 2012).

Food waste varies significantly across different demographic groups, particularly by age. Young adults are more likely to waste food than older generations. In the United States, 21% of 18-29-year-olds throw away excess food once or twice a week, while only 30% of those aged 65 and older do so (YouGov, 2022). Globally, per capita household food waste is 33 kg per year in Russia, while in Nigeria, it reaches 189 kg [2].

Attitudes towards food waste also differ. In Hungary, 24% of respondents claim they do not waste food at all, while 39% feed food leftovers to pets or livestock [3]. In the United States, 53% believe they do not waste food, but 24% find it difficult to reduce waste despite wanting to [4]. Women are more likely to waste food than men [5].

The most commonly wasted foods also vary by age. For example, in the United States, 59% of 18-29-year-olds frequently discard dairy products, while only 41% of those over 60 do so [6]. Reducing food waste is seen as a shared responsibility, with 68% of Americans believing that individuals should take the primary responsibility, while 43% think that food industry companies should develop waste reduction initiatives [7].

Literature review

Losses occur at every stage of the food supply chain, especially in developing countries where transportation and storage infrastructure is less developed. In both developed and developing countries, approximately 30-40% of food is wasted, although the reasons for waste vary greatly (Godfray et al., 2010). Based on a sample of 27 European countries, the European Commission (EC) estimates that 5% of food waste is caused by the retail and distribution sectors, 14% by the food service sector, 39% by industry, and the remaining 42% by households.

The five main categories of food waste are purchasing, over-preparation, pet care, avoiding leftovers, and improper food storage. Several subcategories have been identified, such as impulse buying, lack of planning, and preference for large packaging (Porpino et al., 2015). Consumers' attitudes towards food waste vary; some are aware of the environmental issues related to food waste, while others believe that some food waste is necessary to keep food fresh (Qi & Roe, 2016). Zhang et al. (2018) identified two main drivers of household food waste: household size and income.

Factors influencing the origin of food waste include demographic factors, household size, economic activity, and, not least, the price of food purchased by households. Demographic factors such as age and gender are generally key in all areas of consumer behavior (Mokrysz, 2016) and must be considered when designing consumer education campaigns aimed at changing behavior (Filipová et al., 2017). Talia et al. (2019) suggest that household size plays a fundamental role, as does the gender and educational level of household consumers.

Single-person households produce more food waste than other types of households, and higher-income households, as well as urban households, also waste more food (Tokareva & Eglite, 2017). Filipová et al. (2017) also argue that higher-income households and younger, economically active consumers waste more, while retirees waste less than other groups. Ilakovac et al. (2020) add that respondents' age positively influenced waste prevention, while income level and the number of children under 18 in the household had a negative impact.

Household income also affects consumer behavior. It is said that emotions significantly influence consumer decision-making, but ultimately, consumer actions depend on the contents of the wallet (Achar et al., 2016). Household income is one of the main indicators of living conditions and standards. If a household's income is below the poverty line, it is considered a low-income household, living at risk of poverty (Halleröd & Larsson, 2008). Higher-income households waste more food than low-income households (Filipová et al., 2017). On the other hand, Porpino et al. (2015) add that low-income households also waste food, for example, due to lack of planning or improper food storage. Priefer et al. (2013) note that as prosperity increases, food waste also tends to increase. Household food waste can be expressed as a function of the price of raw materials and the household's available income (Lusk & Ellison, 2017). Priefer et al. (2013) also add that the trend of decreasing food expenditures contributes to the loss of respect for food in society. According to a Dutch study (Dooren et al., 2019), household waste is 30.4 kg per person per year, with the largest waste in households caused by baked goods (22% of waste), followed by dairy products (17%), vegetables (14%), fruits (12%), and the least by meat (7% of waste). This order may be a consequence of the price of certain foods. According to a Croatian study, households produce 75 kg of food waste per person per year, with nearly half of all waste consisting of fruits (23%) and vegetables (23%) (Ilakovac, 2020). Fruits and vegetables are also the most wasted foods in the UK, where nearly 2 million tons of fresh vegetables and salads are thrown away annually (Quested, 2014).

Individualization is linked to consumption (Keller, 2023). In today's economically developed countries, consumers demonstrate or compensate for their social status through higher consumption, resulting in greater demands on household financial well-being and food security (Krautová & Librová, 2009). According to Quested & Murphy (2014), people living alone waste half as much food as multi-person households. The individualization of society thus greatly influences the overall utility of consumption.

At the household level, food waste can be attributed to several factors, such as shopping habits, lack of proper food storage techniques, or low consumer awareness (Keller and Huszka, 2023 so as Keller and Huszka, 2024). In the consumption phase, food is mainly wasted in middle- and high-income countries, where people discard food that is still suitable for human consumption. In low-income countries, losses are much higher in the post-harvest stages, while in developed countries, the greatest potential for reducing food waste lies in retail, food service, and consumers' homes; that is, waste is generated at the end of the food supply chain (retail and final consumption) and is related to the behavior of retailers and consumers (Parfitt et al., 2010).

Methodology

The authors conducted their research on "Managing the Domestic Economic and Energy Crisis and Its Effects" in 2023. The primary goal was to examine how respondents perceive sustainability, their food consumption, and waste. The research was conducted using a non-random sampling method, with a sample size of 798, which is not representative, but the authors aimed to approximate a random sampling approach as closely as possible. To this end, students from the Széchenyi István University in Győr, majoring in commerce and marketing, were asked to randomly survey individuals and record their responses. Thus, 798 respondents were included in the sample. The research lasted two months, and the questionnaire responses were anonymous, voluntary, and served explicit research purposes. The researchers respected the personal data of the respondents, meaning they complied with GDPR regulations and adhered to university ethical guidelines for research.

The questionnaire consisted of three main parts. Likert-scale statements were used to measure attitudes towards food waste in terms of habits and values. Frequency questions were formulated to explore behavioral habits related to the types of food wasted. Standard demographic data, such as gender, age, education, residence, and income level, were collected at the end of the questionnaire.

Out of 800 respondents, after data cleaning, 798 valid questionnaires were included in the database. The respondents were almost evenly split between men (49.6%) and women (50.4%). The demographic characteristics of the sample are shown in Table 1. Based on per capita monthly net income, the majority of respondents classified themselves as average or below average. The demographic profile is particularly informative in the empirical examination of consumer behavior related to food waste, as several studies support the fundamental influence of demographics. Age, gender, and income level are key in all areas of consumer behavior (Mokrysz, 2016). Talia et al. (2019) suggest that household size plays a fundamental role, as does the gender and educational level of household consumers. Filipová et al. (2017) also argue that higher-income households and younger, economically active consumers waste more, while retirees waste less than other groups. Ilakovac et al. (2020) add that respondents' age positively influenced waste prevention, while income level and the number of children under 18 in the household had a negative impact. Household income also affects consumer behavior. It is said that emotions significantly influence consumer decision-making, but ultimately, consumer actions depend on the contents of the wallet (Achar et al., 2016; Gombos – Kézai, 2023). If a household's income is below the poverty line, it is considered a low-income household, living at risk of poverty (Halleröd & Larsson, 2008). Higher-income households waste more food than low-income households (Filipová et al., 2017).

Before finalizing the questionnaires, the authors conducted a pilot survey. This involved about 10 respondents who filled out the questionnaire in advance, and since there were no interpretability issues, the authors used the questions unchanged in the research. The questions were closed-ended, based on metric and categorical variables. Some questions were the authors' own, while others were based on Szabó-Bódi's (2018) doctoral dissertation. Since the questionnaire was the authors' own, its reliability was tested by re-surveying a small group. The results were similar to the original questionnaire, so the authors deemed the questionnaire reliable.

As previously mentioned, 798 respondents were included in the research. In Hungary, approximately 9.7 million people lived in 2023. To calculate the minimum sample size, the

authors used Yamane's (1965) formula. Using a 95% confidence level, this formula requires 400 respondents to be included in the study. Since the number of respondents exceeded this, the authors accepted the sample size. In line with the above and after reviewing relevant domestic and international literature, the research aimed to examine the following research problems:

- Exploration of the most common behaviors related to food waste.
- Frequency questions were formulated to explore the types of food wasted.
- Analysis of the impact of demographic factors on food waste habits.
- Presentation of correlations between environmentally conscious attitudes and food waste habits.

Table 1: Demographic Composition of the Sample

Gender	male 49,6%	female 50,4%		
Age	15-29 years 35,5%	30-45 years 29,9%	46-64 years 19,6%	over 65 15,3%
Residence	rural 35,6%	urban 39,5%	county seat/capital 24,9%	
Education	primary 35,6%	vocational 15,6%	high school 34,4%	higher education 44,5%

Source: Own editing, n=798

Results

The questionnaire results shed light on the most common behaviors related to food waste. The most frequently wasted foods were fresh vegetables and fruits, baked goods, dairy products, and leftovers; while spices, honey, canned goods, and frozen products were less likely to be wasted (Table 2).

Table 2: Frequency of Discarding Certain Foods

Average	Standard	Deviation	Mode
Baked goods	2.56	1.22	2
Leftovers	2.49	1.22	2
Dairy products	2.33	1.10	2
Cold cuts	2.09	1.13	1
Fresh vegetables, fruits	2.02	1.15	1
Fats, butter, margarine	1.67	0.99	1
Frozen products	1.62	1.06	1
Eggs	1.61	1.04	1
Jams	1.02	1.02	1
Chocolate	1.58	0.98	1
Fresh meat	1.57	0.99	1
Canned goods	1.47 0.90	1.47 0.90	1

Source: Own editing, n=798; 1: never; 5: very often

The majority of respondents exhibited environmentally conscious attitudes. Waste levels were more influenced by the efficiency of food storage and usage rather than consumer irresponsibility. The most popular positive habits included conscious shopping (only buying as

much food as they would consume—average: 3.65) and home cooking (average: 3.70). Composting was less common, although environmentally conscious households were more likely to practice it. Rural residents composted more frequently, while urban residents had higher levels of food waste.

The research also revealed the influence of demographic factors in some cases. According to the F-test results, gender had a significant impact on food waste habits. Due to gender differences, women were more likely to shop and cook in an environmentally conscious manner, while men were more likely to discard leftovers. Older age groups (over 46) wasted less food, mainly due to household experience and economic caution. Younger generations (15-29) were more likely to buy ready-made meals, which increased waste. Lower-educated individuals had higher waste levels, while higher-educated individuals were more environmentally conscious. In county seats and the capital, food saving was more important for financial reasons. Higher-income households paid less attention to optimizing food usage. In lower-income households, however, greater emphasis was placed on reusing leftovers.

In the bivariate analysis of the questionnaire data, the relationship between demographic factors (gender, age, education, residence, and income) and food waste habits was examined. The most important results are presented below, including the results of variance analyses (F-tests) and correlation calculations.

Examining gender differences, the analysis showed that women were significantly less likely to discard leftovers than men ($F = 4.32$, $p < 0.05$). This difference is likely explained by women's household responsibilities and more environmentally conscious attitudes. Women exhibited stronger environmentally conscious attitudes (e.g., composting, conscious shopping), while these were less dominant among men. The correlation between genders ($r = 0.28$) was weak but statistically significant.

The analysis based on age also showed significant differences in food waste habits. Younger respondents (aged 15–29) were more likely to throw away fresh vegetables, fruits, and ready-made meals compared to older age groups ($F = 6.78$, $p < 0.01$). Older individuals (aged 46–64 and over 65) placed greater emphasis on reusing food leftovers and composting. Conscious shopping habits were significantly more frequent among older respondents ($r = 0.34$, $p < 0.01$), whereas younger individuals were more prone to impulsive purchases, increasing the likelihood of waste.

According to the study's results, education level was one of the most important determinants of food waste habits. Respondents with higher education levels (e.g., university graduates) wasted less food, particularly basic food items such as dairy products and baked goods ($F = 8.12$, $p < 0.01$). This is likely due to better planning and storage habits. Among individuals with only primary education, the amount of discarded food was higher, especially fresh vegetables and meats ($r = -0.29$, $p < 0.05$). This suggests that education level influences the conscious handling of food.

The relationship between place of residence and food waste habits was also significant. The type of residence (village, town, county-level city, or capital city) showed notable differences. Respondents from villages composted significantly more often ($F = 9.21$, $p < 0.01$) and discarded fewer fresh vegetables and fruits compared to city dwellers. Urban residents were more likely to discard ready-made meals and perishable foods, particularly in the capital, where

45% of respondents wasted food at least weekly. Environmental awareness habits were more prevalent in villages ($r = 0.36$, $p < 0.01$), whereas the level of waste was higher in larger cities.

The impact of income on food waste was clearly observed in the study. Respondents with lower incomes discarded food less frequently ($F = 7.45$, $p < 0.01$), as they placed greater emphasis on reusing leftovers and making conscious purchases. Food waste was more common among those with above-average incomes, especially for fresh meats and dairy products. This likely results from these households paying less attention to optimizing food usage. The negative correlation between income and food waste ($r = -0.31$) indicated that individuals with lower incomes were more likely to exhibit environmentally conscious behavior.

Summary

Multivariate analyses clearly show that food waste is closely linked to demographic characteristics and the economic status of households. Differences stem from variations in education, cultural habits, and economic motivations, all of which play an essential role in determining the extent of waste. A positive correlation was also found between environmental attitudes and food waste habits. Households that prioritized conscious shopping and home cooking generated less food waste.

Education proved to be particularly important: food waste rates were lower among those with higher education. These findings provide a crucial foundation for developing targeted intervention programs to improve food waste habits across different social groups. Future research could focus on factors that lead to effective solutions at both individual and community levels. Expanding environmental education in schools and communities could help reduce food waste. Increasing access to composting systems, especially in cities, would also be beneficial. Supporting food exchange platforms and "food rescue" initiatives could further aid in food reuse. Encouraging simple and cost-effective planning techniques, such as weekly shopping lists, could also help address the issue.

Conclusions

The extent of food waste is closely linked to demographic factors, attitudes, and habits. Education and environmental awareness play a key role in reducing waste. Based on the findings, future research and policy decisions can more effectively target groups with particularly high levels of waste.

To reduce food waste, decision-makers can plan targeted interventions that consider the different habits of various social groups. The study also provides valuable data for companies and retailers, helping them optimize food supply by analyzing consumer behavior. This research serves as a foundation for further in-depth analyses and practical solutions aimed at fostering more sustainable food consumption habits in Hungary.

Additionally, the findings contribute to raising public awareness through school programs or community initiatives focused on reducing food waste. Households can benefit from developing more conscious shopping and storage habits, while food-saving strategies (such as composting and food rescue initiatives) can support a more sustainable lifestyle.

However, it is essential to acknowledge the limitations of the research. Due to the non-representative sampling method, the results cannot be fully generalized to the entire Hungarian population. Further studies are needed to gain a more precise understanding of food waste habits in different social groups. Moreover, the research did not examine all influencing factors, such as psychological and cultural aspects, which also play a crucial role in shaping waste behavior.

In future studies, expanding data collection could lead to more accurate conclusions about the determinants of food waste and identify long-term effective measures to reduce the problem.

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ECONOMICS

TRACK 3: Human Capital Dynamics

PREFACE

ECONOMICS – TRACK 3: HUMAN CAPITAL DYNAMICS

In the contemporary globalized and digitalized society, human capital stands as a pivotal driver of economic growth and societal well-being. This track delves into the intricate interplay between human capital and the broader economy, exploring how individual capabilities, labor market dynamics, and technological advancements shape economic outcomes, while simultaneously examining the economy's impact on human capital development and utilization. The papers within this track collectively contribute to a deeper understanding of these complex relationships, addressing crucial aspects ranging from wage dynamics and demographic shifts to the integration of artificial intelligence and evolving perceptions of financial security.

Specifically, Bačić investigates how worker wages adjust to labor productivity in Croatia under inflationary pressures, providing insights into the economic forces directly impacting the compensation and value of human capital across different ownership structures. Debelak and Pevcin explore the transformative potential of artificial intelligence in mitigating the negative effects of an aging workforce on productivity, illustrating how technological innovation can bolster human capital's contribution even in the face of demographic challenges. Hrenar and Krpan offer a comparative analysis of Generation Z's perspectives on saving, retirement, and insurance, highlighting the evolving financial attitudes and concerns of a new generation entering the workforce, thereby shedding light on future human capital planning. Finally, Strmota, Ivanda, and Nimac explore the crucial role of job stability and flexible work arrangements in influencing fertility intentions in Croatia, underscoring the profound impact of labor market conditions on demographic trends and the future availability of human capital. Together, these contributions illuminate various facets of human capital, its challenges, and its enduring significance in shaping economic and social landscapes.

LABOR PRODUCTIVITY AND WAGE ADJUSTMENTS IN CROATIA UNDER INFLATIONARY PRESSURES

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Abstract

The paper investigates the adjustment of worker's wages to the labor productivity dynamic in the Republic of Croatia during 2018-2023/24, including COVID- and inflationary-conditions. The descriptive statistics method is used and applied to data from a major business database and official statistics. The results indicate that employers in the entrepreneurial sector do respond to nominal labor productivity growth with wages adjustment fully or nearly fully. The wage adjustment was above the average rate of inflation. The magnitude of the response can be distinguished according to types of ownership: in privately-owned enterprises for the annual labor productivity growth of 8.7% in the period 2018-2023, annual nominal gross wage increase amounted to 7.0% while in state-owned enterprises for the annual labor productivity growth of 4.6%, wage adjustment was 4.8% i.e. over the labor productivity dynamic. There are strong indications that the wage adjustment takes place post-factum as to nominal productivity gains in the privately-owned enterprises. The analysis has shown that the average wage in the privately-owned enterprises was persistently lower in 2018-2023 than in the state-owned enterprises or in the entire economy, including the public sector. This public-private wage wedge is likely to further deepen. In January-October 2024 period, wages in the typical public services activities already surpass the economy-wide wage as a result of public wage reform and some previous public wage adjustments. Further wage increases of public servants and staff expected throughout 2025 will place additional pressure on private sector wage rise. It is unlikely this wage dynamic will be fully matched by privately-owned enterprises. This paper contributes to the understanding of the productivity-wages relation specifically during a time of economic turbulence and rising inflation.

Keywords: wages adjustment, labor productivity, inflation, value added

JEL classification: E24, E31, J58

Introduction

Global uncertainties that began with the COVID pandemic marked the beginning of a chain of worrying political and economic events. A global recession was deeply felt throughout 2020, with supply-chain disruptions and later energy crisis also brought about unsettling rates of inflation throughout the EU in 2022-23. The annual change of Harmonized Index of Consumer Prices (HICP) for EU-27 was 9.2%, 6.4%, 2.6% in 2022, 2023 and 2024, according to Eurostat (2025). HICP for Croatia, a post-transition EU economy, rose stronger, by 10.7%, 8.4%, 4.0% in the same period. Rapidly changing prices are blurring market relations as it is difficult to keep up with the changes. As workers begin to feel the loss of purchasing power, wage adjustments are called for. Recent developments show that wage adjustments in Croatia's public sector have been rather large over post-COVID period and uncorrelated with the private sector's

wage dynamics (Nestić, 2024). Word Bank Group Prosperity Data360 for Croatia point to a public sector wage premium in 2017 and 2018 compared to all private enterprises.

A large enough wage premium may drive workers away from the private sector and/or create additional pressure on private sector wage rise unrelated to productivity dynamics, as a type of negative spillover. As to raised issues, Croatia is an interesting case to examine at this very point as it is struggling with demographic drain and is increasingly turning to work immigration from the third countries. In this paper answers will be provided to the following research questions: Is the productivity-based principle of wage adjustment fully exercised by employers during the 2018-2023/4 period, encompassing economic turbulence and growing inflation? What differences can be observed in the level and in the dynamic of private- and public-sector wage during this period? On these issues, wage adjustments in various sectors/areas of economic activity in Croatia are researched to see whether there are any differences in the size and the dynamics of employers' response. Also, private vs. public sector wage adjustment practice and the interplay of the two sectors are of interest in this analysis. Descriptive statistics method is employed for this purpose, applied to data from various sources.

Labor cost is an important cost component in firms due to the fact that its changes can affect price competitiveness. This is highly important for entrepreneurs, in particular those from the manufacturing industry that are placing their products internationally, as many complete in the standardized low-price segment (Stojčić et al., 2012). Furthermore, worker's wages seem to be the key issue for Croatian exporters in the manufacturing industry (Stojčić, 2012). The topic of wage-labor productivity dynamic is also policy-relevant. Thus, the goal of this paper is to learn about the principles of wage adjustment dynamic in the Croatian economy under inflation pressures and economic turbulence and about the effect on the public-private wage sector interplay. The results of this paper will contribute to the body of literature on productivity-wage dynamic and to the public analyses and discussions.

The paper is organized into several sections. After introduction, a literature review follows. The third section provides details of the research framework, and the results of the analysis based on the Croatian data. The paper ends with conclusions and policy implications.

Literature review

Factor productivity growth is at the heart of economic growth and country competitiveness. Increase in labor and capital as production factors leads to higher economic growth, but most often these factors are limited. That is why growth in efficiency of their use, i.e. factor productivity increase, is the main path to growth.

Labor productivity – measures and the long-term dynamic

The most widely used measure of productivity and the simplest in terms of interpretation is labor productivity. It can be calculated in two ways: a) as gross product per worker (or hours worked); or b) as value added per worker (or hours worked). The productivity rationale is applicable for enterprises too as it ensures their competitiveness. Compensation for labor in the entrepreneurial sector should ideally be based on the contribution of workers to creating the product value/output, but it is difficult to distinguish it from other effects such as economies of scale, degree of utilization of production capacities or substitution of factors other than labor. (OECD, 2001) For wage setting in enterprises, relevant product markets (in terms of ability to

realize revenues and profits) as well as the labor market (in terms of availability of labor force and the level of their wages) are also important.

The last two decades have been labeled as decades of low productivity growth in higher-income economies (OECD, 2024; ILO, 2024). As to productivity-wage dynamic, some differences appear across countries and economic blocs, and also across different periods. US data on the 1979-2024 period show that annual productivity growth was at 1.4%, while annual worker compensation growth was at 0.6% (EPI, 2025). Similarly, ILO reports (2024) that on average, labor productivity in higher-income countries increased more rapidly than real wages over the period 1999–2024 (a total of 29% versus 15%). Labor productivity in Croatia has risen modestly (27%) compared to its EU post-transition peers (an average of 73%) over broadly the last two decades (The World Bank, 2022).

Public vs. private sector wage dynamics

An efficient labor market should be an enabling factor of business growth and development; hence it is an important task of economic policy. There is a strong wage-based interplay between the private and the public sector, hence the public sector should at all be careful of wage overshooting: a) to avoid unfounded pressures on wages in the private sector; b) to avoid crowding out of workers, an outflow from the private sector. The private and public sector compete for employees. Caponi & Nobili (2024) note that high public sector employment has reverse effect on overall economic productivity - it may lower it by reallocating resources from the private to the public sector, or from higher to lower productive sectors.

Due to institutional arrangements, public sector wages fluctuate less than those in the private sector and are less procyclical (Gomes, 2014; Caponi & Nobili, 2024). In the Eurozone where the public sector accounts for about one-fifth of employee compensation in the period 2001-21, public wages and compensation per employee grew on average at an annual rate of 2.3%, slightly higher than private wage growth (2.0%) and above HICP inflation (1.7%) (Checherita-Westphal & Vlad, 2023). The effects of public-private wages interplay are well shown in Alfonso and Gomes' quantitative model (2008) where it is found that an increase of 1% in the public sector wages induces an increase of 0.1% in private sector wages and an increase in public employment of 1 percentage point of the labor force increases private sector wages by 0.45%.

In Croatia real wages have been growing more slowly than labor productivity and wage trends in the public and private sectors were generally synchronized up to 2023. The wage growth during the high inflation period of 2022 and 2023 was exceptionally high. This was attributed to the wage catch-up process aimed at preventing a significant decline in real wages during the high inflation period. (Nadoveza, 2025)

The most recent Eurostat data (2024) on nominal hourly labor costs clearly show that Croatia and Romania had the highest wage growth in the EU: in Q3.23 and Q3.24 wages have risen by 16.2% and 15.1% (calendar adjusted) in Croatia compared with same quarter of previous year and, 15.1% and 17.1% in Romania. Double-digit-wage growth was recorded only in several other EU post-transition economies (Hungary, Bulgaria, Estonia, Lithuania, Poland).

Palić & Krizel (2018) find that the rise in public wages in Croatia is associated with a decrease of the manufacturing activity (i.e. output) in the period 2000-2017, but the results in the literature generally depend on the country and the period in question. The negative effects to

economic activity can occur through the increase of the public expenditure and the budget deficit, and in these situations, governments are often turning to introducing additional tax burdens.

Wage adjustment mechanisms in the public sector

The public sector is sustained on a public budget, which is a major determining factor for wage setting in the public sector, but not the only one. The public sector is unionized, and collective wage bargaining prevails. Greece, Cyprus, Ireland, Portugal, Italy and Spain are Eurozone countries that stand out for having a high public sector wage bill; during 2008 crisis they resorted to asymmetric wage cuts in the public sector, centered on the highest earners instead of reforms aligning with that of the private sector wage distribution (Gomes, 2014). As to the latest inflationary circumstances (2022-24) in Eurozone, Checherita-Westphal & Vlad (2023) have found that in Eurozone there is automatic price indexation of public wages and that among other EU members' inflation is increasingly being used as a reference in wage-setting. Croatia's public sector wage adjustment throughout the latest inflationary circumstances was a post factum adjustment and a result of series of wage negotiations.

Inflation and productivity linkages

As to the inflation - productivity – wages relation, scholars are concerned with the possible negative effects of inflation to productivity dynamic and to estimating the effects of rising wages to “feeding” the inflation. Many economists have posited, based on US historical data, that higher inflation may lead to slowdowns/lower productivity via inefficient resource allocation (Sbordone & Kuttner, 1994). A higher variance in the prices system may reduce the ability of the prices to provide proper signals to the market (Clark, 1982). Opposite to causal relation, lies a plausible statistical reasoning: if there is a monetary policy response to inflation via increasing the interest rate, this will first cause contraction of real output; as employers tend to decrease the number of workers less quickly due to labor hoarding, labor productivity will dip “mechanically” (Sbordone & Kuttner, 1994).

Employers' responsiveness to inflation

Finally, in inflationary circumstances workers strive to preserve their real wages and purchasing power, while companies strive to maintain their real revenues and profits intact. These are opposing directions, one placing pressure on enterprise costs, the other being careful to contain them. Wages are “sticky” i.e. employers tend to keep them at their (higher) level even as economic conditions worsen due to worker retention and recruitment. For the same reasons, it may be assumed that employers will adjust wages to reflect the growing inflation rate, but the question is how soon. Empirically it is proven that both private and public sector wage growth are responsive to inflation rate, amongst other factors (Afonso & Gomes, 2014).

Given the degree of institutional wage arrangements both in the public and private sector in Croatia as will be elaborated later in this paper, it may be assumed that the wage adjustment largely takes place through negotiations, post factum to the inflation rate in the public sector and post factum to the business results in the entrepreneurial sector.

The summary of findings from the literature

Literature is clear on the fact that the public sector wage policy has implications for the whole economy. There is strong economic reasoning for adjusting public wages in reference to the labor productivity dynamic; it is to avoid overshooting and its consequences. Because in that case, unfounded pressures on wages in the private sector may appear, exacerbating its price competitiveness. Also, there may be crowding out of workers from the private sector, possibly causing misallocation of resources from higher to lower productive sectors and negative effects to employment.

Eurostat data (2025) show that inflation struck most EU post-transition economies more severely than the rest of the EU in 2022 and 2023, placing more pressure on wage growth that reached double-digit rates in some of these countries. To the knowledge of the author, there is a gap in the literature on the wages – productivity relation during the inflation episode after the COVID-pandemic hit for the case of an EU post-transition economy with pronounced inflation rates. Given Croatia's poor record of labor productivity growth in the pre-COVID period, it makes an interesting case for researching to what extent has wages dynamic been referencing the productivity dynamic during inflationary pressures.

Research framework and findings

Background information

The public sector and enterprises in majority state ownership in Croatia are unionized and as such, work relations are formalized in collective agreements across different areas of activity. But collective agreements are not a mechanism of the public sector alone. Some important private sector industry branches are also regulated via collective agreements such as construction, catering, seafaring, wood processing, paper manufacturing, retail trade, private health services, as well as large private enterprises (overview available in Ling, 2025). Most collective agreements contain minimum wage across jobs of different complexity, the lowest often corresponding to the official minimum wage.

The most comprehensive collective agreement in terms of the number of workers it encompasses is that for public servants and staff. It foresees yearly wage increase for the length of service by a coefficient that is cumulative and applied to the base pay that can also be subject to changes. Inflation per se is not built into collective agreements but may be a trigger for starting negotiations if it exceeds a “critical” value, like in the collective agreement for construction workers. In the rest of the private sector wage adjustments are based on the agreement between the employer and the worker, reflecting trends in the labor market for various professions and job positions. Also, for all enterprises with over 20 employees Internal Staff regulations are compulsory and may contain clauses on wage adjustment, while unobliging enterprises may also opt for this mechanism. In late 2022, a survey of Croatian employers' association has shown that majority of employers have increased wages, ranging from up to 5% to 15%, but in roughly 12% percent of enterprises, there was no wage increase (Čirjak, 2022).

Research framework

Descriptive statistics method is used to ascertain the relations in question. With the purpose of learning about employers' response to changes in productivity including inflationary period across various sectors, in this section two important sources of data on wages, employment and value added are used:

- a) the official data source – Central Bureau of Statistics (CBS); and
- b) data collected by the Financial agency (FINA).

FINA dataset consists of entrepreneurial data that is based on enterprises' annual accounts for the period 2018-2023. The dataset contains data on legal entities that are both private- and state-owned enterprises. The author has set a delineation between private and state ownership by using the following criteria: private ownership refers to all companies in full or over 50% private ownership and cooperatives, while state ownership refers to all companies in full or over 50% state ownership. The dataset contains all sectors of the economy, but financial institutions are not included. Average values such as value added per employee or average monthly wage per annum are available on sectoral- and economy-level in the database. The original data retrieved from FINA are all expressed in nominal values.

As a measure of labor productivity value added per employee is used, and gross monthly wage (termed as "gross 2") is considered as the appropriate measure of worker's compensation and as the cost of labor.

The average gross wage for all legal persons, including those from the private and the public sector, is provided by CBS and these data are expressed at the level of NACE 2007 sections and divisions up to October 2024. CBS collects data on wages from legal entities of all forms of ownership, government bodies and bodies of local and regional self-government units. While FINA data on wages that are used in the paper are following a wider definition of gross wage termed as "gross 2" that includes net payments, income tax, surtax, health and pension contributions, CBS wage data are following a narrower definition termed as "gross 1" that does not include the health contribution. To allow for comparability with FINA data, CBS data were raised for the health contribution. Delineation of the public- and private-sector wage within divisions and sections in the CBS dataset is not possible. The author has thus resorted to defining the activities that are typical for the public sector, as is described more specifically in the later section of the paper.

The minimum wage was also used in the paper and was taken from the Official gazette up to 2025 following a narrower definition ("gross 1") and were hence raised by the author for the compulsory health contribution to attain "gross 2" wage and to allow for intersectoral comparability.

Real values were also assessed in the paper and appropriately, nominal wages in the observed period were deflated with the consumer price index (CPI), while value added was deflated with the GDP deflator in the observed period (2018-2023). Deflation procedure was applied to the entrepreneurial data and thus real growth rates were obtained, allowing different comparisons.

Using gross wage as the compensation of labor measure has its limitations. Instead of adjusting wages via gross wage, some employers resort to introducing non-taxable lump-sum expenditures for workers (e.g. costs of food, kindergarten fees, holiday pay, bonus etc.).

Thereby net *payment* to workers is raised, but the wage remains unchanged. There are indications that this wage adjustment strategy is pursued to some extent in the private sector, thereby keeping the gross wage compressed. It is these types of expenditure that cannot be considered in this research due to the unavailability of more detailed data. The result may be underappreciated compensation of labor in the privately-owned enterprises.

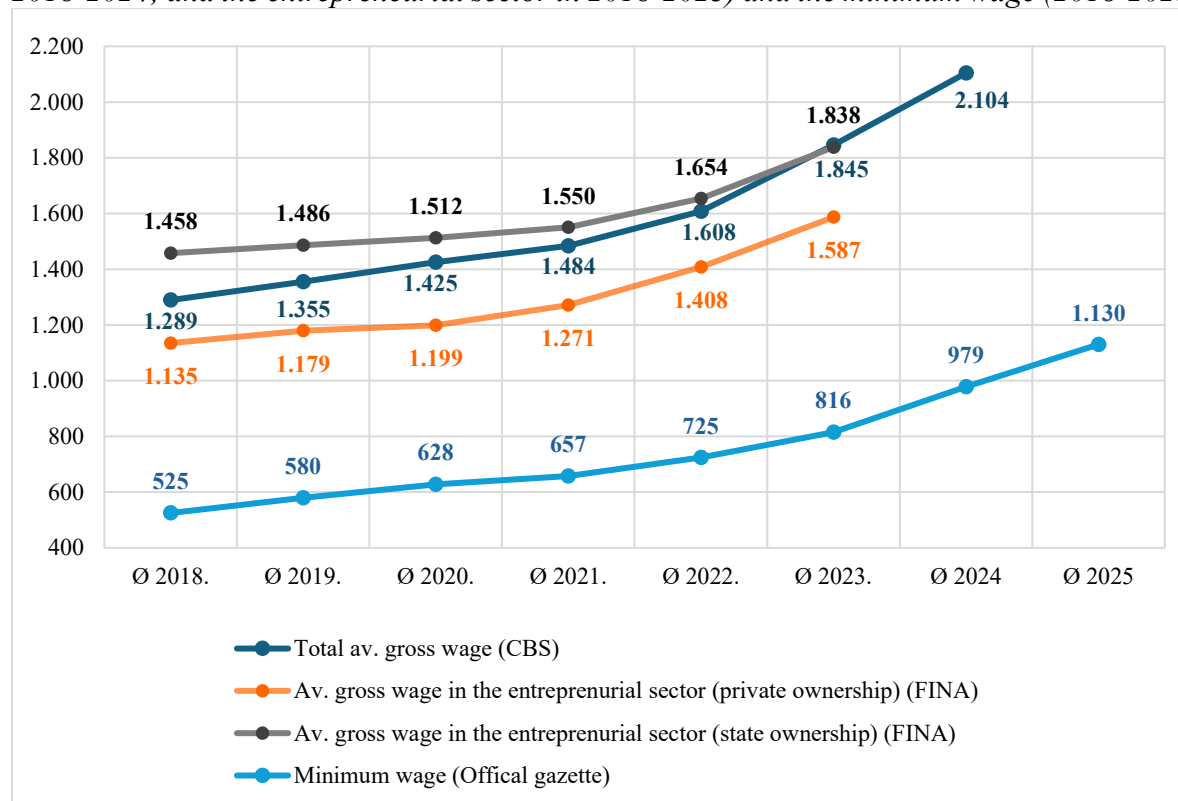
Some limitations of the research can also be seen in the fact that data and results do not allow drawing conclusions on within-firm wage adjustment variation.

Research findings

The data show that outside the privately-owned enterprises wage growth in Croatia was clearly more intense and this created a considerable inter-sectoral wage gap (Figure 1). Some inter-sectoral and other relations can be discerned for the period 2018-2023:

- a) Wage levels of privately-owned enterprises are consistently lower than in state-owned enterprises and the wedge is shrinking toward the end of the period (from -323 euro in 2018 to -251 euro in 2023).
- b) Wage levels of privately-owned enterprises were also consistently lower than the average wage of the entire economy encompassing wages of employed in the legal persons in the public sector, privately- and state-owned enterprises. The gap has widened in the observed period, from -154 euro in 2018 to - 258 euro in 2023.
- c) The average wage of the entire economy was 2,104 euro in 2024, the public sector being the most probably a large source of strong annual growth of 14%. It is highly unlikely that the privately-owned enterprises would reach this wage level in 2024, requiring 33% annual wage growth.
- d) Minimum wage was administratively raised by 86% in 2024 compared to 2018, exerting a certain pressure on the wage rise in the lower end of the total average wage distribution.

Figure 1: Nominal monthly gross wage expressed as annual average (in all legal persons in 2018-2024; and the entrepreneurial sector in 2018-2023) and the minimum wage (2018-2025)



Notes: 1. Private ownership refers to all companies in full or over 50% private ownership and cooperatives, while state ownership refers to all companies in full or over 50% state ownership; 2. CBS collects from legal entities of all forms of ownership, government bodies and bodies of local and regional self-government units.

Source: author according to CBS, FINA, LING-Official gazette and author's calculations of total average wage for 2024 based on January-October 2024 CBS data.

Data on wage growth rates show intensification in the post-COVID period, along with the growing inflation, in 2022 (Table 1). Wages have risen more strongly over the period 2018-2023 in the entire economy (7.5% annually), then in privately-owned enterprises (7.0%) and in state-owned enterprises (4.8%). The data on wages in the entire economy available for 2024 (+14.0% annual growth), confirms that this growing trend continued. One known source of this growth is the public sector wage reform carried out in 2024.

Table 1: Growth rate of the nominal gross wage in privately- and state-owned enterprises and in the entire economy

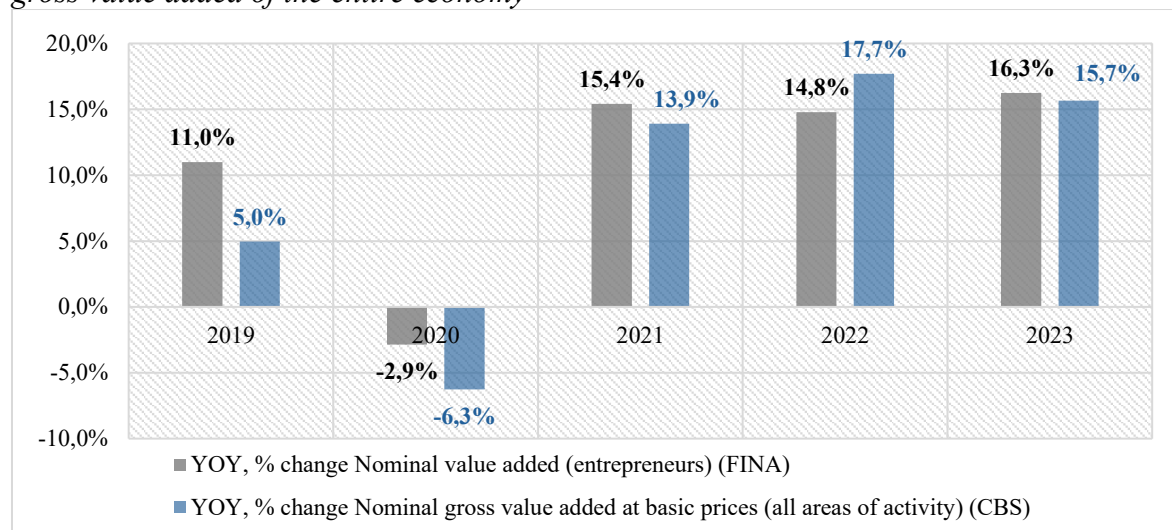
	2019	2020	2021	2022	2023	2024*	2018-23	2018-24
							average ann. growth rate	
Total (CBS)	5.1%	5.2%	4.2%	8.3%	14.8%	14.0%	7.5%	8.6%
Privately-owned enterprises (FINA)	3.9%	1.7%	6.0%	10.8%	12.7%	-	7.0%	-
State-owned enterprises (FINA)	2.0%	1.7%	2.5%	6.7%	11.1%	-	4.8%	-

Source: author's calculations based on FINA and CBS data.

*Average wage in 2024 is based on January-October 2024 data.

Value added (VA) as a measure of output, has been increasing robustly throughout the observed period, except in the COVID year 2020, when it has decreased by 2.9% for the entrepreneurial sector and by 6.3% for the entire economy (Figure 2). The VA growth was more dynamic in the entrepreneurial sector (10.9% annual growth rate) than of the entire economy (9.2%).

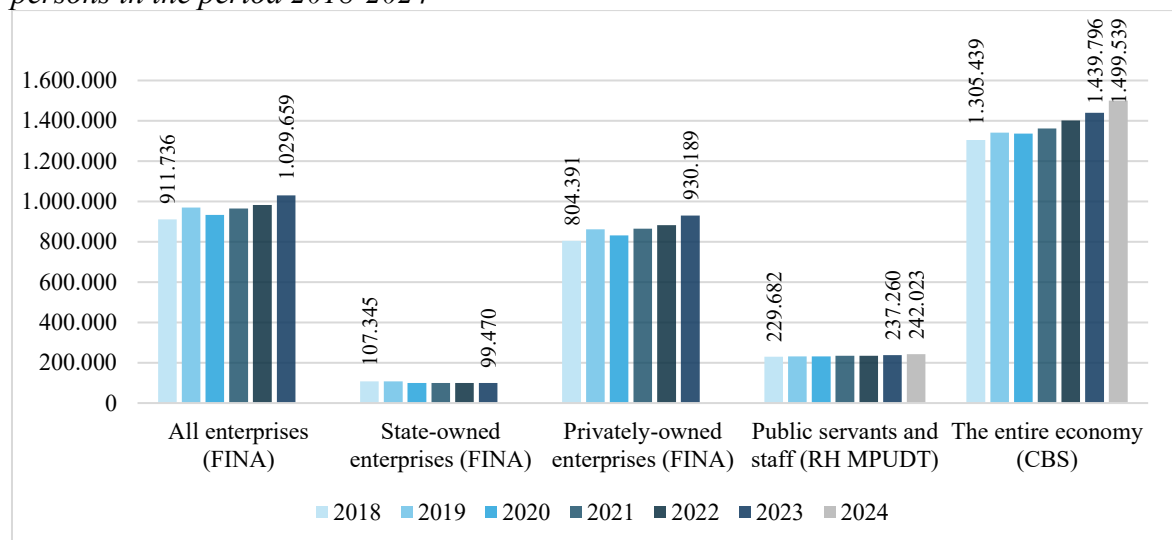
Figure 2: Annual change in nominal total value added of the entrepreneurial sector and gross value added of the entire economy



Note: Base prices are without subsidies and tax changes.

Source: author's calculation.

Figure 3: Number of employed persons by entrepreneurs (total and by ownership) in the period 2018-2023, number of public servants and staff and the total number of employed persons in the period 2018-2024



Source: author according to FINA (number based on hours worked), CBS and RH MPUDT data (number of employed persons).

As deflators are published with some delay, in times of growing inflation, resorting to the number of workers seems appropriate in discerning whether the growing turnover or value added is truly an indicator of an economic upturn. Enterprises will not hire additional workers unless there is real confidence in the market and/or significant increase in the volume of orders that cannot be met with the present number of workers. There is a steady increase in the total

number of workers with the exception of a temporary fall in the COVID year during 2018-2023/4 period (Figure 3; Table 2). The dynamic is similar both in the privately-owned enterprises (3.0% annual growth) and in the public sector (0.9%), but dissimilar in the state-owned enterprises where there was a decreasing trend, by 1.5 % annually on average.

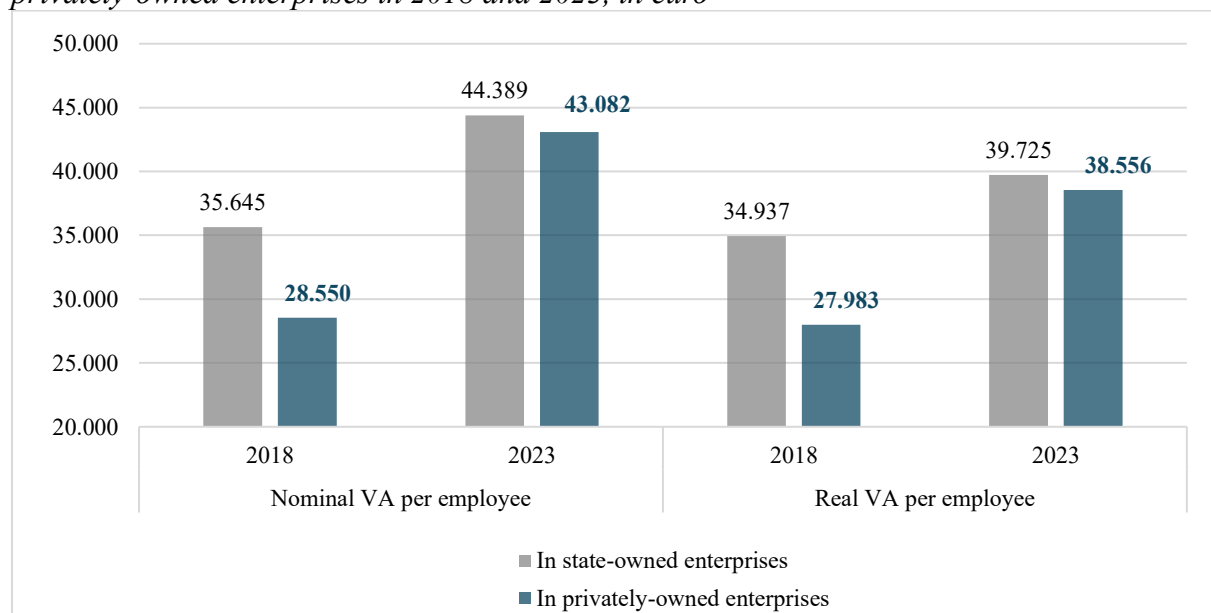
Table 2: Annual change in the number of employed persons across sectors

	2019	2020	2021	2022	2023	2024	Av. ann. growth rate	Cumulative growth
All enterprises (FINA)	6.4%	-3.8%	3.4%	1.8%	4.8%	-	2.5%	12.6%
- State-owned enterprises (FINA)	0.0%	-6.7%	-0.9%	-0.1%	0.2%	-	-1.5%	-7.4%
- Privately-owned enterprises (FINA)	7.2%	-3.5%	4.0%	2.0%	5.3%	-	3.0%	15.1%
Public servants and staff (RH MPUDT)	1.0%	0.0%	1.0%	0.2%	1.0%	2.0%	0.9%	5.3%
The entire economy (CBS)	2.8%	-0.4%	2.0%	2.9%	2.7%	4.1%	2.3%	14.1%

Source: author's calculations based on FINA, RH MPUDT and CBS data.

Labor productivity levels in terms of VA per employee were higher in the state-owned enterprises than in the privately-owned enterprises both in 2018 and 2023 (Figure 4). In 2023 the average VA per employee in the privately-owned enterprises was at 43.082 euro, and in the state-owned enterprises at 44.389 euro. But the gap actually shrunk immensely: from -7.095 euro in 2018 to -1.307 euro in 2023, in nominal terms, while it was slightly lower in real terms. This is due to faster growth of labor productivity in the privately-owned enterprises compared to the state-owned enterprises.

Figure 4: Labor productivity level in nominal and real terms in the state- and privately-owned enterprises in 2018 and 2023, in euro



Source: FINA (nominal values) and author's calculations of real values based on FINA data (VA) and CBS data (GDP deflator).

Average wage growth in enterprises exceeds the average rate of inflation (4.0%) in the observed period. For the nominal productivity growth of 8.1% per annum there is an average increase in wages of 6.6% per annum in the period 2018 – 2023 (Table 3). The gap closes when a lag is

introduced – productivity growth (7.4%; 2018-2022) and wage adjustment (7.4%; 2019-2023) are equal, suggesting *post factum* wage adjustment. Productivity growth has been stronger in the privately-owned enterprises (8.7%) than in the state-owned enterprises (4.6%). The wage adjustment response (4.8%) in the state-owned enterprises is over the accomplished productivity dynamic. When considering wage-productivity dynamic in real terms, wage adjustment in the state-owned enterprises is even stronger.

At the same time, privately-owned enterprises also responded with wage adjustment (7.0%) but not fully corresponding to productivity growth. The gap in privately-owned enterprises narrows when a lag is considered (productivity growth is at 8.2% and wage adjustment at 7.8%).

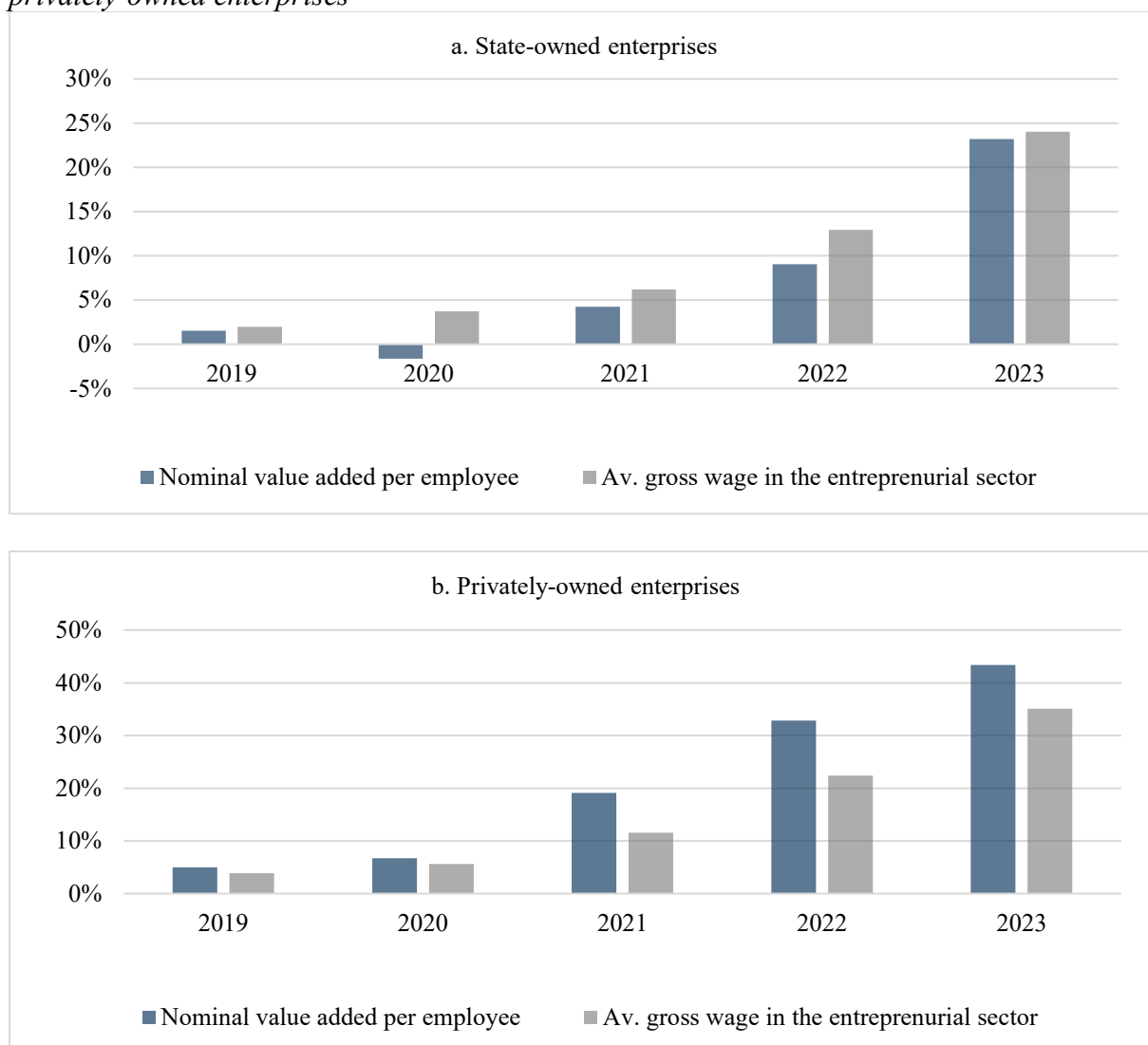
Table 3: Growth rates of average value added per employee and average gross monthly wage of entrepreneurs in the Republic of Croatia in the period 2018-2023

	VA per employee	Gross monthly wage per employee (annual av.)	VA per employee (2018-2022)	Gross monthly wage per employee (annual av.) (2019-2023)	Difference in growth rates	Difference in growth rates (t, t+1)
	1	2	3	4	5 (2-1)	6 (4-3)
All enterprises						
Nominal	8.1%	6.6%	7.4%	7.4%	-1.5%	0.0%
Real	6.1%	5.3%	5.8%	5.6%	-0.8%	-0.2%
State-owned enterprises						
Nominal	4.6%	4.8%	2.3%	5.5%	0.2%	3.2%
Real	2.7%	3.6%	0.8%	3.8%	0.9%	3.0%
Privately-owned enterprises						
Nominal	8.7%	7.0%	8.2%	7.8%	-1.7%	-0.4%
Real	6.7%	5.7%	6.6%	6.0%	-0.9%	-0.6%

Source: author's calculation based on FINA data (VA per employee and wages) and CBS data (GDP deflator, CPI).

As to the question of when wage adjustment takes place, a simple exercise of comparing nominal labor-productivity- and wages-growth cumulative rates in each consecutive year was carried out (Figure 5). The comparison shows that wage adjustment was much slower in privately-owned enterprises. In state-owned enterprises cumulative wages growth surpasses that of labor productivity until the end of observed period – in 2023 it roughly levels out with the cumulative labor productivity growth. In privately-owned enterprises wage growth cumulative is continuously below that of labor productivity and the difference does not even out in 2023.

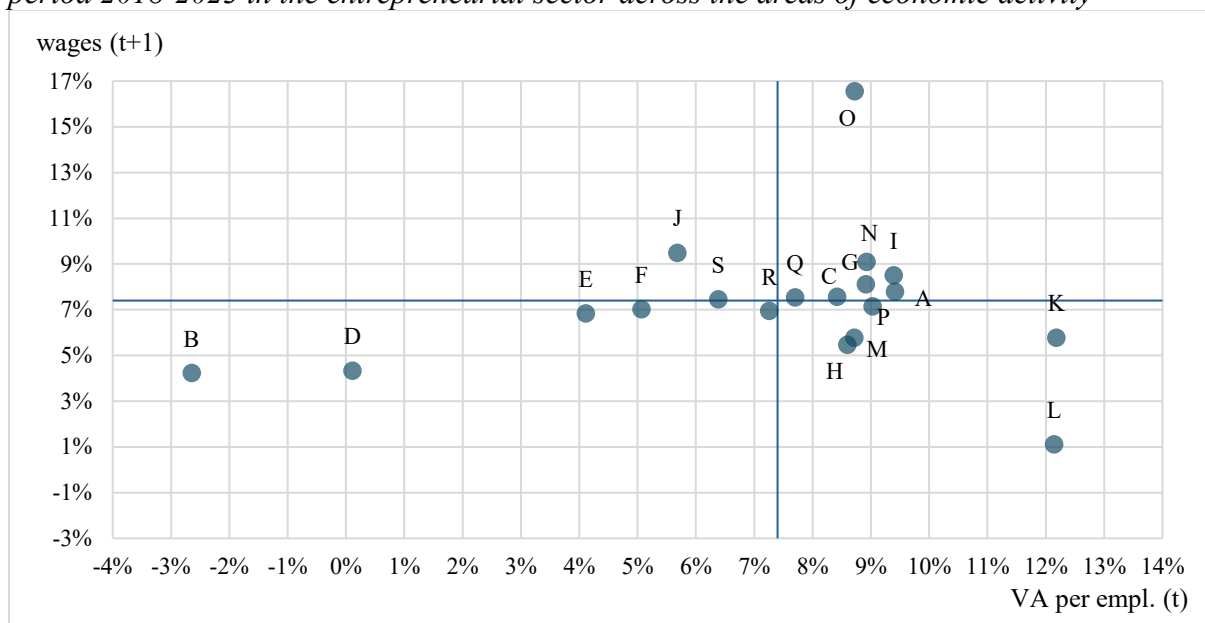
Figure 5: Cumulative growth of average monthly wage and labor productivity in state- and privately-owned enterprises



Source: author's calculations according to FINA data.

The annual changes in nominal labor productivity growth (%; in 2018-2022) and the annual changes in nominal wages (%; in 2019-2023) across different areas of economic activity in the entire entrepreneurial sector are displayed in Figure 6. In terms of the size of wage adjustment, at the forefront with wage adjustment surpassing their labor productivity growth are *J - Information and communication* (9.5%), *O - Public administration and defense* (16.5%) and *N - Administrative and support service activities* (9.1%). In *B - Mining and quarrying* and *D - Electricity, gas, steam and air conditioning supply* labor productivity has diminished or was stagnant, but still wages have increased (4.2% and 4.3%). Above-average labor productivity growth was achieved in *K - Financial and insurance activities* and *L - Real estate activities*, but the wage adjustment was not equally responsive (5.8% and 1.1%).

Figure 6: Labor productivity (t) and nominal wage ($t+1$) average annual growth in the period 2018-2023 in the entrepreneurial sector across the areas of economic activity



Note: Data labels stand for the following: A - Agriculture, forestry and fishing; B - Mining and quarrying; C - Manufacturing; D - Electricity, gas, steam and air conditioning supply; E - Water supply; sewerage, waste management and remediation activities; F - Construction; G - Wholesale and retail trade; repair of motor vehicles and motorcycles; H - Transportation and storage; I - Accommodation and food service activities; J - Information and communication; K - Financial and insurance activities; L - Real estate activities; M - Professional, scientific and technical activities; N - Administrative and support service activities; O - Public administration and defense; compulsory social security; P - Education; Q - Human health and social work activities; R - Arts, entertainment and recreation; S - Other service activities.

Given the issues at hand, the level and growth of wages in the public sector is also of interest in this analysis. Importantly, in the first half of 2024, a major reform of the wage system in public administration was carried out. It encompassed wage changes for 244 thousand public servants and staff. According to RH MPUDT (2024), the reform resulted in 32% higher wages in the public service compared to the same period in 2023. The main principle was to achieve equal pay for equal job positions.

Given the fact that the average gross wage in the public sector is not available, one may resort to approximations. Nestić (2024) provided approximations of the average weighted public and business sector wage based on CBS data up to April 2024 and used employment in legal persons as weights. He found that in 2023, public wage was 23% higher than the business sector wage, but in April 2024, post public-wage reform, it was 42% higher. As this was early on post-wage reform, he found that the business sector was not yet responsive to increased public wages.

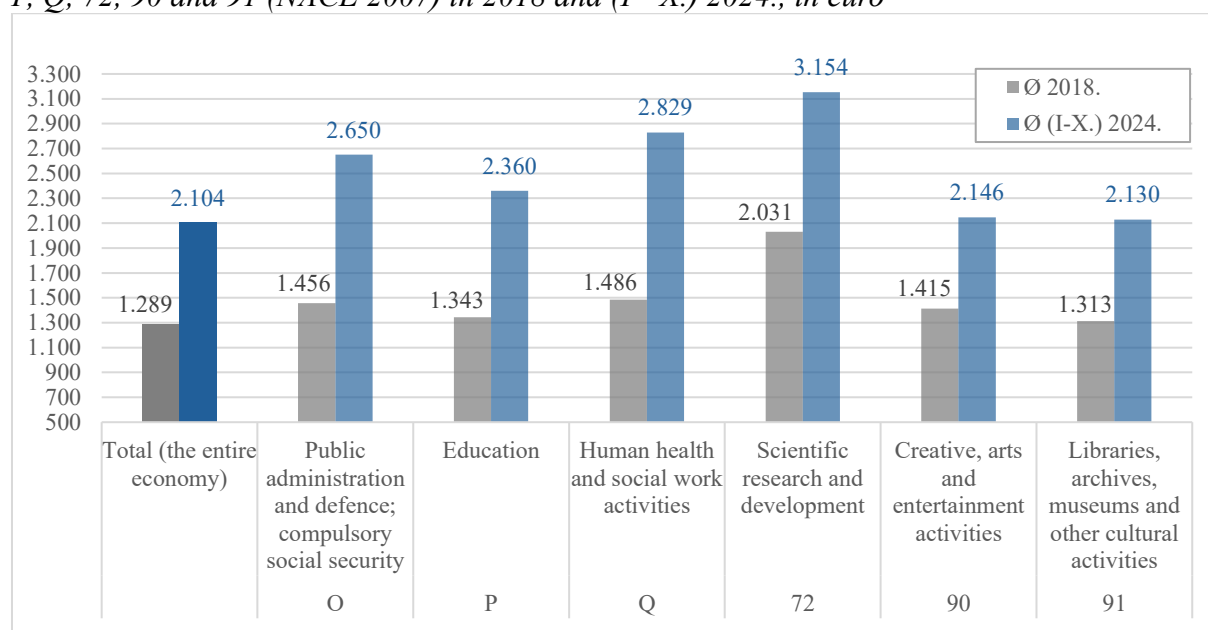
According to Nestić's argument (2024), the employment of public officials and personnel is significantly focused on a limited number of activities, which are thus regarded as indicative of the wage levels in the public sector (NACE 2007):

- O Public administration and defense; compulsory social security
- P Education
- Q Human health and social work activities
- M72 Scientific research and development

- R90 Creative, arts and entertainment activities
- R91 Libraries, archives, museums and other cultural activities

This reasoning was applied to 2024 data and there was a wage premium in these activities compared to the 2024 average wage of the entire economy by: 26% (O), 12% (P), 34% (Q), 50% (M72), 2% (R90) and 1% (R91) (Figure 7). Furthermore, the public servants and staff base pay will further increase throughout 2025 as envisaged in the collective agreement (Ling, 2025): compared to January 2025, in February 2025 it will rise by 3.0% and in September 2025 by 6.1%.

Figure 7: Nominal average gross wage of the entire economy and in largely public activities O, P, Q, 72, 90 and 91 (NACE 2007) in 2018 and (I–X.) 2024., in euro



Source: CBS and author's calculation based on CBS data for average 2024 wage; data were raised for the health contribution by the author.

Wage adjustments of public servants and staff will not be contained to this worker group alone, but it is likely to spill over through unions' pressures to the state-owned enterprises and state-related organizations, sustaining and/or possibly further deepening the wage wedge between privately-owned enterprises and the rest of the economy. The privately-owned enterprises will hardly match the level of gross wage increase in 2024 recorded for the entire economy as it would require approximately 33% annual nominal wage growth to be achieved in 2024. However, this will introduce additional labor cost pressures on entrepreneurial employers, possibly affecting cost competitiveness because it is unrelated to their productivity dynamics.

Wage adjustment in the observed period in Croatia has taken place in the conditions of low unemployment and troubling demographic trends. Among factors that might have influenced wage adjustment in the country beyond productivity issues is the strong European labour demand in certain professions. Demand for health professionals and IT experts and the magnitude of wage adjustments in related areas of activity in Croatia largely reflect this situation. Market orientation in the *Computer programming, consultancy and related activities* has changed as well: during 2019-2023 sales revenues from abroad almost tripled in this activity, according to FINA data. The average gross wage in this activity has been rising by 9.5% per annum. Similarly, average gross wage in *Human health activities*, according to CBS

data, has been rising 12.5% per annum. The wage level in both of these economic activities is among the highest in the Croatian economy.

Large-scale labor shortages were present in tourism, construction, retail trade, manufacturing industry and tourism-associated activities in job positions requiring lower qualifications and thus in the lower-wages-range, sometimes minimum. Shortages were resolved through hiring foreign workers from third countries, but data do not show that wage growth was suppressed in these activities. The consecutive annual administrative rise of the minimum wage during the observed period has certainly contributed to some extent.

The economic outlook in 2025 is uncertain due to rising protectionism and there is possibility of a global recession. Bates et al. (2024) expect the growth of negotiated wages to ease in 2025 and ECB in March 2025 confirmed this expectation for several older Eurozone members. Croatia's inflation rates and wages adjustment were more pronounced and similar to the other post-transition economies. Wages adjustments in Croatia in 2025 are likely to occur in the private sector in response to the public wage reform, also there will be increases of wages of public servants and staff that are envisaged in the collective agreements. In the case of an economic downturn in 2025, the possibilities of wage adjustments will largely be limited.

Conclusion

Results of the analysis have shown that in the period 2018-2023/24, amidst economic turbulence and the inflationary conditions, the entrepreneurial sector employers in Croatia responded to nominal labor productivity growth with wages adjustment fully or nearly fully. The magnitude and the timing of the employers' response can be distinguished for privately- and state-owned enterprises. In privately-owned enterprises for the average annual productivity growth of 8.7% in the period 2018-2023, average annual gross wage increase amounted to 7.0%, while in state-owned enterprises for the average annual productivity growth of 4.6%, wage adjustment was at 4.8%, hence surpassing labor productivity dynamic. Wages are largely adjusted post-factum as to nominal productivity gains in the privately-owned enterprises. Also, the productivity growth was more dynamic in the privately-owned enterprises than in the state-owned enterprises, conditioning the magnitude of the response.

The analysis has shown that wages in the privately-owned enterprises were persistently lower in 2018-2023 than in state-owned enterprises or in the entire economy, including the public sector. Nestić's (2024) public and business wage approximations up to April 2024 show that the noted wage wedge has grown, due to the public wage reform and some previous public wage adjustments. There is likelihood that the wedge may further deepen: data show that, backed up with favorable budgetary conditions, wages of public servants and staff in typical public activities surpass the economy-wide wage (in January-October 2024) by 26% in Public administration and defense; compulsory social security, by 12% in Education, by 34% in Human health and social work activities, by 50% in Scientific research and development, by 2% in Creative, arts and entertainment activities and by 1% Libraries, archives, museums and other cultural activities.

Strong wage increases in the public sector may spill over to state-owned enterprises through unions' initiatives and wage bargaining. Pressure on labor costs will also be further felt throughout the private sector. Given the public-private wage wedge, it is unlikely that 2024 average economy-wide wage can be matched by privately-owned enterprises as it would require

of them approximately 33% annual nominal wage growth to be achieved only in 2024. Labor costs pressures that are unrelated to the productivity dynamic pose a risk to cost competitiveness of Croatian firms in a highly competitive global economy.

As to the limitations of the research, enterprise data and results are provided mostly at the macroeconomic and the sectoral level and no inferences could be made as to within-firm wage adjustment variation to learn whether adjustment was confined to some enterprises or well distributed across the whole structure and what their magnitude was.

This paper contributes to the body of literature on productivity-wages issues by providing an understanding of wages adjustment to productivity dynamic in a post-transition economy amidst economic turbulence and inflationary circumstances. As the public-private sector wage wedge is tackled, the paper has policy implications for the issues of effectiveness of public wage adjustment with regard to wider economic policy objectives such as full employment and competitiveness. Public-sector wage adjustment should be carried out taking into consideration labor productivity dynamic and the private sector wage growth to avoid overshooting and its negative effects to employment and to price competitiveness, through spillover effects. Directions for future research can be seen in a microeconomic (firm-level) analysis of wage adjustment as well as the analysis of the effects of wage adjustments on price competitiveness of tradable sectors.

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THE ROLE OF ARTIFICIAL INTELLIGENCE IN BRIDGING THE NEGATIVE EFFECTS OF AN AGING WORKFORCE ON PRODUCTIVITY

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Abstract

The age distribution of Europe's workforce has shifted towards older workers over the past few decades, a process expected to accelerate in the years ahead. This demographic trend presents significant challenges to productivity and economic growth, particularly in the EU-27, where workforce aging is projected to reduce growth in total factor productivity. This paper studies the effect of workforce aging on productivity, identifies the main transmission channels, and examines policies that could mitigate its effects. The main research question is whether the utilization of artificial intelligence is offsetting the negative impact of workforce ageing on total factor productivity. The study employs a mixed-methods approach, including quantitative analysis of Eurostat labor market data and qualitative insights derived from interviews with managers. The results of the empirical analysis suggest that AI adoption positively affects productivity, even in the context of a demographic shift associated with ageing workforce. Findings also indicate that AI can partially offset the productivity decline by automating repetitive tasks, enabling older workers to focus on higher-value activities, and facilitating continuous learning through advanced training systems. Additionally, policies aimed at reskilling older workers, promoting intergenerational knowledge transfer, and investing in AI infrastructure could further ameliorate the effects of workforce aging. To sum up, the implications of the study are that artificial intelligence utilization contributes to productivity enhancements, therefore there is a need for introducing policies that promote its adoption, as well as reskilling and upskilling of workforce to be able to follow the trends.

Keywords: ageing workforce, EU, artificial intelligence, total factor productivity

JEL classification: E23, O30, O47, M15

Introduction

The demographic landscape of the European Union (EU) is undergoing a significant transformation. In recent decades, the age distribution of the EU-27 workforce has shifted markedly toward older age cohorts (Eurostat, 2022). Projections indicate that this trend will continue, leading to an accelerated pace of workforce aging over the next two decades. This phenomenon is not only a demographic curiosity but also a pivotal economic challenge. A growing body of research suggests that workforce aging is likely to depress labor productivity and dampen economic growth also by reducing total factor productivity (TFP), which is often

referred also as Solow residual (Reati, 2001). For instance, Eurostat (2022) and the Organisation for Economic Co-operation and Development (OECD, 2021) have both noted that TFP growth in the EU may decline by approximately 0.2 percentage points annually if current demographic trends persist.

The motivation of the paper derives from the rise of the Industry 5.0 with advancement of artificial intelligence (AI) and deepened human-machine interactions among others (Barata & Kayser, 2023). Simultaneously, industrialized societies are facing an aging workforce. The objective of the paper is to explore the interplay between workforce aging, AI utilization and TFP changes. We specifically focus on TFP since it is commonly associated with innovation and technological change (Murray & Sharpe, 2016), and this is highly relevant given the context of the study. The main research question is whether the utilization of AI is offsetting the negative impact of workforce ageing on TFP in the EU countries. The study employs a mixed-methods approach, including quantitative analysis of Eurostat labor market data and qualitative insights derived from interviews with managers to get more contextualized insight on the results of the quantitative analysis. The results of the empirical analysis suggest that AI adoption positively affects productivity, even in the context of a demographic shift associated with ageing workforce. The implications of the study are that AI utilization contributes to productivity enhancements, therefore there is a need for introducing policies that promote AI adoption, as well as reskilling and upskilling of workforce to be able to follow the trends.

Theoretical framework

Productivity and workforce aging

The demographic change in the EU-27 has led to an increasing proportion of older workers, a phenomenon that carries significant implications for labor productivity and economic growth. As the workforce ages, several mechanisms may contribute to a decline in productivity. One primary channel is the erosion of human capital through skill obsolescence; older workers may find it increasingly challenging to adapt to rapid technological advancements, resulting in a misalignment between existing skills and the demands of modern workplaces (Acemoglu & Restrepo, 2018). Furthermore, the natural decline in physiological and cognitive capacities that often accompanies aging can lead to higher rates of absenteeism and diminished work efficiency (OECD, 2021). These individual-level challenges are compounded by organizational dynamics, as firms with a predominantly older workforce often exhibit a lower propensity to adopt innovative practices and technologies, thereby impeding effective knowledge transfer between generations (Brynjolfsson & McAfee, 2017). In addition to these issues, demographic pressures, as noted by Bloom et al. (2010), may dampen aggregate economic growth by constraining labor market expansion and reducing the overall dynamism of the economy. The cumulative effect of these factors is a deceleration in total factor productivity—a trend that poses substantial challenges for sustaining economic growth within the EU-27.

Moreover, evidence from longitudinal analyses suggests that workforce aging negatively influences aggregate productivity, primarily through reductions in total factor productivity (TFP). Using data from European countries spanning 1950 to 2014, studies have shown that a five-percentage-point increase in the proportion of workers aged 55–64 correlates with a three-percent decline in labor productivity (Aiyar et al., 2016). These results emphasize the structural challenges posed by demographic shifts, particularly in economies with rapidly aging populations. Breaking down labor productivity into its components—physical capital, human

capital, and TFP research consistently identifies TFP as the primary mechanism through which workforce aging exerts its impact. TFP, which measures the efficiency of input utilization, is crucial for sustained economic growth. An aging workforce has been associated with a 2–4% reduction in TFP, reflecting inefficiencies in adapting to technological change and innovation (Aiyar et al., 2016; Acemoglu & Restrepo, 2017).

The premise for the question is derived from previous research, which has envisaged that workforce ageing will be a significant drag on European labor productivity growth over the next few decades, mainly through its negative effect on TFP growth. However, there might be several conditional factors that might reduce this negative effect, e.g. upgraded human capital, labor market flexibility, and technological innovation and adaptation (Aiyar et.al., 2016), where the last factor seems to be in the new “revolutionary mode” recently, among others through increased utilization of artificial intelligence.

Policy measures to mitigate productivity decline

Policymakers have therefore advocated for a range of interventions aimed at mitigating the adverse impacts of an ageing workforce on productivity. Investments in lifelong learning and reskilling initiatives are essential to ensure that older employees remain competitive in an evolving labor market. Such initiatives help to bridge the technological gap by equipping workers with new competencies and fostering continuous professional development (Acemoglu & Restrepo, 2018).

Moreover, fostering intergenerational knowledge transfer through structured mentorship programs can leverage the strengths of both experienced and digitally proficient younger employees, thereby enhancing overall organizational performance (Brynjolfsson & McAfee, 2017). Complementary strategies include the implementation of comprehensive workplace health and well-being programs to reduce the productivity losses associated with age-related health issues (OECD, 2021). In this context, the risk of automation and the need for technological adaptation have also been analyzed in comparative studies (Arntz et al., 2016), underscoring the importance of policy frameworks that encourage both technological adoption and human capital development. Collectively, these interventions are critical for counteracting the productivity decline linked to an aging workforce and for sustaining economic vitality.

The role of AI in enhancing productivity

Recent advancements in AI offer promising avenues to address the productivity gap created by an aging workforce. AI technologies can automate routine tasks, thereby allowing older workers to concentrate on higher-value, decision-making activities (Bughin et al., 2019). Additionally, AI-driven training systems facilitate continuous learning, thus reducing the skill gap that accompanies aging (Brynjolfsson & McAfee, 2017). These interventions can improve productivity by enabling more efficient allocation of labor and fostering a more dynamic work environment.

Despite the positive potential of AI, there are concerns regarding its integration. Research from the USA suggests that about 80% of the workforce could have at least 10% of their tasks automated with the introduction of large language models, while nearly 20% of employees could see at least 50% of their tasks automated (Brynjolfsson et al., 2021). Unlike previous waves of automation, jobs requiring higher skills, including those of older employees, are more at risk. The European context poses unique challenges; while technology is essential for

preserving the European social model amid demographic changes, AI without proper skills development and adaptation for the aging workforce could threaten jobs. Nearly 70% of participants in Eurofound (2023) survey favored imposing restrictions on AI to protect jobs, indicating widespread anxiety about the displacement effects of technology. The exposure to AI has been generally positive in Europe, enhancing rather than replacing the workforce, although challenges remain in adapting to these changes as the workforce ages.

Methodology

We employed a mixed-methods approach, combining quantitative and qualitative analyses to provide a comprehensive understanding of workforce aging and AI adaptation. Sequential mixed methods are research design that sequentially integrates quantitative and qualitative approaches, enabling researchers to first identify broad patterns and relationships through quantitative analysis and then to elaborate on these findings with in-depth qualitative inquiry. As noted by Venkatesh et al. (2013), this approach facilitates a more comprehensive understanding of complex phenomena by combining the precision of numerical data with the rich, contextual insights gained from qualitative methods.

Quantitative research

The quantitative analysis was conducted using a panel ordinary least squares (OLS) regression model. Panel data regression is a statistical method that analyzes data observed across multiple entities (e.g., countries, firms, or individuals) over time, allowing researchers to control for both cross-sectional and temporal variations (Baltagi, 2021). This approach is particularly useful in economic and social sciences research, as it helps address omitted variable bias and enhances causal inference by leveraging variations within and across units over time (Hsiao, 2014). Data were sourced from Eurostat (2025), which provides comprehensive statistics on labor productivity, workforce demographics, and digital adoption across the EU-27, for the time period from 2013 to 2023. The analysis involves tracking trends in key variables and examining their relationships through statistical modeling.

Moreover, the dependent variable, Total Factor Productivity (TFP) growth, is a continuous measure, making OLS a methodologically sound choice. Although Aiyar et al. (2016) applied a log-log specification for modeling productivity, we opted for a linear-level panel OLS regression, given that our dependent variable, TFP growth, is already expressed as a percentage and includes non-positive values (e.g., -0.2%). Logging such values would violate the assumptions of log transformations and could bias the estimates. Furthermore, the level specification allows for more straightforward policy interpretation of coefficients in absolute terms (i.e., percentage point changes in productivity).

What is more, the model structure follows previous empirical studies on productivity and aging, such as Aiyar et al. (2016) and Kim & Loayza (2019), and was estimated using a Random Effects (RE) specification. This model was selected because it assumes that unobserved country-specific effects are uncorrelated with the regressors — an assumption appropriate for macro-panel data.

To ensure the robustness of the panel regression results, diagnostic tests for key econometric assumptions were conducted. First, we tested for cross-sectional dependence using Pesaran's

CD test. The results did not indicate statistically significant cross-sectional correlation ($p > 0.10$), supporting the assumption of cross-sectional independence across EU-27 countries. Second, we examined the stationarity properties of the panel variables. Unit root tests were applied, including the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) tests. All key variables—including *TFP growth*, *workforce 55+*, *R&D spending*, and *ICT use at work*—were found to be stationary at level ($p < 0.05$), thereby justifying the use of level-level panel regressions without differencing or transformation. These results reinforce the reliability of the estimations presented in subsequent sections.

Model 1 examines how workforce aging affects total factor productivity (TFP) growth. The model is specified as follows:

Model 1 (Aging and TFP Growth):

$$TFP\_Growth_{it} = \beta_0 + \beta_1 Workforce\_55+_{it} + \beta_2 OADR_{it} + \beta_3 YDR_{it} + \beta_4 RD\_Spending_{it} + \beta_5 Employment\_Rate_{it} + \epsilon_{it}$$

where:

- TFP_Growth_{it} = Change in total factor productivity for country i in year t .
- $Workforce\_55+_{it}$ = Share of the workforce aged 55 and above.
- $OADR_{it}$ = Old-age dependency ratio.
- YDR_{it} = Youth dependency ratio.
- $RD\_Spending_{it}$ = Research and development expenditure as a percentage of GDP.
- $Employment\_Rate_{it}$ = Percentage of working-age population employed.
- ϵ_{it} = Error term.
- β_0 is the intercept, and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ are the regression coefficients.

Model 2 extends Model 1 by incorporating ICT use at work as a proxy for AI adaptation, as this variable includes also dimensions that address the utilization of AI, to determine its mitigating effect on productivity decline. Thereby, assessing how enhanced digital competencies contribute to sustaining total factor productivity amid operational disruptions. This indicator comprises values reflecting the use of basic devices, specialized computerized equipment, comprehensive digital work activities, electronic communication and data entry, document creation and editing, social media utilization, task management applications, occupational-specific software, and IT system development or maintenance.

Model 2 (AI Adaptation Effect and TFP Growth):

$$TFP\_Growth_{it} = \beta_0 + \beta_1 Workforce\_55+_{it} + \beta_2 OADR_{it} + \beta_3 YDR_{it} + \beta_4 RD\_Spending_{it} + \beta_5 Employment\_Rate_{it} + \beta_6 ICT\_Use_{it} + \epsilon_{it}$$

where:

- ICT_Use_{it} = Level of ICT use at work, representing AI adaptation.

The coefficient β_6 is of particular interest, as it captures the effect of AI adaptation on TFP growth.

Table 1: Variables specification

Variable Name	Acronym	Definition / Description	Measurement	Data Source
Total Factor Productivity Growth	TFP_Growth	Annual percentage change in total factor productivity, a measure of output not explained by inputs.	% change per year	Eurostat (2025)

Variable Name	Acronym	Definition / Description	Measurement	Data Source
Share of Workforce Aged 55+	Workforce_55+	Percentage of the workforce aged 55 years and older.	% of total employed population	Eurostat (2025)
Old-Age Dependency Ratio	OADR	Ratio of population aged 65+ relative to population aged 15–64.	% (per 100 working-age individuals)	Eurostat (2025)
Youth Dependency Ratio	YDR	Ratio of population aged 0–14 relative to population aged 15–64.	% (per 100 working-age individuals)	Eurostat (2025)
R&D Spending	RD_Spending	Gross domestic expenditure on R&D as a share of GDP.	% of GDP	Eurostat (2025)
Employment Rate	Employment_Rate	Proportion of the working-age population (15–64) that is employed.	%	Eurostat (2025)
ICT Use at Work (Proxy for AI)	ICT_Use	Composite indicator of digital technology use at work, including computer usage, task automation, and digital communication.	Index (0–1 scale)	Eurostat (2025)

Source: Authors' work

Qualitative research

To complement the quantitative findings, a qualitative study was conducted to explore managerial perspectives on AI adaptation in the workplace. A purposive sampling strategy was employed to identify participants with relevant knowledge and practical experience in managing workforce aging and implementing AI tools. This approach is widely accepted in qualitative research when the goal is to gain in-depth insights from information-rich cases (Patton, 2002).

Four senior managers from key service sectors in Slovenia — healthcare, education, public administration, and tourism — participated in semi-structured interviews. Although five individuals were invited to participate in a focus group setting, four agreed to individual interviews. The interviews were conducted during winter of 2024/25.

Each interview lasted approximately 45 to 60 minutes and followed a guided protocol that included the following themes: definitions and perceptions of AI within their organization, observed changes in workflows and productivity, experiences with aging employees adapting to AI tools, and organizational strategies for digital upskilling and intergenerational collaboration.

The interviews were noted and subsequently reviewed and analyzed using thematic analysis as described by Braun & Clarke (2006). This method enabled the identification of recurring themes and conceptual patterns across participants, while maintaining analytical rigor and transparency.

Results

The proportion of workers aged 55+ increased steadily from approximately 16% in 2013 to over 25% in some EU-27 countries by 2023 (see Table 2). This trend reflects broader demographic shifts and longer working lives. Labor productivity, measured as GDP per hour

worked, showed moderate growth but exhibited stagnation in recent years, aligning with workforce aging trends. Total Factor Productivity (TFP) growth, a key driver of economic efficiency, displayed a declining trend, averaging between -0.2% and 1.0% annually. Countries with higher R&D spending tended to exhibit stronger TFP performance.

Table 2: Trends (EU-27, 2013-2023)

Year	Workforce_55plus (%)	Labor Productivity (GDP/hour, index)	TFP Growth (%)	R&D Spending (% of GDP)
2013	16.1	95.0	0.9	1.6
2014	17.2	96.2	0.7	1.7
2015	18.4	97.8	0.6	1.8
2016	19.5	99.5	0.5	2.0
2017	20.3	100.1	0.3	2.1
2018	21.0	100.4	0.4	2.3
2019	22.1	100.7	0.2	2.4
2020	23.2	101.0	0.1	2.5
2021	24.1	100.9	0.0	2.6
2022	25.0	100.7	-0.1	2.7
2023	25.3	100.6	-0.2	2.8

Source: Eurostat (2025)

Moreover, the predicted decline in TFP growth alongside an increasing median age of the workforce raises substantial concerns regarding the long-term sustainability of economic expansion in the EU-27, as an aging workforce may not only reduce the overall number of economically active individuals but also limit the adaptability and innovative capacity of organizations.

Table 3: Descriptive Statistics (EU-27, 2013-2023)

Variable	Min	Max	Mean	Std Dev
Workforce 55+ (%)	16.0	28.0	22.5	3.5
Old-Age Dependency	28.0	38.0	33.0	3.0
Youth Dependency	20.0	30.0	25.0	2.8
Labor Productivity	90.0	110.0	100	6.0
TFP Growth (%)	-0.2	1.0	0.4	0.4
R&D Spending (%GDP)	1.5	3.2	2.3	0.5
Employment Rate (%)	65.0	80.0	72.5	4.0
ICT Use at Work	0.0	1.0	0.5	0.25

Source: Eurostat (2025), authors' calculations

A panel ordinary least squares (OLS) regression model with Random Effects (RE) specification was applied to assess the impact of workforce aging on TFP growth (see Table 4). A Hausman test confirmed the validity of the RE approach over Fixed Effects. The results indicate that workforce aging has a statistically significant negative effect on productivity (coef. = -0.0182, SE = 0.005). The coefficient of -0.0182 for Workforce 55+ in Model 1 reflects

marginal effect, rather, an elasticity. This suggests that *ceteris paribus*, an aging workforce contributes to a widening of the TFP gap, not its narrowing.

The old-age and youth dependency ratios, R&D spending, and employment rate did not exhibit statistically significant relationships with TFP growth, yet all theoretically relevant control variables were retained for consistency across models and to avoid omitted variable bias.

For Model 1 the results indicate that workforce aging has a significant negative effect on TFP growth, with an overall R^2 of 0.045, suggesting that the included variables explain 4.5% of the variation in productivity. The Breusch-Pagan test ($p=0.312$) confirms that heteroskedasticity is not an issue, while the Breusch-Godfrey test ($p=0.401$) indicates that serial correlation is also not present. These results suggest that workforce aging contributes to lower productivity growth, but other factors not captured in this model may also play an important role.

Table 4: Regression Results for Workforce Aging and AI Adaptation

Variable	Model 1 (Aging Impact)	SE	p	Model 2 (AI Adaptation)	SE	P
Intercept	1.4325	0.500	.004	1.2874	0.487	.009
Workforce 55+	-0.0182	0.005	.001	-0.0176	0.005	.001
Old-Age Dependency	-0.0019	0.007	.793	-0.0021	0.007	.780
Youth Dependency	-0.0047	0.007	.497	-0.0042	0.007	.543
R&D Spending	-0.0210	0.041	.608	-0.0187	0.040	.641
Employment Rate	-0.0067	0.005	.174	-0.0062	0.005	.182
ICT Use at Work	-	-	-	0.0543	0.018	.002
R^2	0.045			0.082		
Breusch-Pagan p	0.312			0.284		
BreuschGodfrey p	0.401			0.378		

Source: Authors' calculations (2025)

A second regression model was estimated to assess whether AI adaptation, measured as ICT use at work, influences TFP growth. The results suggest that ICT use at work has a positive and statistically significant impact on TFP growth (coef. = 0.0543, SE = 0.018), while workforce aging continues to have a negative and statistically significant impact (coef. = -0.0176, SE = 0.005). Moreover, R^2 of 0.082 indicates that the inclusion of ICT use at work increases the explanatory power of the model to 8.2%, highlighting the importance of AI adaptation in productivity, serving as conditional factor to increase TFP. Although these are rather low values, yet still statistically significant, they correspond to figures of some other empirical studies that have investigated the phenomenon in the pooled data context (Kim & Loayza, 2019), as well as potentially in the limitations poised by the understanding of Solow residual per se (Reati, 2001). The Breusch-Pagan ($p=0.284$) and Breusch-Godfrey ($p=0.378$) tests confirm that heteroskedasticity and serial correlation do not affect the reliability of the estimates. The positive and statistically significant coefficient for ICT use suggests that AI adaptation mitigates the negative effects of an aging workforce on productivity by improving efficiency and workplace innovation. Therefore, the findings indicate that AI adaptation through ICT use plays a crucial role in counteracting the negative productivity effects of workforce aging.

Furthermore, to assess the robustness of the findings, a secondary regression was performed using a log-transformed dependent variable: $\log(\text{TFP\_Growth} + 1)$. This transformation addresses potential non-linearities and allows inclusion of non-positive values. Results from this log-linear model confirmed the directionality and statistical significance of core relationships, particularly the negative effect of aging and the positive role of ICT use (see Table 5).

Table 5: Regression results for workforce aging and AI adaptation

	Coef.	Std.Err.	t	P> t 	[0.025	0.975]
Intercept	0.4153	0.3849	1.0789	0.2815	-0.3423	1.1729
Workforce_55plus	0.0058	0.0043	1.3441	0.18	-0.0027	0.0143
OADR	0.0003	0.0056	62	0.9506	-0.0106	0.0113
YDR	0.0016	0.0053	0.2975	0.7663	-0.0088	0.0119
RD_spending	0.0366	31	1.1816	0.2384	-0.0244	0.0976
Employment_rate	-0.0055	0.0036	-1.5104	132	-0.0126	0.0017
ICT_use	0.0306	0.0548	0.5574	0.5777	-0.0774	0.1385

Source: Authors' calculations (2025)

The results of this specification indicate that the coefficient for the share of the workforce aged 55 and over (Workforce_55plus) is positive ($\beta = 0.0058$, $SE = 0.0043$), but statistically insignificant at the 5% level ($p = 0.180$). Other demographic controls, including the old-age dependency ratio (OADR) and youth dependency ratio (YDR), also exhibit statistically insignificant effects, with coefficients close to zero. The coefficient for R&D spending remains positive and of moderate magnitude ($\beta = 0.0366$, $SE = 0.0310$), although it is not statistically significant. Overall, while the direction of key coefficients remains broadly consistent with the baseline model, the lack of statistical significance suggests that the linear-level specification may provide a more precise estimation framework in this context, particularly given the percentage-based nature and limited range of the dependent variable.

Moreover, to better understand the practical implications of AI adoption in the context of an aging workforce, a qualitative study was conducted. Four in-depth interviews were held with managers from various industries within Slovenia. Participants were selected based on their experience with workforce aging and AI implementation in the workplace. The sample included individuals from both the public and private sectors, ensuring diverse perspectives on AI adaptation. Three participants were from the public sector, while one represented the private sector.

Table 6: Sample characteristics of interview participants

Participant	Gender	Age	Industry	Organization Type	Years in Managerial Role	AI Experience (Years)
Manager A	Male	52	Healthcare	Public Sector	15	3
Manager B	Female	47	Education	Public Sector	12	2
Manager C	Male	58	Government	Public Sector	20	4
Manager D	Female	54	Tourism	Private Sector	18	3

Source: Author's work (2025)

The participants' ages ranged from 47 to 58 years old ($M=52.75$, $SD=4.57$). They had extensive experience in managerial roles, with tenure ranging from 12 to 20 years ($M=16.25$, $SD=3.59$). Their AI experience varied from 2 to 4 years ($M=3.00$, $SD=0.82$), reflecting early-stage but active engagement in AI implementation within their respective organizations.

Of the four participants, three (75%) were from the public sector, and one (25%) was from the private sector. Industries represented included healthcare, education, government, and tourism, providing insights into AI adoption across service-based and commercial sectors.

Furthermore, the following themes emerged:

(1) **Enhanced Task Automation:** Managers reported that AI tools have effectively automated repetitive tasks, which has led to increased efficiency and allowed workers, particularly older employees, to focus on tasks requiring critical thinking (Manager A, personal communication, 2025).

(2) **Facilitation of Continuous Learning:** AI-powered training programs have been instrumental in upskilling older workers. Manager B noted that these programs not only improve individual performance but also foster a culture of lifelong learning (Manager B, personal communication, 2025).

(3) **Improved Decision-Making:** Several managers highlighted that AI analytics have improved decision-making processes by providing real-time insights, thus compensating for potential declines in cognitive agility among older workers (Manager C, personal communication, 2025).

(4) **Challenges in Implementation:** Despite the benefits, managers also cited challenges such as ethical concerns, data privacy issues, and resistance to change among some staff members (Manager D, personal communication, 2025).

These qualitative findings suggest that while AI offers considerable potential to enhance labor productivity in an aging workforce, successful implementation requires addressing both technological and human factors.

Discussion

The statistical models confirm the significant negative impact of workforce aging on productivity, aligning with prior research on the topic. However, this study also highlights the critical role of AI adaptation in mitigating productivity declines. ICT use at work emerges as a key driver of efficiency, demonstrating a statistically significant positive effect on TFP growth. These findings indicate that AI adoption can effectively compensate for workforce aging by enabling automation, improving decision-making, and fostering a culture of continuous learning.

The findings confirm the hypothesis that workforce aging exerts a negative effect on TFP growth. This result is consistent with the existing literature, particularly Aiyar et al. (2016), who estimated similar effects of demographic aging on productivity using log-linear panel models. Our estimates, although using a linear specification, show similar directionality and statistical strength. The positive and significant effect of ICT use at work provides support for

the notion that digitalization, including AI tools, can serve as a conditional productivity enhancer in the context of aging labor markets. This aligns with Acemoglu & Restrepo (2017), who argued that intelligent automation can increase efficiency and offset age-related productivity declines, especially when paired with human capital strategies.

Moreover, the explanatory power of the models (R^2 values below 10%) may seem low, but this is typical for macroeconomic panel data models that estimate TFP growth, which is itself a residual of unexplained factors (Reati, 2001). The results are also consistent with studies using pooled data from global samples (e.g., Kim & Loayza, 2019). Overall, the regression results support the argument that AI can be a complementary force in addressing productivity challenges posed by demographic aging — but it must be strategically implemented alongside reskilling and institutional adaptation.

Furthermore, the qualitative findings further support these conclusions. Managers reported that AI tools streamline repetitive tasks, allowing older employees to focus on high-value cognitive tasks. AI-powered training programs enhance workforce adaptability by facilitating upskilling opportunities. Despite these benefits, challenges such as resistance to change, skill disparities, and ethical considerations remain barriers to full-scale AI implementation across industries. Overall, findings indicate that AI can partially offset the productivity decline. This can be done, e.g., by automating repetitive tasks, enabling older workers to focus on higher-value activities, and facilitating continuous learning through advanced training systems (Acemoglu & Restrepo, 2018; Bughin et al., 2019). Additionally, policies aimed at reskilling older workers, promoting intergenerational knowledge transfer, and investing in AI infrastructure could further ameliorate the effects of workforce aging. However, we must acknowledge that challenges remain, including ethical concerns, potential skill disparities, and uneven adoption of AI technologies across industries (Eubanks, 2018).

Conclusion

This paper has examined the interplay between an aging workforce and labor productivity in the EU-27, highlighting the potential of AI as a mitigating tool. Quantitative analysis using Eurostat data reveals that AI adoption is significantly associated with higher productivity levels, even in the context of a demographic shift toward older workers. Qualitative interviews with managers further underscore the practical benefits and challenges of AI implementation.

While workforce aging poses a considerable threat to productivity and economic growth, targeted policies that promote AI integration, reskilling, and intergenerational knowledge transfer offer a promising pathway to sustaining productivity growth in Europe. Future policy efforts must address the ethical and infrastructural challenges inherent in AI adoption to ensure that technological advancements translate into tangible economic benefits.

This study is subject to several limitations. First, the qualitative component is based on a small sample, which may limit generalizability. Second, the ICT variable may not fully capture AI-specific use. Third, panel data limitations and residual-based TFP estimation constrain the explanatory power of the models. Future studies should expand the qualitative sample and test more targeted AI indicators.

To sum up, this study contributes to the literature by linking workforce aging, TFP growth, and AI-driven productivity enhancements. Findings underscore the need for policies that promote

AI adoption, reskilling initiatives, and digital literacy programs to sustain economic growth in an aging workforce. Policymakers should therefore adopt a multifaceted strategy that not only promotes AI adoption but also invests in reskilling programs and ensures robust regulatory frameworks to manage ethical issues. As the paper presents introductory study, future research should explore the long-term impact of these policies and extend the analysis to additional sectors within the EU.

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GENERATION Z'S VIEWS OF SAVING, RETIREMENT, AND INSURANCE: A COMPARATIVE STUDY OF CROATIA AND SELECTED COUNTRIES

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Abstract

Generation Z, having grown up in a world primarily dominated by the Internet, is gradually entering the workforce, leading to a heightened interest in exploring their views on saving and retirement. This article examines Generation Z's perspectives on saving, financial planning, retirement, and the pension system in Croatia, comparing them with research findings from selected countries (the USA, Japan, and Germany). The study aims to provide insights into Generation Z's understanding of the pension system and insurance, as well as their perceptions of their financial future in Croatia. The data for this study is based on a survey of Generation Z members in the Republic of Croatia. The analysis reveals that while most Generation Z members express interest in saving and finances (a trend noted in all selected countries), many lack a concrete financial plan for the future (particularly regarding retirement). The key conclusion pertains to future financial security. Generation Z generally feels uncertain about their economic security at a certain age, with many believing that they will not be able to retire at a reasonable age or will have to continue working after retirement.

Keywords: Generation Z, financial literacy, pension, pension system, savings, Generation Y

JEL classification: A20, D14, G53, I20

Introduction

A generation comprises individuals who share everyday experiences and values during a specific timeframe, as outlined by the Croatian language portal, and is intrinsically linked to its surroundings. While definitions for neighboring generations were once distinct, the rise of the baby boomer generation blurred these lines, making it difficult to establish clear boundaries among later generations. Generation Z, encompassing those born between 1997 and 2012 (sometimes noted as 1995 to 2010, depending on the source), recognizes the Internet as their primary means of communication. As they enter the workforce, there is increasing interest in understanding their perspectives on saving and retirement planning. Researching Generation Z's attitudes toward pensions and financial planning is crucial, as their financial behavior will shape future economic stability and the pension system. Their upbringing, heavily influenced by technology, has fostered varied attitudes toward work (Gaidhani et al., 2019) and a desire for earlier retirement compared to older generations (Stack Wealth, 2023).

According to the Travis Credit Union Savings Survey (2020), nearly all members of Generation Z place a high value on saving. The majority commence saving at approximately age 19 and make monthly contributions to their savings. Retirement planning constitutes a significant saving priority for this demographic, as evidenced by 26% of participants emphasizing its importance, a figure closely followed by home savings, which is prioritized by 30% of respondents (Travis Credit Union Savings Survey, 2020). Notably, Generation Z initiates their retirement savings approximately 15 years earlier than Baby Boomers; however, some studies indicate this may prove insufficient. They begin saving in their early twenties, significantly earlier than the preceding generations. Young individuals today face considerable economic challenges, including high housing costs, student debt, and rising childcare expenses, all of which impede saving efforts. Nevertheless, recent years have seen younger generations accumulating wealth at a rate surpassing that of any prior generation (Adameczyk, A., 2024). Concurrently, certain studies suggest that Generation Z tends towards "soft saving," which indicates a tendency to save less aggressively for the future in favor of prioritizing present enjoyment. This behavior reflects their aspiration for a less stressful lifestyle centered on personal development and mental well-being. Many individuals within Generation Z endeavor to balance saving and current enjoyment, allocating funds towards travel and hobbies rather than long-term savings objectives. This trend further illustrates a transformation in how younger Americans perceive retirement, with numerous individuals planning to work beyond the traditional retirement age (Dickler, J., 2023; Intuit, 2023).

Despite Generation Z's recent entry into the workforce and the perceived distance of their retirement, it is worthwhile to examine their perspectives on the pension system in the Republic of Croatia at the start of their careers, along with their views on financial security in later life. Given that this generation has been raised in an environment dominated by smartphones, social networks, and constant connectivity (Dimock, M., 2019), one might infer, assuming they care about financial matters, that their financial literacy is adequate, possibly surpassing that of previous generations. Furthermore, due to their upbringing amid various challenges concerning the sustainability of the pension system, such as demographic aging and other structural issues within the Croatian pension framework (Nestić et al., 2023), they may generally have doubts about their long-term financial security; as a result, many might question the feasibility of retiring at a reasonable age or think they will need to continue working after retirement.

This article examines the views of Generation Z on saving, financial planning, retirement, and the pension system in Croatia, and compares them with research findings from selected countries (the USA, Japan, and Germany) (Chindemi, G., 2022; Travis Credit Union Survey, 2020; Goldman Sachs, 2024). The objective is to clarify Generation Z members' awareness of the importance of the pension system and insurance, as well as their perceptions of their financial futures. This study is based on primary research conducted through a survey of Generation Z members, drawing insights from studies in the selected comparative countries. The research offers more profound insights into the levels of financial literacy and attitudes toward retirement planning and saving among Generation Z members in Croatia. The contribution of this paper is grounded in research findings that reveal Generation Z's views on the pension system in the Republic of Croatia and their attitudes toward saving, which are compared with studies from selected countries, including the USA, Japan, and Germany.

Literature review

Opinions differ on the start and end of Millennials (Generation Y) and Generation Z. Generally, Millennials were born in the 1980s. At the same time, Generation Z encompasses those born between 1995 and 2010 or 1997 and 2012, with some considering it began in the early 2000s. Dimock (2019) defines Generation Y as individuals born before 1996. These generations differ primarily due to social, political, and technological changes that have influenced their experiences.

Generation Z, also known as "Generation 2020," grew up connected, often encountering social media before school (Šimunić Rod, 2020). Entering the workforce in 2020, they possess strong digital skills. Brkljačić (as cited in Rimac, 2012) identifies three key traits of Generation Z: advanced information scanning—quickly choosing what to click based on visuals, multitasking—managing homework, social media, and music simultaneously, and non-linear learning—seeking specific answers instead of following traditional paths (Rimac, M., 2012). Constant access to information allows them to find data easily (Fistrić, M., 2018). Despite increased digitalization, they feel more disconnected from family and friends than previous generations. Known for their multitasking abilities, they exhibit introversion and reduced social sensitivity (Fistrić, M., 2018). While they absorb vast amounts of information, they suffer from shorter attention spans (Rupčić, 2021). Soon entering the workforce, they typically hail from smaller families with older or single parents (Krasulja et al., after Wartzman, 2014). Generation Z is fast-moving, tech-savvy, and values freedom and fun (Krasulja et al.). They are considered environmentally conscious and skeptical of corporations, which often prompts them to make career changes or pursue entrepreneurial endeavors (Han, 2007). They are self-confident, creative, and quick learners, thriving in growth-oriented environments (Krasulja et al., 2015).

In contrast, Millennials faced economic turmoil and rapid internet growth during their formative years, experiencing turbulent times such as the fall of the Berlin Wall. Their optimism and social sensitivities were shaped by political and social unrest. Strong communication skills fostered global engagement, and they were introduced to the Internet at an early age, influencing their outlook (Fistrić, 2019). Generation Y uses various devices daily and remains constantly online. They are intelligent and creative, seeking personal growth, meaningful careers, and work-life balance (Jovanovski, 2012). They prioritize flexibility, mentorship, and meaningful work, feeling comfortable in team settings due to their experiences in childhood sports and group activities. Raised by protective parents, many still seek their guidance (Jovanovski, 2012).

Noctor et al. (1992) define financial literacy as the ability to make informed financial decisions. It includes awareness, knowledge, skills, and behaviors necessary for personal financial well-being (Anđelinović et al., 2022; OECD, 2020). Financial knowledge is the first essential component of financial education, encompassing both theoretical and practical understanding of financial concepts. The OECD (2017) describes financial education as improving individuals' understanding of financial products and decisions. Lučić et al. (2020) emphasize the importance of understanding fundamental financial concepts, including income, debt, and money management, as critical for making sound financial decisions. Financial choices that young people make, such as saving, can have significant long-term effects (Montoya & Scott, 2013). The economic crisis has underscored the importance of financial literacy and increased demand for education (Balen, 2017). Balen points out that globalization and technology have heightened access to financial products, necessitating more daily financial decisions. Thus, financial education is essential for personal well-being. Financial behavior involves applying

financial knowledge (Barbić & Lučić, 2018). Though not primary goals, improving financial literacy and knowledge about retirement aids retirement planning (Anđelinović et al., 2022). Regular financial planning correlates with higher financial knowledge (Anđelinović et al., 2022). According to an S&P survey, Croatia ranks 35th in financial literacy, with only 44% of adults being financially literate, which is below the European average of 52%. Globally, about 33% of adults are financially literate, with Norway and Denmark leading at 71% (S&P Global FinLit Survey, 2019). While Croatia's financial literacy improved slightly from 2015 to 2019, it remains a concern, with points increasing from 12.3 to 21. GFLEC research shows that in developed countries, millennials are more literate than those in developing nations, with rates ranging from 43% in Japan to 72% in Germany (Lusardi et al., 2020). Generation Z is generally more financially literate than previous generations, better at retirement savings, and more financially concerned (Hall, 2024). In 2023, 82% of Generation Z U.S. investors began investing before 21, compared to 31% of Millennials and 14% of Generation X (Hall, 2024). A 2021 Financial Times study found that young people, particularly those in Generation Z and Millennials, have the lowest financial knowledge, primarily due to insufficient education in this area in schools. A UK study found that 20% of 16-24-year-olds use financial tips from social media (Fox, 2021), which can be beneficial if accurate; however, they should be cautious of influencer advice as a source of financial information. Financial knowledge should come from credible sources beyond social media.

A 2023 survey shows that Generation Z in the USA has begun saving for retirement. On average, they begin this process at 19 years old, contributing about 20% of their salary primarily through employer pension plans. However, over half of the respondents (57%) reported facing financial challenges, with 30% juggling two or more jobs. Although they generally enjoy good physical health, 71% are worried about their mental well-being (Gupta, 2023, via Transamerica Center for Retirement Studies). Additionally, some research indicates that Generation Z tends to adopt a "soft saving" approach, prioritizing current enjoyment over aggressive future savings. This reflects their aspiration for a less stressful life, emphasizing personal growth and mental health. Consequently, many in this generation strive to balance saving and enjoying the present, spending on experiences like travel and hobbies rather than focusing solely on long-term savings goals. This trend highlights a shift in how younger Americans perceive retirement, as many intend to continue working beyond the traditional retirement age (Dickler, 2023).

This paper contributes to the existing literature by examining Generation Z's awareness of the pension system's importance and their perspectives on their financial future in the Republic of Croatia in comparison to research findings from the USA, Germany, and Japan (Chindemi, 2022; Travis Credit Union Survey, 2020; Goldman Sachs, 2024). The study examines respondents' socio-demographic information, income, expenditure, financial habits, and attitudes toward money, as well as their interest in financial topics. Additionally, it examines respondents' savings habits, including the existence, amounts, origins, and goals related to saving, to gain insight into Generation Z's perspective on the importance of saving. The final section addresses attitudes toward financial security in retirement and the pension system, exploring financial plans, retirement savings, and opinions on the sustainability of Croatia's pension system.

Data and methods

The data for this study are based on a survey of Generation Z members in the Republic of Croatia. An anonymous online survey comprising 25 questions was selected as the research tool and distributed via a link to a Google Form through social media networks. The survey, conducted in July 2024, targeted Generation Z. A total of 133 respondents participated, with the survey divided into four sections. The first section presents the respondents' general socio-demographic information, including age, gender, highest level of education completed, income, and expenditure, as shown in Table 1.

Table 1: Observed explanatory variables related to general socio-demographic data, including income and expenditure

Gender	Responders' gender	Two levels: male and female
Age	Responders' age	18-27
Employment	Respondent's employment status	Four levels: employed; unemployed; university student; student (in school)
Education	The highest level of education completed	Four levels: completed secondary school, completed high school, completed university education, other
Income	Respondent's income	Four levels: less than 100 EUR; 100-250 EUR; 250-500 EUR; 500 EUR or more
Expenditure	Respondent's expenditure	Four levels: less than 100 EUR; 100-250 EUR; 250-500 EUR; 500 EUR or more

Source: Authors

The questions compiled for the second part of the survey were derived from inquiries made by Gregory Chindemi in his study comparing the financial literacy of young Japanese and Americans (Chindemi, G., 2022). Additionally, the second part includes questions from a study conducted by the Croatian Catholic University, which primarily focused on the financial literacy of youth (HKS, 2019). This study examined respondents' financial habits, attitudes toward money, and interest in financial topics—the second part sought to showcase Generation Z's level of financial knowledge in the Republic of Croatia.

The third part of the research used questions from the Travis Credit Union Survey, which investigated the saving habits of young Americans (Travis Credit Union Survey, 2020). This segment concentrated on savings; thus, the main questions related to the existence of savings, the amounts respondents allocated to savings, and the origins and goals of saving. This part sought to gain insight into Generation Z's understanding of the importance of saving.

The fourth and final section of the study examines respondents' attitudes toward financial security in retirement and the pension system as a whole, drawing on questions from the Goldman Sachs survey (Goldman Sachs, 2024). These questions were combined with those from the Renosy study (Gehrke, 2023) and the previous study by Chindemi, contributing to the second part of the survey. The questions addressed financial plans, retirement savings, and, more generally, the sustainability of the Croatian pension system.

The survey was designed so that most questions were closed-ended, meaning multiple-choice. In addition to the multiple-choice format, a Likert scale was also utilized, allowing respondents to indicate their level of agreement (1-5) with specific statements. The number 5 represented the most favorable and desirable response.

When crafting the questions, particular emphasis was placed on simplicity and clarity of language, as the survey was administered to a diverse population whose financial education level was not predetermined. The primary goal was to gather data on the respondents' financial knowledge, attitudes toward saving, and opinions on pensions, the pension system, and its sustainability in the Republic of Croatia.

Results

Of the 133 Generation Z respondents who participated in the online survey, 69.6% were women, and 30.4% were men. Most respondents identified as students (78.9%), followed by employees (18.05%). Regarding the highest level of education, nearly half of the respondents (49.6%) had completed high school, followed by those with a college degree (Bachelor's or Master's) at 28.9%. The smallest proportion comprised individuals who had only completed elementary school (2.2%). Among the student respondents, the majority were from the Faculty of Humanities (33.3% of the student population), followed by the Faculty of Economics (17.1%) and the Faculty of Law (6.7%). All other faculties are also represented, but to a lesser extent.

A significant portion of respondents (69.92%) who belong to Generation Z save some of their money, whereas only 6.77% indicated that they live beyond their means.

Table 2: Respondents' financial habits, attitude towards money, interest in financial topics

Monthly Expenditure:	69.92% save some of their money	23,31% spend as much as they can	6.77% spend beyond their mean
Who do you consult regarding finances? (There may be multiple answers to this question.)	72.6% consult with family 66.7% with friends 42% with partners	13.3% do not talk to anyone about finances and are not interested in finances 8.2% online	3.7% do not talk to anyone about finances, but read literature on finance
In your opinion, which form of investment is the safest?	68.42% Cash	16.54% Shares 14.29% Bonds	0.75% Cryptocurrencies
How interested are you in enhancing your financial knowledge? (Likert scale)	41.35% expressed high interest, rating it as 5, while 26.32% rated it as 4.	22.56% gave a rating of 3	7.52% rated it as 2. Furthermore, 2.25% showed no interest, rating it as 1.

Source: Authors

Similar to research conducted in other countries, family and friends were the primary sources for discussing finances in this study. The smallest group consists of those who do not discuss finances with anyone but read financial literature. 13.3% of respondents indicated that they either do not discuss finances or are not interested in them. Slightly less than 70% of respondents believe cash is the safest form of financial asset, consistent with results from similar surveys in other countries. 16.54% of respondents considered shares the safest

investment, while 14.29% viewed bonds as the safest. Only one respondent identified cryptocurrencies as the safest investment option.

Many respondents expressed a desire to enhance their financial knowledge. When asked to rate their interest in improving this knowledge on a scale from 1 to 5, 41.35% of respondents reported being very interested, rating it a 5, followed by 26.32% who rated it a 4, 22.56% who rated it a 3, 7.52% who rated it a 2, and only 2.25% of respondents indicated they were not interested at all.

Table 3: Respondents' views on saving

How often do you think about your financial future?	Daily: 41.5% Very often: 38.5%		Often: 14.5% Rarely: 5.5%	
When did you start considering saving?	57.14% in high school or earlier	18.05% in college	17.29% in their first job	7.52% do not think about saving
How often do you contribute to your savings account?	74.5% monthly	14% annually	9% weekly	2.5% daily
Do you have a savings account or another type of savings?	54.8% yes		45.2% no	
What are you saving for? (multiple answers allowed)	49.6% Travel	40.7% Residence	26.7% Car	19.4% Education 9.6% Retirement

Source: Authors

In the third part of the questionnaire, which focuses on saving, it is encouraging that no respondent stated they never thought about their financial future. Additionally, 54.8% of respondents reported having some form of savings, while the remaining 45.2% did not. Comparing this result to the previous one, where 69.92% indicated that they save some of their money, this discrepancy may suggest that many individuals do not fully understand the concept of savings. They might save by keeping cash at home or spending less than their disposable income without depositing funds in a separate account. This could indicate a lack of financial inclusion, distrust of financial institutions, or limited awareness of available savings options.

Most respondents, 49.6%, cited travel as their primary reason for saving. Other popular reasons included buying a home (40.7%) and a car (26.7%). Only 9.6% of respondents mentioned a pension as the reason for saving.

Table 4: Respondents' views on retirement and insurance

I have a financial plan for my retirement with clearly defined goals. Likert scale: 1 (I completely disagree) – 5 (I completely agree)	Average 2.4, 30% disagree entirely, 6.7% completely agree

How confident are you in your retirement financial plans? Likert scale: 1 (I am not at all sure) – 5 (I am entirely sure)	Average 2.2, 37% are not at all sure, 4.4% entirely sure		
I have never considered retirement planning before. 1 (I completely disagree) – 5 (I completely agree)	41.5 % fully agree with this statement	11.9% of respondents disagree entirely.	
When do you plan to start saving for retirement?	65.41% when I have a job	21.05% I have no plans	13.54% I already am saving
Do you believe your pension contributions will be enough for a decent retirement?	8.27% say yes	91.73% say no	
Do you think the Croatian pension system is sustainable?	12.03% say yes	87.97% say no	
Do you believe you will be able to retire at a reasonable age?	39.85% say yes	60.15% say no	
Are you considering contributing to the third pension pillar?	56.39% are unsure about what it entails	30.83% say yes	12.78% respond with no

Source: Authors

Just 6.7% of respondents have a financial plan for the future with specific goals, while 30% do not have a retirement plan. Among those with a plan, over 60% are uncertain whether they can achieve those goals.

When asked about the best time to begin retirement savings, 65.41% responded that it should be when they start working. Furthermore, 13.54% are already saving, but 21.05% expressed no intention to save for retirement. Nearly 92% of participants believe that current pension contributions are insufficient for a comfortable retirement, and 87.97% view Croatia's pension system as unsustainable. Additionally, 60.15% doubt their ability to retire at an appropriate age. Regarding the third pillar of pension insurance, almost 57% of the majority admitted they were unaware of its existence.

Discussion and limitations

Most respondents belong to the 20-27 age group, indicating a substantial representation of the younger population. Many support themselves independently, with some receiving partial assistance from their parents, reflecting a transitional phase toward financial independence. Regarding savings habits and economic behavior, more than two-thirds of respondents regularly save a portion of their income, suggesting that awareness of the importance of saving is relatively high among young people. Most savers set aside specific amounts each month. The

primary motivations for saving include short-term goals, such as travel, housing, and car purchases. Saving for retirement is infrequent, which is expected given the life stage of young individuals. Family and friends are the primary sources of information and advice on finance, consistent with findings from similar surveys conducted in other countries. Only a tiny percentage of respondents express disinterest in financial topics, suggesting that some financial literacy still exists. Approximately two-thirds of respondents consider cash the safest asset, which may indicate a lack of confidence in or understanding of more complex financial instruments. When asked about financial futures and retirement planning, while most often think about their future and savings, only a few have a solid financial plan with clearly defined goals. Less than half of the respondents have thought about retirement planning, and just over a tenth are actively saving for retirement. Approximately one-fifth of respondents do not plan to save for retirement, which is a concerning sign given the increasing uncertainty surrounding state pension schemes. Furthermore, when asked about their attitudes toward the pension system, an overwhelming majority of respondents (nearly 90%) expressed distrust in the sustainability of the pension system in the Republic of Croatia, and over 90% believe that current contributions are inadequate for a dignified retirement. Approximately half of the respondents are uncertain about being able to retire at a reasonable age, underscoring the need for enhanced financial education and awareness regarding the importance of long-term planning. Over half of the respondents were unaware of the third pillar, and fewer than one-third considered making a contribution. The media's longstanding scrutiny of the pension system likely shapes these attitudes. The fact that many members of Generation Z have not considered financial retirement plans may indicate several factors: economic uncertainty, rising cost of living, an uncertain job market and high housing costs that could affect future financial security, distrust in traditional systems, doubts about traditional pension funds and state systems leading to delayed planning, lack of financial education with insufficient knowledge about retirement plans and investments leading to avoidance of long-term planning.

Chindemi's 2022 study analyzed the financial literacy of Generation Z in the US and Japan, using identical questions in Croatia for comparison. With similar sample sizes—102 participants in Japan (35 Americans and 67 Japanese) and 133 in Croatia—findings show that 68.42% of Croatian and 87% of Japanese respondents view cash as the safest investment. In contrast, in the US, 37% prefer bonds. Notably, 0% of Japanese, 0.75% of Croatians, and 17% of Americans consider cryptocurrencies the safest option. Only 6.7% of Croatian respondents have a financial plan, compared to 17% of Americans and 19% of Japanese. About 80% of people in all countries discuss financial matters with their families and friends, while around 15% of Croatians and Japanese, and 6% of Americans, show no interest. A stark 60.15% of Croatian Generation Z respondents are skeptical about retiring at a reasonable age, contrasting with 49% of Americans and 39% of Japanese who express similar doubts, with 25% of Japanese expected to continue working post-retirement age.

Therefore, studies indicate that cash is considered the safest investment in Japan and Croatia, reflecting a conservative approach to money management. In contrast, most Americans view bonds as the safest option, which suggests a more developed investment culture and greater financial literacy. The percentage of Americans favoring cryptocurrencies reveals a higher risk tolerance and confidence in emerging financial technologies. Croatian respondents show the least awareness of financial planning among the three countries, while awareness of long-term planning is the highest in Japan and the lowest in Croatia. Many respondents across all three countries engage in financial discussions with family and friends, highlighting the importance of informal learning within Generation Z. However, a lack of interest in finance signals a lower financial culture in Japan and Croatia. Croatia exhibits the most pessimistic views on pensions,

whereas the USA is the most optimistic. In summary, Generation Z in Croatia has limited financial knowledge, particularly in the areas of planning and trust in pensions. At the same time, American respondents demonstrate greater openness to investing and confidence in their financial abilities. Japanese respondents tend to adopt a conservative approach to investing, often supported by better financial planning. These findings highlight the need for enhanced financial education, particularly in Croatia, to equip young people for a more secure financial future.

In 2023, the German Insurance Association (GDV) surveyed 1,582 individuals aged 20-45, with a particular focus on Generation Z (aged 20-29), regarding their retirement concerns in comparison to older cohorts. The survey revealed that 50% of younger participants and 44% of those aged 30-39 actively consider retirement planning. In Germany, younger respondents regularly review their investments, showing optimism and a willingness to sacrifice for retirement. In contrast, only 13% of Croatians in the same age bracket save for retirement, with travel being prioritized. Among Generation Z in Germany, 40% fear insufficient pensions in old age, while 92% of Croatians share the same concern about inadequate contributions. Furthermore, only 35% of Germans discuss finances with close ones, in contrast to approximately 80% in Croatia. Notably, around 36% of Germans consult financial advisors for guidance. The GDV concluded that Generation Z is broadly financially literate and interested in retirement planning, akin to Generation Y, but shows distinct preferences for flexibility and sustainability, often seeking information from social media and comparison platforms, reflecting their upbringing in the digital age. Therefore, in Germany, particularly among Generation Z, young people show increased financial awareness and a strong sense of responsibility for retirement planning. They think more often about retirement and actively invest, reassessing their investment strategies and seeking professional advice. In contrast, young individuals in Croatia express considerable pessimism about the state system but do not engage significantly in personal savings or planning. They rely primarily on informal conversations, which may limit their access to quality financial information. This comparison underscores the pressing need for comprehensive financial education and enhanced access to financial guidance in Croatia to enhance the financial security of future generations.

The research employed an anonymous online survey as its tool, distributed through a Google Form link on social media, which means the results pertain only to the sampled participants. Expanding the sample size could enhance the empirical aspect of the study. As the survey was exclusively distributed via social media, it is most likely to have been completed by digitally active users, automatically excluding those who do not or rarely use social media, which can significantly affect the results and their balance. Respondents participated voluntarily, suggesting they are likely individuals with some interest in financial topics or are more willing to engage in surveys. Many respondents are students aged 20 to 27 years old. This suggests that the study may not accurately capture the attitudes and habits of Generation Z individuals who are already working, have children, or possess different educational or socio-economic backgrounds. The survey automatically excludes individuals without internet access or those who are not proficient in using technology, which can skew the results in favor of more digitally literate respondents.

Despite its limitations, an online survey of 133 respondents offers key insights when interpreted accurately. While it may not represent the entire population, it reflects the views of younger, digitally savvy Generation Z, which is crucial for targeted research. The results inform more extensive studies on Generation Z's perspectives on the pension system in the Republic of

Croatia and their attitudes toward saving, refining research questions, and informing the design of qualitative interviews.

Conclusion

Generation Z differs from previous generations because they grew up with technology. Consequently, they are accustomed to having all information "at their fingertips," instantly available everywhere. While they can multitask, they may also feel more isolated from those around them. They can easily locate important information. Research indicates that members of Generation Z are moderately financially literate, a prerequisite for a sustainable pension system. Their attitude toward money is positive; they spend within their means and set aside some for savings. Most members of Generation Z understand the importance of saving and often begin saving during school (or earlier). Generation Z tends to view cash as the safest form of money and usually saves through bank deposits or keeps their cash "in a shoe." They are not well-acquainted with various savings options and forms. As they gradually enter the labor market, their perspective on the pension system presents an intriguing area for research. Researching Generation Z's attitudes toward pensions and financial planning is crucial, as their financial behavior will shape future economic stability and the pension system. Our results show that over two-thirds of respondents regularly set aside some of their income, reflecting a strong awareness of saving among young people. Most prioritize short-term objectives, such as travel and housing, while retirement savings remain rare, aligning with their current life circumstances. Family and friends are considered essential financial advisors, consistent with similar global surveys. Only about 10% show disinterest in financial matters, indicating a level of financial literacy. Approximately two-thirds of respondents view cash as the safest asset, likely due to a lack of confidence in more complex financial products. Regarding retirement, while many think about their financial futures, few have actionable plans; less than half are actively involved in retirement preparation. Merely 10% save for retirement, and around 20% do not plan to start, which raises serious concerns. The fact that many members of Generation Z have not considered financial retirement plans may indicate several factors: economic uncertainty, rising cost of living, an uncertain job market and high housing costs that could affect future financial security, distrust in traditional systems, doubts about traditional pension funds and state systems leading to delayed planning, lack of financial education with insufficient knowledge about retirement plans and investments leading to avoidance of long-term planning. More than 90% express distrust in the sustainability of Croatia's pension system, with nearly 90% believing that contributions are inadequate for a dignified retirement. Half are uncertain about retiring at an appropriate age, emphasizing the urgency for enhanced financial education. Over half were not informed about the third pension pillar, and fewer than one-third contemplated contributing to it. The media's unfavorable portrayal of the pension system likely influences these views.

Survey findings align with data from several countries, including the USA, Germany, and Japan, regarding Generation Z's perspectives in Croatia. The key takeaway revolves around future financial security. Many from this generation express uncertainty about their financial plans and lack confidence in the sustainability of the pension system, underscoring the critical need to enhance financial literacy among Generation Z. Educating them on financial concepts is essential for strengthening the pension system and ensuring this generation's financial future. Without adequate knowledge of retirement planning and investments, young people tend to shy away from long-term planning. Financial institutions and educational systems should better cater to the needs of young individuals and adjust their strategies to promote long-term

planning. Overall, Generation Z is generally apprehensive about their financial security as they age, with many fearing they will not be able to retire at a reasonable age or will have to work beyond retirement. Their uncertainty extends to their future financial plans, if any exist. Regarding Croatia's pension system, studies suggest that this generation could considerably impact their pension financing if they are well-informed about financial issues. This concern is particularly significant in Croatia and other developed nations facing an aging population. Tackling this challenge requires public education, improved financial literacy, and a deeper understanding of the financial landscape, ultimately benefiting any country's economy.

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WORK ARRANGEMENTS AND FERTILITY INTENTIONS: THE ROLE OF JOB STABILITY AND FLEXIBILITY IN CROATIA

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Abstract

The decline in fertility is a key aspect of demographic development, as acknowledged by numerous studies on contemporary demographic challenges in developed countries. Various factors influence fertility decisions, with employment conditions playing a particularly significant role. The main goal of this paper is to explore how different work arrangements (job stability and flexible work options) influence the fertility desires of partnered and employed individuals in Croatia. The Generations and Gender Programme (GGP) Round II – Wave 1 survey is used as data source, and we performed logistic regression models to evaluate the effects of employment conditions on respondents' plans to have children within the next three years. The results reveal that job stability has a positive effect on fertility intentions since those with permanent contracts show higher intentions of planning for parenthood than those in precarious situations. Although previous research shows flexible work arrangements improve work-life balance, our results indicate that workplace flexibility does not directly impact fertility intentions or that other factors might have a stronger explanatory role in fertility decision within the Croatian population. These findings emphasize the crucial role of employment security in shaping reproductive decisions, reinforcing the need for policies that promote stable employment to support a family-friendly labor market. By bridging demographic trend analysis and labor market dynamics, the research provides valuable insights for policymakers striving to balance economic priorities with family planning considerations in low-fertility societies.

Keywords: fertility, work-life balance, childcare

JEL classification: J13, J22, J18

Introduction

Fertility decline is a central demographic challenge affecting many European societies, including Croatia. Low fertility rates threaten long-term population sustainability, economic growth, and social welfare systems (Lutz et al., 2006; Esping-Andersen, 2017). While multiple factors shape fertility decisions, labor market conditions play a crucial role in shaping reproductive choices (Adsera, 2011). Traditional economic theories, such as Becker's New Home Economics Theory (1981), emphasize that individuals and families make fertility decisions based on economic stability, opportunity costs, and resource allocation. More recent studies explore how changing labor market structures—marked by rising precarious work, automation, and flexible employment—affect childbearing intentions (Matysiak & Vignoli, 2021; Alderotti et al., 2021).

Within this framework, job stability and work flexibility emerge as two key employment dimensions influencing fertility intentions. Research indicates that permanent contracts and stable employment conditions provide financial and psychological security, making parenthood more feasible (Kreyenfeld, 2010; Vignoli et al., 2020). Conversely, labor market precarity and temporary contracts are associated with postponed or reduced fertility (Alderotti et al., 2021). While some studies argue that flexible work arrangements (FWAs)—such as remote work, hybrid models, and flexible scheduling—help individuals balance work and family responsibilities (Allen et al., 2013; Wang & Dong, 2024), others suggest that FWAs may lead to blurred work-life boundaries, increased stress, and delayed fertility (Glavin & Schieman, 2012; Kurowska, 2018).

Despite the growing body of research on work arrangements and fertility, most existing studies focus on Western European labor markets (Adsera, 2011; Matysiak & Vignoli, 2021), while Eastern European contexts remain underexplored. Croatia, a post-socialist economy, has undergone significant labor market transformations over the past three decades; however, its fertility rates continue to decline. The interplay between employment stability, workplace flexibility, and fertility intentions in Croatia remains insufficiently studied, creating a pressing research gap. The central problem this study addresses is how job stability and flexible work arrangements influence fertility intentions in Croatia. While Croatia faces one of the lowest fertility rates in the EU (Eurostat, 2023), there is limited empirical research on how labor market conditions shape reproductive choices in this specific national context. Existing studies on work and fertility typically analyze job security and work flexibility separately, without assessing their combined impact on fertility planning. Understanding the relationship between employment conditions and fertility is essential for academia, policymakers, and businesses. In academic discourse, this research contributes to debates on labor market precarity and family formation. In public policy, it provides insights for designing family-friendly labor policies that promote economic security and fertility. In corporate settings, the study highlights whether flexible work policies enhance employees' reproductive planning, which has implications for workforce retention and gender equality strategies.

Previous studies have demonstrated that job security and work flexibility are key determinants of fertility intentions. Employment instability, characterized by temporary or precarious work contracts, is often associated with delayed family formation, particularly in contexts where social protection is limited. Conversely, stable employment provides financial and emotional security, which facilitates family planning. However, the influence of work arrangements on fertility intentions is not uniform; it varies across gender, education level, and broader social structures. To address this issue, our study investigates the relationship between work

arrangements and fertility intentions through two central hypotheses:

- Hypothesis 1: *Individuals with stable work arrangements (e.g., permanent contracts) are more likely to intend to have a child within the next three years than those with temporary or precarious contracts.* This hypothesis is grounded in Becker's New Home Economics Theory (Becker, 1981), which argues that job security provides financial and emotional stability, reducing uncertainty in family planning decisions.
- Hypothesis 2: *Employees with flexible work arrangements (e.g., remote or hybrid work) are more likely to plan for children due to better work-life balance.* This hypothesis is supported by Work-Family Conflict Theory (Greenhaus & Beutell, 1985), which suggests that flexibility in work schedules allows individuals to better manage parenting responsibilities, making childbearing more feasible.

The primary objective of this study is to analyze the relationship between work arrangements and fertility intentions among partnered, employed individuals in Croatia. Specifically, it aims to examine the influence of different employment contracts—permanent, temporary, and precarious—on fertility intentions, assess the impact of flexible work arrangements on child planning, and provide evidence-based recommendations for labor market policies and employer practices that support fertility. By addressing these objectives, the study contributes to discussions on work-life balance, labor market precarity, and demographic sustainability, offering insights for scholars, policymakers, and business leaders navigating the intersection of employment and fertility in contemporary society.

Literature review

Employment instability, characterized by temporary or precarious work, generally has a negative impact on fertility decisions. Job security reduces uncertainty and provides the financial and emotional stability needed for family planning. Uncertainty in employment can lead to delays in family formation or a reduction in childbearing intentions. People may postpone having children if they anticipate difficult conditions such as unemployment or insecure working conditions (Buhr & Huinink, 2014). Having a stable employment and an adequate income are essential conditions for starting a family. The impact of employment stability on fertility intentions is complex and may vary based on individual circumstances.

Several sources support the idea that job security positively influences fertility intentions. People are more likely to plan for children when they have a stable income and reliable employment. Job security reduces uncertainty, making the prospect of parenthood less daunting (Buhr & Huinink, 2014). However, some studies suggest that the impact of economic conditions on fertility decisions varies. For example, among women, the impact of unemployment on fertility appears to vary based on educational background (Kreyenfeld, 2010). In periods of job insecurity, highly educated women are more likely to postpone motherhood in comparison to women with lower education who respond to an uncertain employment status by having children (Kreyenfeld, 2010).

Work-family conflict arises when demands from work and family interfere with each other, such as when long hours at work clash with childcare duties (Allen et al., 2013). Flexible work arrangements can potentially reduce this conflict by allowing individuals to adjust their work schedules to better fit family needs. Flexible work arrangements allow employees greater

control over when, where, and how they perform their job tasks (Allen et al., 2013). These arrangements can include options such as flexible working hours, remote work, compressed workweeks, job sharing, and part-time employment.

Several studies strongly support the positive impact of flexible work arrangements on fertility intentions (Wang & Dong, 2024; Allen et al., 2013; Kurowska et al., 2023). Flexible work arrangements are thought to provide employees with the control and autonomy needed to adapt to simultaneous work and family demands.

Employees who can handle personal matters like attending dental appointments or caring for a sick child at home experience less worry and distraction compared to those without flexible work options (Allen et al., 2013). It also minimizes commuting time to and from the workplace, which leaves more space for private obligations (Allen et al., 2013).

On the other hand, some studies indicate that flexible work arrangements might blur the boundaries between work and personal life leading to increased work-family conflict and a workload (Kurowska et al., 2023). The lack of a clear separation between work and home can cause work to spill over into family time, potentially resulting in longer working hours and greater multitasking demands (Kurowska et al., 2023) especially for women. These challenges can create an unfavorable environment for making childbearing decisions and may negatively impact fertility intentions.

The literature suggests that both job stability and work flexibility are important factors influencing fertility intentions. Stable work arrangements provide the necessary financial and emotional security, while flexible work arrangements help to alleviate work-family conflict, making parenthood more feasible. However, the specific types of flexibility and individual circumstances can influence these relationships.

From a geographical perspective, studies also indicate some correlations. In Italy, for instance, temporary employment is shown to delay first births, highlighting how precarious work discourages the transition to parenthood among young Italians (Guetto et al., 2023; Scherer & Brini, 2023). This negative association is further supported by a meta-analysis of European data, which indicates that employment instability, particularly unemployment, has a detrimental effect on fertility, with the impact being more pronounced in Southern European countries where social protection is less generous (Alderotti et al., 2021). Conversely, improvements in job stability, such as those resulting from the regularization of undocumented immigrants in Spain, have been associated with increased fertility rates, suggesting that stable employment encourages childbearing (Monras et al., 2023). Regarding work flexibility, studies indicate that flexible working arrangements (FWAs) can positively influence fertility intentions. In Singapore, FWAs, including reduced hours and increased schedule flexibility, significantly enhance fertility intentions, especially among women in professional and managerial roles (Wang & Dong, 2024). Similarly, during the COVID-19 lockdown in Norway, increased work flexibility led to a rise in births, particularly among women in high-demand jobs, as it alleviated the career-family trade-off (Bratsberg & Walther, 2024). In the UK, the use of FWAs by wives, particularly in dual-earner couples, is associated with a higher likelihood of first births, underscoring the gendered effects of work flexibility on fertility (Wang & Tan, 2024). However, the perception of employment stability alone has a limited impact on fertility intentions, whereas resilience to potential job loss is a more powerful predictor (Gatta et al., 2021). These findings collectively suggest that while job stability is crucial for encouraging fertility, work flexibility also plays a significant role, particularly in mitigating work-family

conflicts and supporting family planning among working individuals.

Data and methodology

The Generations and Gender Programme (GGP) is a social science Research Infrastructure that provides harmonized, large-scale, longitudinal, cross-national panel data on individual life courses and family dynamics. Its longitudinal approach is designed to enhance understanding of demographic and social developments across various countries. The GGP is a successor to the Fertility and Family Survey (FFS) which was conducted in the 1990s, whose micro-level data is compatible and comparable with the GGP. The first round (GGS-I) has started in 2004 as a three-wave panel study and the second round of the Generations and Gender Survey (GGS-II) started in 2020, employing an updated methodology and a refreshed baseline questionnaire (Generations & Gender Programme, n.d.). In Croatia, the GGS-II was conducted between May and July 2023, targeting individuals aged 18 to 54 years. The survey utilized a Computer-Assisted Web Interviewing (CAWI) mode to efficiently gather data on a wide array of topics, including fertility intentions, partnership dynamics, and employment patterns. The Croatian Round II - Wave 1 data contribute significantly to the broader GGP dataset, enabling comprehensive cross-national analyses of demographic behaviours and trends (Čipin et al., 2024).

In this study, we utilized the full sample from the Croatian Round II - Wave 1 of the GGP survey, focusing specifically on respondents who reported being in a partnership and engaged in paid employment (*wrk2* variable). This selection criterion was essential for this study since we assume that fertility intentions are strongest in partnerships (compared to general population aged 18-54 that includes singles) and that currently employed (or-self-employed) individuals are the most representative group for studying work-related matters. To ensure data integrity, we excluded individuals flagged for potential misinformation within the dataset (which is represented by *flag* variables), thereby enhancing the reliability of our findings.

Our dependent variable centers on fertility intentions within the next three years. The original responses, which included options such as "definitely yes," "probably yes," "probably no," and "definitely no," were dichotomized into a binary variable: "yes" (encompassing both "definitely" and "probably yes") and "no" (comprising "definitely" and "probably no"). This binary classification simplifies the analytical framework, allowing for a clearer interpretation of factors influencing positive versus negative fertility intentions.

The variable representing educational attainment, originally categorized into eight ISCED levels, was recoded into three distinct groups: low (pre-primary, primary, and lower secondary education), medium (upper secondary and post-secondary non-tertiary education), and high (tertiary education). This recoding aligns with standard practices in demographic research, facilitating a more streamlined analysis of educational influences on fertility intentions. The analysis incorporated several control variables: age, gender, region, and the recoded education variable. These variables are well-established determinants of fertility behavior and were included to account for their potential confounding effects. The primary independent variables of interest were *wrk18* and *wrk20*. The *wrk18* variable assesses the nature of the respondent's employment contract, distinguishing between permanent, fixed term, and temporary contracts. The *wrk20* variable examines the availability of various forms of flexible working arrangements, specifically whether employers permit adjustments to accommodate personal needs, such as childcare schedules.

To explore the relationships between these variables and fertility intentions, we employed logistic regression modeling. Logistic regression is particularly suited for this analysis due to the binary nature of the dependent variable. It estimates the probability of a particular outcome—in this case, the intention to have a child within the next three years—based on a set of predictor variables. This method is widely used in demographic research to model dichotomous outcomes and to understand the influence of various factors on individual decision-making processes.

The models were fitted using the *glm()* function in R with a binomial family and logit link. We tested for multicollinearity among independent variables by calculating variance inflation factors (VIF), and no values exceeded conventional thresholds, suggesting acceptable levels of collinearity. All categorical variables were entered as factor variables, allowing the model to estimate coefficients relative to a designated base category. Model assumptions related to independence of observations and linearity in the logit for continuous variables were checked and met.

Although we considered testing for interaction effects—particularly between employment contract type and flexible work arrangements—we opted against their inclusion in the final models due to concerns about statistical power and model interpretability. This remains a valuable opportunity for future research.

We developed four distinct models to systematically assess the impact of our variables of interest:

Model 1: Included only the control variables (age, gender, region, and education) to establish a baseline understanding of their effects on fertility intentions.

Model 2: Added the *wrk18* variable to the control variables to evaluate how the type of employment contract influences fertility intentions.

Model 3: Incorporated the *wrk20* variable alongside the control variables to assess the impact of flexible working arrangements on fertility intentions.

Model 4: Combined both *wrk18* and *wrk20* with the control variables to examine their joint effect on fertility intentions.

This stepwise modeling approach allows for a comprehensive analysis of each variable's contribution, both independently and in combination, providing insights into the factors shaping fertility intentions among partnered, employed individuals in Croatia. The application of logistic regression in this context is appropriate due to its robustness in handling binary dependent variables and its capacity to adjust for multiple covariates. This statistical technique enables the estimation of odds ratios, offering a clear interpretation of the likelihood of intending to have a child based on various predictor variables. Although the current model includes only a limited set of controls, these reflect key demographic factors consistently identified in fertility research. Additional robustness checks and confounders may be explored in future studies.

Results

The logistic regression results provide important insights into the relationship between employment conditions, demographic factors, and fertility intentions among partnered individuals in paid employment in Croatia. The results of our models can be found in Table 1.

Table 1: Logistic Regression Models

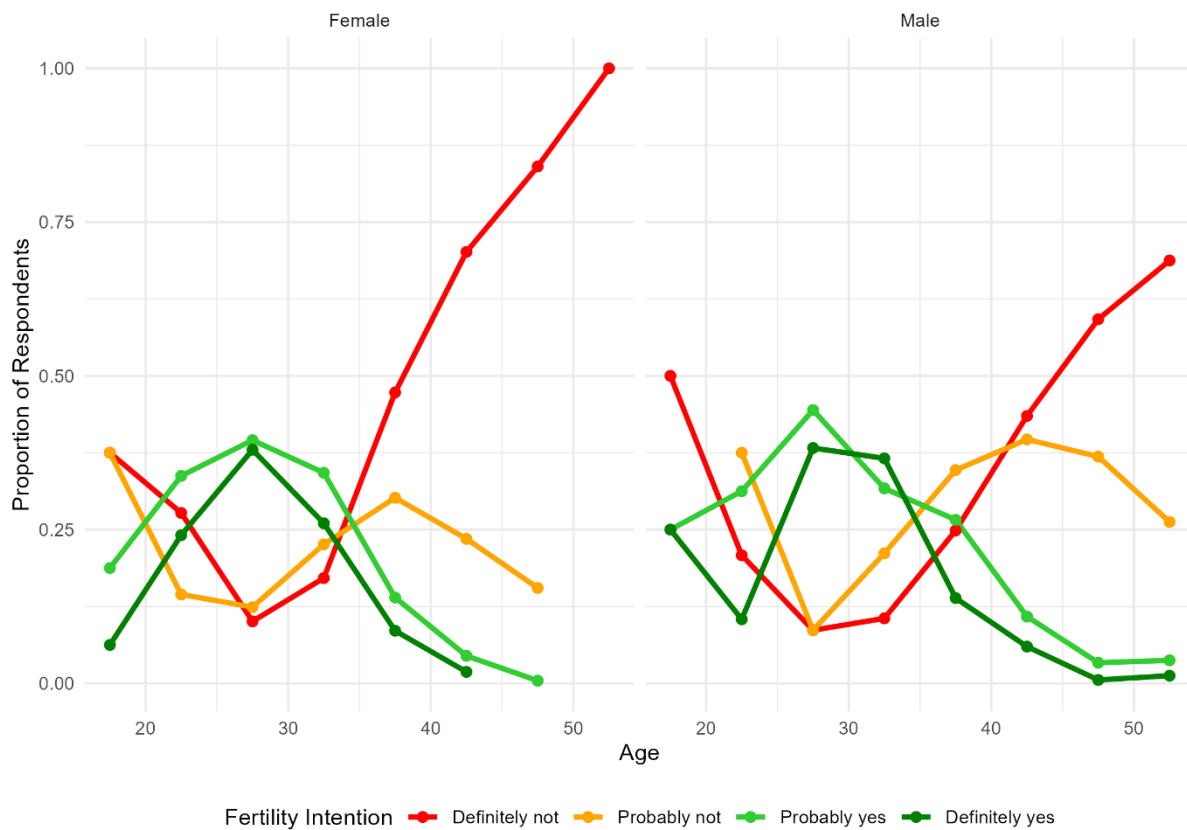
Logistic Regression Models Predicting fertility intentions

Predictors	Model 1			Model 2			Model 3			Model 4		
	Odds Ratios	std. Error	p	Odds Ratios	std. Error	p	Odds Ratios	std. Error	p	Odds Ratios	std. Error	p
(Intercept)	392.19	133.86	<0.001	922.19	365.62	<0.001	425.28	151.26	<0.001	924.89	373.87	<0.001
age	0.84	0.01	<0.001	0.81	0.01	<0.001	0.84	0.01	<0.001	0.81	0.01	<0.001
gender [Male]	2.16	0.27	<0.001	2.11	0.27	<0.001	2.18	0.27	<0.001	2.11	0.27	<0.001
education [low]	0.27	0.20	0.083	0.32	0.25	0.141	0.28	0.21	0.090	0.32	0.25	0.142
education [medium]	0.36	0.05	<0.001	0.37	0.05	<0.001	0.36	0.05	<0.001	0.37	0.05	<0.001
region [City of Zagreb]	0.91	0.16	0.589	0.91	0.16	0.599	0.92	0.16	0.630	0.91	0.16	0.602
region [Northern Croatia]	0.98	0.16	0.886	0.88	0.15	0.467	0.98	0.16	0.908	0.88	0.15	0.468
region [Pannonian Croatia]	0.84	0.14	0.293	0.77	0.13	0.141	0.83	0.14	0.269	0.77	0.13	0.141
wrk18 [No written contract]				0.24	0.18	0.051				0.24	0.18	0.052
wrk18 [Permanent]				1.94	0.42	0.002				1.94	0.42	0.002
wrk18 [Temporary]				0.14	0.05	<0.001				0.14	0.05	<0.001
wrk20 [Yes]							0.90	0.11	0.402	1.00	0.13	0.970
Observations	1969			1969			1969			1969		
R ² Tjur	0.321			0.356			0.321			0.356		

Source: Authors' calculation

One of the most significant predictors of fertility intentions is age. Across all models, age has a negative association with the likelihood of intending to have a child in the next three years. The odds ratios for age are consistently below 1 and statistically significant ($p < 0.001$), indicating that as individuals grow older, their fertility intentions decrease. This finding is consistent with broader demographic research, which demonstrates that fertility intentions tend to decline with increasing age due to biological constraints and changing life priorities. Figure 1 shows the connection between age and fertility intentions in the final subsample that was used for logistic regression, yet it differentiates for gender. The results of logistic regression models indicate that men have higher fertility intentions than women, as shown by the statistically significant odd ratio for the male category.

Figure 1: Age, gender, and fertility intention



Source: Authors' calculation

Figure 1 shows that “Definitely not” is strongly associated with age, especially after age of 40, and more intensively among women. This trend is mirrored in the regression results, reinforcing the salience of age and gender as predictors of fertility intentions.

Education is another important factor influencing fertility intentions. The base category in our models is high education, meaning that individuals with low or medium education are compared to those with higher education. The results show that both lower and medium levels of education are associated with lower odds of intending to have a child compared to those with high education. This is somewhat unexpected; as lower educational attainment is often linked to earlier childbearing. However, in the Croatian context, this result may reflect the fact that individuals with lower education levels face greater financial insecurity and precarious employment, which may discourage them from planning children. In contrast, those with higher education may have more stable career prospects, enabling them to plan for children more confidently.

Regarding employment conditions, the type of contract (*wrk18*) emerges as a significant factor shaping fertility intentions. The results show that individuals with a permanent contract have higher odds of intending to have a child compared to those on fixed-term contracts. The effect is statistically significant, suggesting that job security plays a crucial role in reproductive decision-making. This finding aligns with research emphasizing the importance of economic stability in family planning, as individuals in precarious employment situations may delay or forgo having children due to uncertainty about their future financial situation.

In contrast, flexible work arrangements (*wrk20*) do not reach statistical significance in any of

the models. While this prevents us from drawing firm conclusions about their impact, it does not imply that such arrangements are unimportant. While previous studies have suggested that flexible work arrangements help individuals balance work and family responsibilities, this relationship does not appear significant in our models. Non-significant findings must be interpreted with caution, as they may result from limited statistical power, measurement limitations, or unobserved confounding. The lack of a statistically significant association in this context suggests that more research is needed to understand whether and how flexibility interacts with other factors—such as gender roles, family structure, or institutional support—to influence fertility planning.

Future research could build on these findings by examining how actual childbirth outcomes align with stated fertility intentions, using longitudinal data to track whether employment stability translates into realized fertility. Additionally, qualitative research could explore the underlying reasons why individuals with lower education levels report lower fertility intentions, shedding light on economic and social barriers to family formation. Further investigation is also warranted into whether the effect of flexible work arrangements may be more pronounced for specific subgroups, such as mothers of young children, dual-earner households, or individuals in urban regions. Lastly, a comparative study using GGP data from other European countries could help contextualize Croatia's trends within broader regional fertility patterns and labor market conditions.

Conclusion

The paper examined the relationship between work arrangements—specifically job stability, flexible work options, and remote work—and fertility intentions among partnered, employed individuals in Croatia. Using data from the Generations and Gender Programme (GGP) Round II - Wave 1 survey, our findings underscored the critical role of job security in shaping reproductive decisions. Individuals with permanent employment contracts exhibit a higher likelihood of intending to have children within the next three years, whereas those in precarious employment demonstrate lower fertility intentions. This reinforces the idea that economic stability is a fundamental prerequisite for family planning.

Contrary to some expectations, our results indicate that flexible work arrangements do not significantly influence fertility intentions in Croatia. While previous research suggests that workplace flexibility can alleviate work-family conflicts, our findings suggest that in the Croatian context, job security remains a more pressing concern than flexibility. However, these findings should be interpreted with caution, as non-significance does not necessarily imply the absence of an effect. Limitations related to sample size, measurement precision, or unobserved variables may account for the null result. This may be attributed to broader socioeconomic conditions, cultural expectations, and the traditional gendered division of labor, which continues to place a disproportionate burden of household and childcare responsibilities on women.

Additionally, our analysis reveals notable gender differences, with men exhibiting higher fertility intentions than women, particularly as age increases. This suggests that structural and cultural barriers may disproportionately influence women's reproductive decision-making, further emphasizing the need for policies that promote gender equality in both the labor market and family life.

From a policy perspective, these findings highlight the importance of employment stability in fostering a more family-friendly labor market. Policymakers should prioritize measures that enhance job security, such as reducing labor market segmentation and supporting long-term employment contracts. Additionally, while flexible work arrangements alone may not directly impact fertility intentions, their effectiveness could be strengthened if combined with broader family policies, such as parental leave reforms and affordable childcare options.

Nevertheless, this study has several limitations that should be acknowledged. The cross-sectional nature of the data restricts our ability to draw causal conclusions about the relationship between work conditions and fertility intentions. In addition, our models include a limited set of control variables and do not account for all potentially relevant confounders such as income, number of existing children, or partner characteristics. Further theoretical development is also needed to better integrate cultural and institutional perspectives into the interpretation of the findings.

Future research could build upon these findings by exploring how actual childbirth outcomes align with stated fertility intentions, using longitudinal data to determine whether employment stability leads to higher birth rates. Moreover, future studies should explore subgroup heterogeneity, such as differences across age groups, household structures, or occupations, to gain a deeper understanding of the diverse pathways influencing reproductive decisions. Comparative studies across different labor market contexts would provide valuable insights into the extent to which national policies and cultural factors mediate the relationship between employment conditions and fertility decisions.

By shedding light on the complex links between work and family life, this study enhances the broader discourse on demographic sustainability and labor market policy. While our findings are modest in scope, they underscore the potential role of employment security in shaping fertility intentions. Continued research and dialogue are needed to understand how evolving work environments can support individuals and families in achieving their reproductive goals.

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Odyssey
Conference

EDUCATION

TRACK 1: Educational Innovation and Trends

PREFACE

EDUCATION – TRACK 1: EDUCATIONAL INNOVATION AND TRENDS

Education is a cornerstone of individual and societal development, continuously adapting to new pedagogical approaches, technological advancements, and evolving student expectations. This thematic section explores critical aspects of the contemporary educational landscape, examining how institutions respond to student needs, the integration and impact of emerging technologies in learning, and the role of educational programs in fostering good governance. The papers in this track collectively highlight the dynamic nature of education and its crucial role in preparing individuals for the future and equipping them with relevant skills for a changing world, thereby contributing to achieving the defined aim and scope of the Odyssey conference. These papers focus on understanding and enhancing the educational experience, addressing contemporary challenges, and preparing learners for a technologically advanced and transparent society.

Antičić and Repalust investigate perceived consumer values in higher education in Croatia, exploring the alignment between student expectations and instructor perspectives in private institutions, offering insights into optimizing the educational environment. Pandža Bajs examines how the frequency of ChatGPT usage shapes student perception, academic achievements, and future intentions for AI tool adoption, shedding light on the challenges and benefits of AI integration in education. Vitálišová, Vavrušová, Vaňová and Laco explore the current state of education in open governance within Slovak Republic universities and non-profit organizations, highlighting the importance of equipping public administration employees with skills to navigate the evolving governance landscape driven by digital transformation.

PERCEIVED CONSUMER VALUES IN HIGHER EDUCATION: EXPLORING THE ALIGNMENT BETWEEN STUDENT EXPECTATIONS AND INSTRUCTOR PERSPECTIVES IN PRIVATE INSTITUTIONS IN CROATIA

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Abstract

This research investigates perceived consumer values in higher education, focusing on the shared and divergent values of students and instructors in private institutions in Croatia. Through primary market research using discussions in two focus groups – one with students and the other with instructors, the study aims to examine the alignment between student expectations and the values offered by instructors and institutions. It provides insights into various dimensions of values, such as study environment, practicality, innovativeness, communication, internationalization, cost, financial support, and time management. The findings highlight significant perspectives on enhancing alignment between student perceptions and institutional performance in the Croatian private higher education market. Students acknowledged the importance of facilities in enhancing their overall experience but suggested enhancements such as larger libraries and additional communal spaces like cafeterias. Instructors emphasized dynamic study environments, technological integration, and the importance of creating collaborative and adaptable spaces. Communication emerged as a critical factor. Students valued reliable support services and open communication channels with instructors, while instructors stressed effective feedback mechanisms and the use of both formal and informal communication platforms. Regarding internationalization, both groups underscored the importance of inclusivity and global perspectives. Financial aspects revealed that students generally perceived high tuition costs as justified by the quality of education and unique experiences. Instructors noted challenges in balancing academic rigor with financial sustainability. The study concludes that private higher education institutions in Croatia must align their offerings more closely with student expectations. Despite limitations such as participant motivation and time constraints, the findings contribute to the broader understanding of consumer values in higher education within the Croatian context. Recommendations for future research include quantitative surveys of perceived dimensions of value in private higher education market. Furthermore, a deeper exploration of differences between dimensions of perceived value should be conducted across diverse study programs.

Keywords: consumer values, value dimensions in private higher education, student expectations, instructor perspectives, focus group research

JEL classification: M31, A22, I21, N30

Introduction

This paper explores perceived consumer values in higher education and describes the process of conducting primary market research to uncover the shared desires of both students and instructors. The study discusses convergence and divergence of their perspectives, with the primary objective of scrutinizing and drawing conclusions regarding the values held dear by students in their higher education experience, in contrast to the values propagated by instructors and institutions. We seek to bring understanding and clarity to the differences or similarities that exist between what students value in higher education and what instructors offer as values. Studies in focus groups appeared as the best possible methodology. Two distinct focus groups were coordinated and moderated, bringing together students from diverse private higher education institutions in the first group and instructors from various academic backgrounds, teaching in private higher education institutions, in the second. The paper unfolds the findings obtained from these focus group discussions and provides insights into various dimensions of values in private higher education. By collapsing the complexity of value perspectives into value dimensions, this research aspires to contribute to a more informed dialogue between students and instructors, with the objective of enhancing the alignment of student expectations and their perceptions (Khondkar & Muzareba, 2024), hence instructors' performance.

Theoretical background

Kunanusorn and Puttawong (2015) identified student satisfaction and loyalty as paramount objectives for private higher education institutions (HEIs). It is the perceived value that influences the creation of customer satisfaction and customer loyalty in private HEIs (Barusman, 2014). This work underscores the significance of understanding the factors influencing student perceptions in the context of higher education.

Zeithaml (2000) provides a conceptual framework for perceived value, defining it as the consumer's comprehensive evaluation of a product or service based on the perceived balance between what is received and what is given. In the higher education landscape, students assess the net worth of the service based on the benefits received and the costs or sacrifices incurred.

Notably, Kunanusorn and Puttawong (2015) assert that a positive perception of service value directly impacts overall student satisfaction. The intensified competition in the private higher education sector necessitates institutions to excel in delivering quality education, fostering a constructive environment, and providing comprehensive facilities. Appuhamilage and Torii (2019) highlight the pivotal role of universities as service organizations and stress the importance of understanding the determinants of customer satisfaction to maintain a high monetary value. Student satisfaction, a complex construct influenced by various factors, surrounds the university's image, perceived value, environmental aspects (such as location and cleanliness), available facilities (e.g., parking, classrooms, athletics, cafeteria, elevators), opportunities for internationalization (exchange programs, language learning support), and services offered by academic and administrative staff (Appuhamilage & Torii, 2019, O'Driscoll, 2012, as cited in Barusman, 2014). Expectedly, students' fulfilled expectations and customer satisfaction significantly impact their loyalty to the institution. In another stream of research, Goh et al. (2017) challenge the notion that trust is positively correlated with student loyalty. They argue that the university students may exhibit lower trust when they perceive staff and lecturers as lacking dependability, competence, integrity, and responsiveness. Examining

the image dimension, Brown and Mazzarol (2009) assess whether an institution is perceived as friendly, supportive, innovative, student-focused, and offers a diverse range of courses.

Obviously, scholars use diverse dimensions of value to describe the value delivery systems of private higher education institutions. Sheth et al. (2001, as cited in Barusman, 2014) conceptualize the perceived value in the private HEIs as a multidimensional phenomenon, consisting of functional value, social value, emotional value, epistemic value, and conditional value. However, the diverse and sometimes conflicting research findings point that there is no common taxonomy of perceived value that could fit all such institutions worldwide. We believe that it is possible to identify such a taxonomy that would be characteristic for the Croatian market of private higher institutions.

The definition of private higher education and its difference from public higher education

In order to establish the framework for this research, it is necessary to precisely define how private higher education institutions differ from public ones.

Private higher education institutions (HEIs) operate independently of direct government control, relying primarily on tuition fees and private funding for their financial sustainability (Hasan et al., 2008). These institutions are characterized by their ability to offer flexible, market-driven programs, often designed to meet industry-specific needs and cater to niche markets. By contrast, public HEIs are state-funded and often follow rigid administrative and curricular structures, with affordability being one of their primary attractions (Simic et al., 2019, Uroš, 2019).

Private HEIs are typically associated with smaller class sizes, personalized attention, and a focus on practical and employment-oriented education. Their competitive advantage lies in providing better facilities, international exposure, and access to global academic networks (Kruja et al., 2021; Bezuidenhout & De Jager, 2014). However, critics argue that private HEIs may prioritize profitability over academic rigor, especially in post-communist contexts like Croatia, where private institutions are perceived as providing easier degrees (Uroš, 2019).

Conversely, public HEIs are regarded as bastions of tradition, offering broader program accessibility and more diverse student populations. However, public HEIs often face criticism for overcrowding, outdated facilities, and bureaucratic inefficiencies (Bartkute, 2017). The competitive dynamics between private and public institutions are further shaped by evolving student expectations and the marketization of education (Molesworth et al., 2011; Ostojić & Leko Šimić, 2021).

Regardless clear distinctions in the definition of the private and public HEIs, many scholars argue that public HEIs too should include a market orientation in their strategic planning (Conway et al., 1994, as cited in Guilbault, 2016) because customer-centric focus adds value to the educational process, despite the resistance of the traditional academic community in accepting the notion that students are customers (Maguad, 2007, as cited in Guilbault, 2016).

Value dimensions in higher education

Perceived value in private higher education represents students' assessment of the benefits they receive relative to the costs they incur, including tuition fees, time, and effort (Woodall et al., 2014). In private HEIs, this phenomenon is particularly significant due to the higher financial

investment required. Bartkute (2017) and Osman and Saputra (2019) highlight that perceived value is influenced by functional factors, such as employability and academic quality, which Sheth et al. (2001, as cited in Barusman, 2014) call the epistemic value. Another dimension that influences the perceived value are the emotional factors (Bartkute, 2017; Osman & Saputra, 2019; Sheth et al., 2001, as cited in Barusman, 2014), specifically, a sense of belonging and self-worth (Bartkute, 2017; Osman & Saputra, 2019).

Da Silva et al. (2019) expand on this by introducing the concept of value of co-creation, where students and institutions collaboratively shape the educational experience. By involving students in curriculum design, extracurricular activities, and decision-making processes, institutions can enhance perceived value and foster deeper engagement. Khondkar and Muzareba (2024) conceptualize the perceived value of HEIs through the prism of SERVQUAL model, consisting of tangibles, reliability, responsiveness, assurance, and empathy. Furthermore, Gallarza et al. (2013) emphasize that perceived value extends beyond individual benefits to include societal contributions, such as addressing global challenges and fostering sustainability.

Based on a review of the available literature, the following key value dimensions that play a prominent role in describing the value delivery process of HEIs stand out.

Institutional Image

Institutional image is critical to shaping student perceptions and satisfaction. Brown and Mazzarol (2009) demonstrate that a positive institutional image enhances student loyalty by fostering trust and pride. Elements such as inclusivity, innovation, and a student-centric approach define a favorable institutional image, which influences prospective students' decision-making and current students' satisfaction levels. Institutions perceived as friendly, supportive, and forward-thinking often enjoy stronger reputations, particularly in the competitive private education market (Brown & Mazzarol, 2009; Ostojić & Leko Šimić, 2021).

Comparative research by Ostojić and Leko Šimić (2021) reveals that private institutions in Croatia often outperform public HEIs in brand perception due to their superior facilities and emphasis on personal attention. Furthermore, Molesworth et al. (2011) highlight how the marketization of education pushes private HEIs to build a strong image aligned with modern students' expectations. This alignment is not merely promotional but also reflects the institution's adaptability to contemporary demands, enhancing perceived value (Bartkute, 2017). In addition, Gallarza et al. (2013) identify institutional image as a key factor influencing students' sense of pride and advocacy, which in turn contributes to satisfaction and loyalty.

Service Quality

Service quality is a multifaceted construct encompassing functional value, reliability, responsiveness, assurance, empathy, and tangible resources. Sohail and Saeed (2003) note that private HEIs often prioritize service quality to distinguish themselves from public institutions, which may struggle with outdated facilities or less student-centric approaches. Hasan et al. (2008) identify that students value modern infrastructure, competent instructors, and well-organized administration as integral to high service quality.

Azam (2018) and Bezuidenhout and De Jager (2014) emphasize that continuous evaluation and improvement of service quality are essential for maintaining competitiveness in the higher

education market. This includes integrating technological advancements, such as online portals and virtual classrooms, to enhance administrative efficiency and teaching quality. However, technology alone is insufficient; human interactions, particularly in academic advising and mentorship, remain critical (Bezuidenhout & De Jager, 2014; Yusoff et al., 2015). Institutions that succeed in creating a balance between digital innovation and personal connections often report higher satisfaction rates among students (Azam, 2018).

Learning Environment

The learning environment, encompassing physical facilities, social dynamics, and academic culture, plays a pivotal role in shaping the educational experience. Simic et al. (2019) observe that private HEIs often excel in providing modern, well-maintained facilities that support both academic and extracurricular activities. Cleanliness, accessibility, and the availability of recreational spaces are critical aspects of the learning environment that directly influence student satisfaction (Kruja et al., 2021).

Interactive classrooms, collaborative workspaces, and technological tools are particularly valued by students in private HEIs, as they facilitate active learning and engagement (Yusoff et al., 2015; Khondkar & Muzareba, 2024). Bartkute (2017) notes that smaller class sizes in private institutions create opportunities for more personalized attention and peer-to-peer learning. Moreover, Kruja et al. (2021) highlight the importance of fostering inclusivity, particularly for international students who may face cultural or linguistic barriers.

Practicality and Employability

Practicality refers to the relevance of curricula to real-world applications, a priority for students in private HEIs. Goh et al. (2017) emphasize that institutions offering industry-aligned programs and experiential learning opportunities are more likely to meet student expectations. Internships, capstone projects, and case-based learning are examples of practical approaches that enhance employability (Appuhamilage & Torii, 2019).

Employability is further strengthened by institutional collaborations with industry partners. Da Silva et al. (2019) discuss value co-creation in this context, where students work alongside instructors and industry experts on projects that simulate professional challenges. This approach not only builds technical skills but also fosters adaptability and problem-solving capabilities, essential for career success. Gallarza et al. (2013) identify employability as a core dimension influencing students' perceived return on investment in education.

Internationalization

Internationalization is a critical dimension in private higher education, reflecting the institution's ability to integrate global perspectives and offer diverse opportunities for international exposure. Erasmus programs, foreign exchange initiatives, and partnerships with global universities are hallmarks of successful internationalization strategies (Simic et al., 2019). These programs provide students with cross-cultural competencies and broaden their career horizons in a globalized job market.

However, internationalization must be inclusive and accessible. Gallarza et al. (2013) caution against creating elitist opportunities that exclude students from less privileged backgrounds. Instead, institutions can integrate international elements into regular curricula, such as global

case studies, foreign language instruction, and virtual collaborations (Ostojić & Leko Šimić, 2021). Creating a welcoming environment for international students, including cultural sensitivity training and support services, is equally important (Kruja et al., 2021).

Innovativeness

Innovativeness reflects an institution's ability to adopt modern teaching methodologies, technologies, and policies that align with contemporary student needs. Molesworth et al. (2011) argue that private HEIs must innovate continuously to maintain relevance in an increasingly competitive market. Examples of innovation include blended learning models, digital simulations, and AI-driven academic support systems (Azam, 2018; Hasan et al., 2008).

Innovativeness is not limited to technology but also includes pedagogical creativity. Case-based learning, flipped classrooms, and collaborative projects are examples of innovative teaching methods that engage students more effectively than traditional lectures (Woodall et al., 2014). Institutions that encourage creativity and adaptability in their teaching approaches are more likely to foster student satisfaction and academic success (Goh et al., 2017).

Cost and Financial Support

Cost remains a critical factor for students in private HEIs, where tuition fees are typically higher than in public institutions. Bartkute (2017) and Osman and Saputra (2019) emphasize that the perceived value of education must justify these costs through superior quality, facilities, and career outcomes. Transparent financial policies, including scholarships, installment plans, and need-based aid, play a significant role in shaping students' financial satisfaction (Kruja et al., 2021).

Financial support is also crucial for promoting diversity and inclusivity. Khondkar and Muzareba (2024) conceptualize it as giving promised financial aid, scholarships, and course and tuition fee waivers, under the dimension of SERVQUAL's reliability dimension. Bezuidenhout and De Jager (2014) note that robust financial aid programs enable students from varied socioeconomic backgrounds to access quality education. However, Uroš (2019) highlights the challenge of balancing affordability with financial sustainability, a persistent issue for many private institutions.

Communication and Responsiveness

Effective communication between students and instructors is essential for fostering trust and satisfaction. Yusoff et al. (2015) and Khondkar and Muzareba (2024) identify timely feedback, clear communication channels, and instructors' accessibility as key elements that enhance the student experience. Institutions that actively seek student feedback and address concerns promptly are better positioned to build strong relationships with their students (Bezuidenhout & De Jager, 2014).

Responsiveness extends beyond academic interactions to include administrative processes. Students value efficient and transparent procedures for admissions, financial aid, and academic advising (Azam, 2018). Kruja et al. (2021) found that institutions with high levels of responsiveness often report better retention and satisfaction rates.

Value dimensions influencing customer satisfaction

Value dimensions play distinct roles in influencing customer satisfaction in private higher education. Dimensions such as institutional image, service quality, and perceived value directly drive satisfaction. Students seek a balance between the tangible and intangible benefits of their education, prioritizing personalized attention, state-of-the-art facilities, and supportive instructors (Hasan et al., 2008; Woodall et al., 2014). Practicality and employability are particularly influential, as students gauge the relevance of their education in achieving career goals (Goh et al., 2017). Additionally, internationalization and the learning environment significantly enhance satisfaction by fostering inclusivity and providing global perspectives (Gallarza et al., 2013; Simic et al., 2019). However, the biggest gaps between students' expectations and perceptions lie in the responsiveness and empathy of private HEIs (Khondkar & Muzareba, 2024).

Value dimensions influencing customer loyalty

Value dimensions play distinct roles in influencing customer loyalty in private higher education. While satisfaction is a precursor to loyalty, other dimensions such as emotional attachment to the institution and a sense of belonging also play critical roles (Appuhamilage & Torii, 2019). Institutional image and brand value are pivotal in fostering loyalty, as students who associate positive attributes with their institution are more likely to recommend it to others (Brown & Mazzarol, 2009). However, Gallarza et al. (2013) argue that loyalty is multifaceted, encompassing behavioral, attitudinal, and emotional dimensions, which can vary significantly among students.

Methodology

To accomplish the research objectives, different scientific and research methods were employed. Desk research, involving the examination of extant literature, was undertaken to process secondary data, drawing upon existing knowledge related to the research topic. Various databases, encompassing scientific literature and articles, were consulted to enrich the secondary data analysis. The analysis of the literature served as a foundational phase for the subsequent exploratory research through focus groups.

Field research was conducted to gather primary data, employing a qualitative focus group discussion. The primary aim of the research in focus groups was to discern the distinctive value dimensions inherent in the market of private higher education institutions.

During the preparation and implementation of research in focus groups, a review of foreign literature was intentionally taken as a foundation for identifying the initial dimensions of value. Although the connection between the international education market and Croatian higher education institutions (HEIs) may seem weak at first glance, the Croatian market is, in fact, fully internationalized due to both inbound and outbound mobility. Moreover, internationalization is the only viable way to compensate for declining student enrollments in a country experiencing depopulation. International students are, and will increasingly be, key clients of HEIs. This convergence justifies the initial conceptualization of value dimensions in Croatian HEIs based on international literature.

Based on the literature review and identified value dimensions that are characteristic of the market of private higher education institutions, two sets of discussion questions were prepared:

One for the focus group of students and the other for the focus group of instructors. All discussion questions are open-ended to elicit as much information as possible from the participants. Each value dimension is covered by at least two questions: one asking about the perceived values of the private higher education institutions and the other about the possibilities for improvement in the field discussed. The value dimensions addressed are study environment, practicality, conservativeness, facilities, reliability/responsiveness, internationalization, price, financial support, time, and overall quality. Questions for students and questions for instructors that were discussed are provided in the appendix.

Five students participated in the students' focus group discussion. Representatives from the following private higher education institutions participated in the discussion: RIT Croatia, Libertas, Vern, Baltazar Zaprešić and Algebra.

Four instructors participated in the instructor focus group discussion. Instructors were from the following private higher education institutions: RIT Croatia, Zagreb School of Economics and Management, Effectus, and Libertas.

The research employed a group discussion approach, utilizing a nonprobability sampling method that combined convenience and judgment sampling techniques (Kotler, 2018). Two distinct groups of participants were formed, comprising students and instructors from private HEIs. The selection of discussants for participation in the focus groups was based on several criteria, prioritizing individuals who constituted the easiest population to access for information (convenience sample). Additionally, emphasis was placed on their capacity to articulate thoughts, motivation to engage in the research, and a comprehensive understanding of the research subject (judgment sample).

Throughout the analysis of both secondary and primary data, a range of general scientific methods were applied. In order to deconstruct the studied variable and comprehend its perceived value comprehensively, a method of proof was employed. This method involved various procedures, including analysis, synthesis, generalization, induction, deduction, abstraction, and concretization (Zelenika, 2000).

The classification method was utilized to categorize attributes and value dimensions, offering a systematic approach to organizing the research findings. Descriptive methods were applied to elucidate the research topic, providing a detailed account of the subject. A comparative method was employed to scrutinize facts, phenomena, processes, and relationships, comparing perspectives and values articulated by students and instructors. This approach aimed to uncover similarities and differences in their perceptions of what holds value in private higher education.

Findings of the focus group discussions

Based on the suggested taxonomy of value dimensions found in the literature that characterizes the HEI market, the results of the focus group discussions are presented below. The results are derived by regrouping the value dimensions according to the participants' comments, and where necessary and feasible, they are assigned more suitable titles that better reflect respondents' insights and observations.

Study environment and facilities

While students generally expressed positive feelings about facilities, there was a common desire for larger libraries and the need for cantinas. Students appreciate elements like fun corners and extracurricular activities. On the instructors' side, instructors portrayed their study environments as dynamic and adaptive, integrating the latest educational trends while recognizing potential improvements in the infusion of technological advancements and practical assignments. Instructors emphasized the importance of facilities in enhancing the overall teaching and learning experience, recognizing students' needs for relaxation and collaborative spaces. Conversely, the quality of facilities was deemed integral to the overall educational experience. Features such as small class sizes, a cozy learning environment, and adaptable furniture were particularly highlighted. Finally, it was emphasized that universities are ultimately about people, not just buildings.

Learning experience

Both students and instructors highlighted the need for more real-life examples in coursework, expressing skepticism about the relevance of certain theoretical knowledge to their future jobs. Students conveyed confidence in their employability. Instructors, in turn, discussed their implementation of practical elements using various methods, including oral presentations, producing country reports, mirroring tasks encountered in professional settings, and utilizing the capstone model.

Moreover, instructors underscored the importance of students engaging in hands-on learning experiences rooted in real-world examples. This emphasis aims to foster teamwork and encourage collaboration among international students. To facilitate effective interaction, smaller groups of students are organized into sections, creating a conducive setting for meaningful engagement.

Innovativeness

Students offered insights into their perception of their colleges' policies, emphasizing the importance of flexibility in attendance policies and the integration of online alternatives for those unable to attend physically. Simultaneously, they regarded their colleges as innovative, seamlessly combining a modern approach with adherence to regulatory standards. The perceived conservatism was counterbalanced by an acknowledgment of innovation, particularly evidenced in student-led initiatives such as instructors' festivals.

Instructors acknowledged the need for a balance between traditional and innovative teaching methods, highlighting the freedom to shape courses. They also mentioned the use of graphical tablets for creating digital notes alongside traditional methods like case studies. Additionally, there was an emphasis on certain study programs providing extensive opportunities for co-op experiences. This includes inviting industry representatives for lectures that bridge theoretical knowledge with practical insights. Students actively engage in real projects sponsored by industry partners, enriching their understanding of the professional landscape.

Communications

The reliability of communication channels emerged as a vital factor for students, who emphasized the importance of support services as primary sources of information.

Consultations with instructors were deemed crucial, as were interpersonal relationships. Both students and instructors acknowledged the great availability of materials on software platforms. Instructors ensure reliability through in-person observation, direct communication with students, and effective feedback mechanisms. They also employ workshop efficiency rate tracking to ensure consistent and reliable communication with students. Some instructors also utilize learning management systems for formal communication and announcements, complemented by informal channels such as social media groups.

Internationalization

The global perspective held significance for both students and instructors. Some students emphasized the importance of international study programs, particularly through projects like Erasmus. While the participants strongly advocated for internationalism, concerns were raised about the potential exclusion of international students from the conversation when students start talking in the Croatian language during breaks.

One student perceived inclusiveness in their academic program and department. Instructors actively incorporated international perspectives into their teaching methodologies. Some utilized comparisons between domestic and international case studies, emphasizing diversity in student collaborations. Others applied executive education models from leading global universities, asserting that diversity and internationalization were focal points of educational institutions. Teaching in an English program with a diverse student body, one instructor actively incorporates different perspectives, especially those outside a Eurocentric focus.

Price

Despite acknowledging high tuition fees, students believe that the value of private colleges justifies the cost. The emphasis was placed on the quality and variety of study programs and the unique experiences facilitated by private institutions. The close collaboration with instructors and peers was deemed a pivotal aspect that distinguished private education from state-run alternatives. Instructors mentioned how in the past, some students may have expected to pass simply because they attend a private institution, presenting challenges in maintaining academic rigor while ensuring financial sustainability. Maintaining a balance is particularly challenging for private HEIs, given the financial limitations and the necessity to justify high standards amid potential student reduction.

Financial support

Students mentioned the need for transparent criteria for financial aid decisions, recognizing private college education as a luxury product that may not need broad financial support. Scholarships, while valued, were not viewed as the sole method of recognition. Instructors recognized the need for understanding students' work commitments and proposed financial support mechanisms tied to demonstrating excellence in various projects.

Time

Student perspectives on time management varied. Comments primarily focused on the perceived abundance of estimated independent work time. Nevertheless, students highlighted the flexibility to customize their study schedules according to personal needs and capabilities.

Overall, all students expressed satisfaction with the balance between academic responsibilities and personal life.

Instructors affirmed their dedication to investing ample time in interacting with students, both within and beyond the classroom. Strategies such as consultation hours, availability on request, and proactive engagement were underscored as means to support students.

Discussion of results

This paper discusses the intricate dynamics of perceived consumer values in higher education, specifically focusing on private institutions. The exploration of both student and instructor perspectives, guided by a theoretical foundation, has yielded a profound understanding of the values inherent in this educational realm. The focus group discussions, conducted with students from diverse private institutions and instructors teaching at these establishments, have brought forth invaluable insights.

Within the domain of facilities and study environment, students expressed positivity while indicating a desire for more extensive libraries and cafeterias. This finding is partially aligned with the earlier work of Appuhamilage and Torii (2019), who also emphasized the importance of social spaces such as cafeterias. However, a contribution of this present study is in highlighting the library as a critical facility that students perceive as essential to their overall learning experience. Instructors' acknowledgment of the importance of dynamic and adaptive study environments, integrating technological advancements for enriched teaching and learning experiences, supports similar earlier findings of Yusoff et al. (2015).

Learning experiences were scrutinized through the lenses of practicality. Students emphasized the necessity for real-life examples. This conclusion aligns with earlier findings by Goh et al. (2017), who emphasized the role of industry-aligned programs and experiential learning in meeting student expectations. Instructors in the present study described various ways of integrating practical elements into their courses, demonstrating flexibility in teaching approaches. Similarly, Appuhamilage and Torii (2019) highlighted employability as a key perceived benefit of higher education. However, insights from the two focus group discussions suggest that employability is not viewed as a primary outcome of the HEI's value delivery. This may reflect the institution's emphasis on providing knowledge and skills, with the assumption that employment will naturally follow once the appropriate competencies are acquired.

In terms of innovativeness of HEIs, while earlier studies (e.g., Molesworth et al., 2011, Azam, 2018) focus on institutional strategies and technologies, findings of this research highlight the lived students' experience of innovation, such as co-op projects and industry collaboration, offering a more practice-based perspective (Goh et al., 2017).

Communication with instructors, identified in the literature as a key factor (Yusoff et al., 2015), is further emphasized in this study through students' expressed need for reliable and multi-platform communication. This expectation reflects both the rapid evolution of digital technologies and the digitally native upbringing of Gen-Z. Additionally, students' appreciation for support services and efficient administrative processes reinforces the earlier findings of Kruja et al. (2021).

Internationalization is recognized as important by both students and instructors, highlighting the value of inclusivity and diversity in academic programs. For students, it primarily centers on mobility opportunities, aligning with Simic et al. (2019), who identify exchange initiatives as key indicators of successful internationalization. However, this study also reveals a significant barrier: language. Students acknowledge that the preference for speaking Croatian may inadvertently exclude international peers, thereby undermining the international dimension of the private HEI. A comparable obstacle to internationalization of the private HEIs is the elitist student clustering as a threat to diversity (Gallarza et al., 2013). Instructors in this study associate internationalization more with teaching practices, such as incorporating global case studies and foreign language instruction, detailed by Ostojić and Leko Šimić (2021).

Findings of our study related to price and financial support complement prior research (Bartkute, 2017; Kruja et al., 2021) by confirming that students link high tuition to educational value. The nuance that was highlighted by a focus group discussion with students is that relational benefits, such as close instructor-student ties, are a key justifier of higher cost. However, unlike earlier work focusing on broad financial aid provided to students (Bezuidenhout & De Jager, 2014), findings in this research reveal that students view private education as a luxury. They also favor merit-based over universal support. This can be considered a new insight into perceived fairness and sustainability in comparison with the public HEIs, as already discussed by Uroš (2019).

While existing literature focuses on institutional responsiveness and timely feedback (Yusoff et al., 2015), this study introduces students' appreciation of flexible study pacing and instructors' time investment beyond formal teaching. This highlights a more personalized and balanced time management approach, which is consistent with Gen Zers' preference not to sit through a college lecture when they could read the same material three times as fast, while also navigating to different web sources simultaneously (Rue, 2018).

These findings suggest that private higher education is perceived by key stakeholders—students and instructors—as a holistic experience. Academic rigor is not overlooked; rather, the discussions indicate that scientific and academic quality is seen as a prerequisite for enrolment and studying. A key contribution of this research is the discovery of the prominent role of "soft" value dimensions in shaping the overall perception of the educational experience—a conclusion that requires further testing through factor analysis. The initial assumption that private and public HEIs differ in their value systems is supported by the findings, aligning with previous insights on public institutions provided by Uroš (2019) and Bartkutė (2017). In conclusion, this paper provides a comprehensive review of consumer values in private higher education in Croatia, drawing from theoretical foundations and focus group discussions. The objective of identifying these values was achieved, providing a clearer understanding that shapes student and instructor perceptions.

Practical implications

Findings of this study point to a need to incorporate some of its conclusions in the managerial processes of the HEIs. Private HEIs should focus on developing novel approaches to studying that emphasize soft value dimensions, such as personalized learning experiences, quality communication, inclusive international environments, and strong student-instructor relationships. These elements are crucial for enhancing the perceived value of education among Gen Z students, who prioritize emotional engagement, flexibility, and real-world applicability

over a +strict academic approach, traditional prestige or institutional authority. HEIs should also tailor their services and curricula to better reflect Gen Z's expectations by integrating practical learning, digital innovation, and diverse, student-centered support systems. In doing so, institutions would not only meet academic demands but would also foster a more engaging and holistic student experience. These innovative approaches and strategic emphasis on soft dimensions should be integrated along with responsiveness to Gen Z characteristics, such as their digital fluency, desire for autonomy, and appreciation of inclusivity. Empirical findings of this study indicate that these approaches would strengthen the competitive positioning of private HEIs and increase student satisfaction and retention.

Limitations

It is crucial to acknowledge certain limitations to this research, including the challenge of participant motivation and time constraints, which may have impacted the depth of the discussions. Some participants misunderstood the research objective, assuming it was about testing their satisfaction or comparing private higher education institutions (HEIs), rather than identifying their personal perceptions of the values provided by private HEIs. Another challenge was the scarcity of time, especially in the focus group of instructors. Some respondents finalized their responses through the social network LinkedIn, thereby disabling further discussion. Additionally, the number of participants in each focus group only meets the minimum acceptable threshold.

In this paper, the researchers conducted the study with participants from their own institution, which may introduce a potential bias in the responses. Additionally, respondents in focus groups were from various fields of study (business, IT & computing), which may distort the perceived values, particularly concerning infrastructure needs for engineering studies participants. Despite these limitations, the findings contribute to a more informed dialogue, offering valuable insights that can inform future improvements in private higher education institutions.

Further research

Further research on the topic will focus on surveying the target groups of private HEIs regarding their perceived value dimensions. The results of the focus group research will serve as the foundation for designing the primary survey-based research. The quantitative data collected will be analyzed using factor analysis to determine which value dimensions best describe the value delivery system of HEIs and how they relate to student satisfaction and loyalty. Additionally, an exploration into the differences in value perceptions among students in diverse study programs would offer more detailed and specific insights. Pursuing both research avenues would establish foundations for generating insightful recommendations for HEI management.

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Appendix

A. Questions for Students:

Study environment and facilities:

1. How would you describe the current study environment from your perspective?
2. What aspects of the study environment contribute positively to your learning experience?
3. Are there any improvements you would suggest to enhance the study environment?
4. How satisfied are you with the available academic facilities (library, lab, etc.)?
5. Are there specific facilities you think need improvement or expansion?
6. Are there facilities you believe significantly impact the learning environment?

Learning experience:

1. How do you assess the practicality of the courses and programs offered? Do you expect to find a job easily and fulfill the employer's requirements with the knowledge and skills that you acquired during your studies?
2. In what ways do you think the curriculum could be more practical and applicable to real-world scenarios?

Innovativeness:

1. To what extent do you feel the academic environment encourages or discourages innovative and unconventional ideas? Explain and describe on examples.
2. Are your college's academic policies conservative or modern? How do they affect your learning experience?

Communications

1. How reliable do you find the communication channels between students and instructors/administration?
2. Do you feel you can rely on your teachers?
3. To what extent do you perceive teachers as responsive to student needs and concerns?

Internationalization:

1. How inclusive and international do you perceive the academic programs and campus environment?
2. In what ways does the institution promote global perspectives in education?

Price:

1. How do you perceive the value for money in terms of tuition and other expenses?
2. In what ways do you think the cost of education aligns with the quality of services provided?

Financial Support:

1. How satisfied are you with the financial support and scholarship opportunities provided by the institution?
2. Are there specific areas where you feel additional financial assistance is needed?

Time:

1. Do you think you spend enough time interacting with instructors, and do you believe it adequately supports your learning experience?
2. How would you describe the balance between class time and independent study in your current academic schedule?
3. Are there specific challenges you face in managing your time effectively to engage with course materials and interact with instructors?

B. Questions for Instructors:

Study environment and facilities:

1. Can you describe the study environment?
2. How do you perceive the study environment impacting students' engagement and performance in your classes?
3. What changes in the study environment do you think could positively influence teaching effectiveness?

4. How do you think the quality of facilities contributes to the overall teaching and learning experience?
5. How do you utilize tangible resources to enhance your teaching methods?

Learning experience:

1. How do you incorporate practical elements into your teaching methods?
2. What challenges do you face in making your courses more practical for students?
3. Do you think that the students who completed the program in which you teach will be able to immediately start working effectively when they get their first job?

Innovativeness:

1. How do you navigate the balance between traditional teaching methods and incorporating innovative approaches in your courses?
2. Is your college's academic environment conservative or modern? Does it impact your teaching strategies? If yes, how?

Communications:

1. How do you ensure your communication with students is reliable and effective?
2. How responsive do you think the institution is in addressing the needs and concerns of students?

Internationalization:

1. How do you incorporate international perspectives into your teaching methods?
2. What challenges do you face in promoting diversity and internationalization in your courses?

Financial support:

1. How do you see financial support impacting students' academic performance and overall well-being?
2. What improvements in financial support would you suggest to enhance student success?

Time:

1. Do you think you spend enough time interacting with students, and do you believe it adequately supports their learning experience?
2. How do you manage your time to ensure meaningful interactions with students both inside and outside the classroom?
3. What strategies do you employ to make yourself accessible to students who may need additional support or clarification?

FROM OCCASIONAL TO DAILY USERS: HOW DOES THE FREQUENCY OF CHATGPT USAGE SHAPE STUDENT PERCEPTION?

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Abstract

Over the past few years, artificial intelligence (AI), especially ChatGPT (Chat Generative Pre-Trained Transformer), has become a popular tool in education. This tool allows students quick access to information, simplifies complex concepts, and helps structure academic tasks. While it offers numerous benefits, such as better content accessibility and the development of analytical skills, the use of ChatGPT raises challenges related to academic integrity, dependence on technology, and optimal integration into the educational system. A study conducted on 600 students in Croatia showed that students who use ChatGPT daily for studying achieve better results in learning and problem-solving. These students report higher confidence, and a better perception of academic achievements compared to those who use it rarely. Additionally, their intention to continue using this tool in the future is more pronounced, indicating the perception of long-term usefulness of AI in education. However, there are concerns in the academic environment about the potential decrease in autonomous critical thinking, which makes it important to encourage responsible use of AI tools in the educational system.

Keywords: artificial intelligence, ChatGPT, education, student perception, frequency of use

JEL classification: A2, I23, O3, M31

Introduction

In the past few years, the influence of artificial intelligence (AI) on education, its application, and its impact on student learning have been increasingly researched. Caldara et al. (2022) highlight that AI in education offers personalized, tailored support and enhances students' academic achievement. Consequently, higher education institutions are progressively incorporating AI tools for writing assistance, plagiarism detection, automated grading, and curriculum evaluation to improve the teaching process (Farhi et al., 2023).

ChatGPT (Chat Generative Pre-Trained Transformer), as one of the leading large language models, has rapidly gained popularity for its capability to produce high-quality responses instantly (Lock, 2022). Its accessibility and ease of use have contributed to its widespread adoption among students and teachers. ChatGPT is increasingly cited as a tool that could transform education by enabling content customization to meet the specific needs of each student (Almogren et al., 2024; Rejeb et al., 2024), while also supporting teachers in creating teaching materials and assessments. Due to its ability to follow the conversation flow and provide coherent responses, ChatGPT has the ability to revolutionize the educational process by facilitating learning, preparing teaching materials, and developing critical thinking. It can

also assist in STEM education, especially in learning mathematics, science, and programming, making education more flexible and accessible.

However, uncritical use of ChatGPT may reduce students' ability to think independently and engage in academic research. Moreover, AI tools are not infallible and can generate inaccurate or outdated information. Additionally, concerns have been raised about academic dishonesty, as students may use ChatGPT to automatically complete tasks and essays, which diminishes the need for developing their own writing and analysis skills (Rejeb, 2024). Furthermore, excessive use may reduce creativity and originality, as automated responses limit freedom of expression and innovation.

While numerous studies have been conducted worldwide on the impact of artificial intelligence on education, there are notably fewer studies in Croatia. Given the increasing role of ChatGPT in learning, it is crucial to investigate how often and for what purposes students in Croatia use ChatGPT, in order to better understand the potential benefits and challenges of this tool in the educational process.

The paper is divided in four chapters: introduction, theoretical framework, empirical research, and conclusion. The introduction explains the role of artificial intelligence in education, while the theoretical framework presents the significance of the ChatGPT tool, as well as the advantages and disadvantages of its use among the student population. The chapter on primary research analyzes how frequently students in Croatia use ChatGPT for academic purposes and examines the differences between students who use the tool regularly and those who use it rarely. The conclusion presents views based on the conducted research.

ChatGPT and its use among the student population

ChatGPT (Chat Generative Pre-Trained Transformer), developed by OpenAI and released in late 2022 (Pabreja & Pabreja, 2024), has become a key technology in education, academia, the medical industry, and many other fields due to its ability to respond to a wide range of topics (Gilson et al., 2023). Due to its simplicity and accessibility, ChatGPT quickly gained millions of users, reaching one million users within just a few days of its release (Tech Desk, 2023). As a "large language model" (LLM), ChatGPT generates natural-sounding responses based on a vast corpus of data taken from the internet (Samarth, 2023). It allows users to pose queries on various subjects, including programming, technical support, and medical advice, providing answers within seconds (Pabreja & Pabreja, 2024).

Thanks to its accessibility and ease of use, ChatGPT has become one of the most widely used AI tools among students (Baidoo-Anu & Owusu Ansah, 2023; Ngo, 2023). It provides linguistically sophisticated and expert responses, useful in academic settings, ranging from essay writing to solving academic tasks (Rospigliosi, 2023). Additionally, it supports students' critical and creative thinking, which justifies its integration into educational programs (Essel et al., 2024; Rejeb et al., 2024). Its speed in delivering information is especially valuable in time-sensitive situations, and the ability to customize responses allows for personalized learning (Albayati, 2024; Rahman and Watanobe, 2023). Moreover, the availability of free versions makes it accessible to a wide range of users, contributing to its broad application.

In addition to the advantages mentioned, a significant number of studies also highlight the limitation of using the ChatGPT tool in higher education (Ngo, 2023; Shoufan, 2023). Students

are aware of the drawbacks of ChatGPT, considering that its responses are not always accurate, and that effective use requires some prior knowledge, as ChatGPT cannot fully replace human intelligence. The biggest challenges students faced when using ChatGPT relate to the provision of unreliable information (Rahman & Watanobe, 2023), the inability to evaluate the credibility and quality of sources, inaccuracy in citing references, and difficulties in properly using idiomatic expressions (Ngo, 2023).

A comprehensive study by Ravšelj et al. (2025), conducted with over 23,000 students from more than 100 countries, showed that ChatGPT is most used for idea generation, summarizing texts, and finding research sources. According to the study, students in the humanities and arts fields more frequently use ChatGPT for creative writing, editing, idea generation, translation, and personal support, while students in applied sciences use the tool more often for academic and professional writing, summarization, calculations, and coding, as well as for learning and research support. Although students highlight its usefulness in simplifying complex information and improving academic efficiency, they note its limited reliability and insufficient support for classroom learning. Students perceive ChatGPT as contributing to digital communication and content creation, but it is not seen as equally effective in developing social and critical skills. Additionally, there are concerns about encouraging academic dishonesty, plagiarism, and social isolation, emphasizing the need for regulation of AI technologies.

Despite the potential of artificial intelligence to enhance education, ethical issues arise, particularly concerning the authenticity of student work (Lo, 2023; Stokel-Walker, 2022). Farhi et al. (2023) conclude that the use of ChatGPT in education provides numerous benefits but also brings up troubling concern related to academic integrity. Firat (2023) states that AI can increase student engagement and relieve teachers from routine tasks, allowing them to focus on mentoring and developing higher cognitive skills. Welding (2023) emphasizes the importance of ethical application of ChatGPT to preserve academic integrity and promote independent reasoning, while Farhi et al. (2023) conclude that properly regulated use could bring long-term benefits to education.

Research on the frequency of ChatGPT use among students in Croatia

Research objectives and methodology

The main goal of this study is to determine how frequently and for what purposes students in Croatia use ChatGPT as a learning aid and to examine the differences in attitudes and perceptions between frequent and occasional users. Accordingly, the following research questions have been formulated:

1. What is the frequency and perception of ChatGPT usage as a learning aid among students in Croatia?
2. What are the differences in attitudes and perceptions between students who frequently use ChatGPT and those who use it rarely?

In line with the stated objectives, a quantitative study was conducted using a survey questionnaire as the research instrument. The questionnaire was designed based on methodologies used in relevant scientific literature (Almogren et al., 2024; Farhi et al., 2023; Ngo, 2023; Niloy et al., 2024; Shoufan, 2023; Yu et al., 2024). A 5-point Likert scale was used to measure the researched variables. The study was carried out in May 2024 on a convenience sample of students from the University of Zagreb. The sample consisted of 600 students, of

whom 473 confirmed that they use ChatGPT for academic purposes. Descriptive statistics were used to analyze the results, while the Kruskal-Wallis test was conducted to determine differences among students. Since the analysis showed that the assumption of normal distribution of variables was not fulfilled, the Kruskal-Wallis test was used instead of ANOVA to compare differences among students based on the frequency of ChatGPT usage. The Kruskal-Wallis test is a nonparametric method for comparing three or more independent groups to determine if there is a statistically significant variation in their data distribution. This test does not require normal data distribution, which makes it appropriate for data that are not normally distributed or have unequal variances.

Research results

The study was conducted on a sample of 600 students from the University of Zagreb, of whom 473 stated that they use ChatGPT, meaning that 79% of the surveyed students utilize ChatGPT for their studies. Among the respondents who use ChatGPT, the majority were women (68%), aged between 20-23 years (80%), undergraduate and graduate students (96%), from the social sciences and humanities field (88%), with an average grade of 3 during their studies (52%). Additionally, most of them reported that their faculty does not have clear rules on the use of ChatGPT (76%), does not prohibit its usage (82%), do not use other AI-based tools (87%), and use ChatGPT once a week or less (79%).

A more detailed analysis of ChatGPT usage frequency for academic purposes shows that only 11% of students use ChatGPT daily or 4-5 times a week, 10% use it 2-3 times a week, while nearly 80% use it once a week or less. This indicates that students in Croatia do not frequently rely on ChatGPT for their studies as a continuous learning aid. Among the 600 respondents, 20% had never used ChatGPT, suggesting that the tool is not yet fully widespread among the student population in Croatia, but its increased adoption can be expected in the near future.

The descriptive analysis of the research results indicates that students in Croatia perceive ChatGPT as a useful learning tool that saves time, provides information, and that AI tools have become a standard in education. This means that students in Croatia value ChatGPT primarily for its speed, ease of use, and usefulness in research and information retrieval. On the other hand, most respondents do not believe that ChatGPT can think critically, accurately cite sources, or distinguish between reliable and unreliable information. They also do not use it for fully writing papers, suggesting that it is primarily used as an additional tool rather than a replacement for their own work. Many students are aware that ChatGPT can provide inaccurate or biased information and may violate copyright laws. There is also an ethical dilemma—while the tool is beneficial, some students believe it is unethical to use it for writing assignments and papers. Additionally, there is mild concern that AI could threaten future job opportunities.

It is important to emphasize that the majority of surveyed students use ChatGPT infrequently and that its usage frequency in Croatia is not at the same level as reported in other studies. This highlights the need to explore differences in attitudes and perceptions between students who regularly use ChatGPT as a learning aid and those who use it less frequently. To determine in which aspects there are significant differences among respondents, the Kruskal-Wallis test was conducted. The test results (Table 1) indicate that students' experience and perception of ChatGPT's usefulness change significantly depending on the frequency of its usage.

Table 1 presents only the statements for which a statistically significant difference was observed, while for the remaining statements, it is implied that there is no statistically

significant difference between respondents. Accordingly, the analysis of differences among respondents based on the frequency of ChatGPT usage for academic purposes was conducted.

Table 1: Kruskal-Wallis test results

Item	How often do you use ChatGPT for your studies?	N	Mean Rank	Chi-square	Asymp.Syg
I use ChatGPT as a learning aid.	Once a week or less	373	215,86	50,422	,000
	2-3 times a week	48	286,63		
	4-5 times a week	28	324,98		
	Daily	24	363,69		
	Total	473			
I use ChatGPT for translation.	Once a week or less	373	221,80	23,918	,000
	2-3 times a week	48	303,92		
	4-5 times a week	28	284,18		
	Daily	24	284,33		
	Total	473			
I use ChatGPT as a writing aid.	Once a week or less	373	224,67	23,751	,000
	2-3 times a week	48	291,19		
	4-5 times a week	28	228,52		
	Daily	24	330,10		
	Total	473			
I use ChatGPT to solve complex problems and tasks.	Once a week or less	373	219,75	32,696	,000
	2-3 times a week	48	276,13		
	4-5 times a week	28	321,61		
	Daily	24	328,08		
	Total	473			
ChatGPT is a useful tool for learning.	Once a week or less	373	224,44	21,646	,000
	2-3 times a week	48	263,35		
	4-5 times a week	28	272,86		
	Daily	24	337,69		
	Total	473			
ChatGPT helps students improve their grades and academic performance.	Once a week or less	373	222,67	29,519	,000
	2-3 times a week	48	284,36		
	4-5 times a week	28	247,45		
	Daily	24	352,73		
	Total	473			
ChatGPT helps students enhance their creativity.	Once a week or less	373	224,94	23,173	,000
	2-3 times a week	48	271,11		
	4-5 times a week	28	244,14		
	Daily	24	347,92		
	Total	473			
Using AI tools positively impacts my confidence.	Once a week or less	373	222,68	32,749	,000
	2-3 times a week	48	265,75		
	4-5 times a week	28	265,80		
	Daily	24	368,48		
	Total	473			
Using AI tools positively affects my grades and performance.	Once a week or less	373	224,37	20,453	,000
	2-3 times a week	48	278,07		
	4-5 times a week	28	257,20		
	Daily	24	327,52		
	Total	473			
In the future, I plan to use ChatGPT even more for my studies.	Once a week or less	373	223,66	26,273	,000
	2-3 times a week	48	278,18		
	4-5 times a week	28	247,98		
	Daily	24	349,13		
	Total	473			
I can't imagine studying in the future without using AI tools.	Once a week or less	373	221,14	31,006	,000
	2-3 times a week	48	265,78		

Item	How often do you use ChatGPT for your studies?	N	Mean Rank	Chi-square	Asymp.Syg
	4-5 times a week	28	306,61		
	Daily	24	344,73		
	Total	473			
ChatGPT is nothing but my assistant for learning and work.	Once a week or less	373	224,58	22,591	,000
	2-3 times a week	48	282,23		
	4-5 times a week	28	240,91		
	Daily	24	335,06		
	Total	473			
ChatGPT is an excellent tool for enhancing traditional learning methods.	Once a week or less	373	222,01	25,437	,000
	2-3 times a week	48	287,31		
	4-5 times a week	28	274,21		
	Daily	24	325,88		
	Total	473			

Source: author's preparation

The analysis of the results presented in Table 1 shows a connection between the frequency of ChatGPT usage and the perception of its usefulness in an academic context. Students who use this tool daily have significantly higher mean ranks across various aspects of application, suggesting a positive correlation between the intensity of use and perceived benefits. Specifically, the results show that daily users use ChatGPT for learning significantly more often (Mean Rank = 363.69) compared to those who use it once a week or less (Mean Rank = 215.86; Chi-square = 50.422, $p < 0.001$). A similar pattern was observed in its application for solving complex problems (Mean Rank = 328.08 vs. 219.75; Chi-square = 32.696, $p < 0.001$), suggesting that students who rely more on ChatGPT perceive its usefulness in supporting their understanding of the course content. Intensive users believe that ChatGPT helps improve their academic performance and boosts their confidence. Additionally, their intention to continue using this tool in the future is more pronounced, suggesting the perceived long-term usefulness of artificial intelligence in education and its growing role in the academic environment.

In addition to academic outcomes, significant differences in mean ranks show that students who use ChatGPT more frequently believe that it helps them enhance creativity (Mean Rank = 347.92 vs. 224.94; Chi-square = 38.547, $p < 0.001$). This data suggests that interaction with ChatGPT may stimulate creative thinking by generating ideas, shaping written content, and solving problems from different perspectives. Furthermore, daily users more strongly perceive that AI tools enhance traditional learning methods (Mean Rank = 325.88 vs. 222.01; Chi-square = 28.913, $p < 0.001$), which further supports the trend towards increasing integration of artificial intelligence into the educational process.

One key indicator of the changing perception of technology is the attitude towards the long-term impact of AI on education. Students who use ChatGPT daily are significantly more likely to believe they cannot imagine studying without AI tools. This points to the growing reliance of intensive users on AI tools and their belief that artificial intelligence is becoming an integral part of modern education. In conclusion, the data shows that more frequent use of ChatGPT not only improves academic outcomes and boosts student confidence but also positively affects creativity, changes the way students perceive learning, and strengthens the inclination to integrate AI technologies into the educational process. These findings underscore the importance of conducting further research to gain a deeper understanding of the long-term impacts of artificial intelligence in education and to identify the most effective ways to implement it within an academic context.

Conclusion

Students in Croatia show a positive attitude towards using ChatGPT, primarily due to its speed, simplicity, and usefulness in learning. As a tool that provides fast and easily accessible answers, ChatGPT helps students in research, information processing, and literature search, allowing them to save time and handle academic responsibilities more efficiently. Moreover, its practical application in education increasingly makes it a standard tool in academic environments. However, it is important to emphasize that students in Croatia do not grant full autonomy to ChatGPT in academic work; they do not use it for fully writing tasks and papers, but rather as an additional tool for data search and processing, being aware of its limitations. The results largely align with those of other studies where students recognize ChatGPT as a useful, motivating, and easy tool for study and work (Shoufan, 2023). An important aspect of the negative perception among Croatian students relates to the possibility of recognizing works generated by artificial intelligence. Some students fear that their work could be identified as plagiarism if they use ChatGPT to create it, and they consider the use of artificial intelligence to complete tasks to be unethical. This highlights concerns and the problem of defining ethical guidelines for the use of AI tools in education. It would be useful for future research to place greater focus on the ethics of using artificial intelligence and defining clear guidelines for its use in the education system.

The analysis of the results shows that the frequency of ChatGPT usage significantly influences how students perceive its usefulness and role in academic work. Students who use the tool regularly not only view it as a means to solve complex problems and improve grades but also as a key support in learning and a source of increased confidence and creativity. Interestingly, daily users express a greater inclination towards the integration of artificial intelligence into the educational system, with many stating that they can no longer imagine their studies without AI tools. This suggests that prolonged and more intensive use leads to a deeper understanding and acceptance of AI technologies as an integral part of academic experience.

These results open important directions for future research and the application of artificial intelligence in education. Future studies could focus on measuring the actual academic outcomes of using ChatGPT, as well as examining potential challenges, such as AI tool dependence or ethical concerns related to their use. Additionally, the data obtained can serve as a foundation for developing strategies that will enable the optimal use of ChatGPT in the educational context, for example, by educating students about its advantages and limitations. Ultimately, this research confirms that artificial intelligence is increasingly shaping the way students approach learning, and its integration into the educational system is becoming an unavoidable component of future academic development.

The main limitation of this research is the use of a convenience sample of students from just one Croatian university (the University of Zagreb), with a higher proportion of respondents from the social sciences studies. This limits the possibility of generalizing the results to the entire student population in Croatia. Future research should include a larger and more representative sample of students from various higher education institutions and different scientific fields to provide a broader and more comprehensive picture of ChatGPT usage among students in Croatia. Additionally, it would be useful to further investigate how continuous and frequent use of ChatGPT affects students' development of critical thinking, their ability to generate ideas, independence in learning, and writing skills.

Acknowledgement on the use of artificial intelligence (AI)

During the preparation of this work the author used ChatGPT to check writing style, translate and make language improvements. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the paper.

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OPEN GOVERNANCE AS A PART OF EDUCATIONAL PROGRAMMES: CASE STUDY OF SLOVAK REPUBLIC UNIVERSITIES AND NON-PROFIT ORGANISATIONS

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Abstract

Modern technologies are reshaping governance tools and methods in the public sector, significantly improving the delivery and accessibility of public services. This transformation also influences how stakeholders collaborate, contributing to lower transaction costs. Innovative forms of collective action now address complex public policy issues, enhance public knowledge, and replace traditional service delivery models— all foundational to the concept of open governance. These changes involve not only a broader network of digitally connected actors but also a redefined and less conspicuous role for. Successfully harnessing these changes in a form of innovations requires equipping public administration employees with the skills to apply them and understand the broader framework of open governance. This paper examines the current state of education in open governance within the Slovak Republic, as offered by universities and nonprofit organizations and identifies its strengths and weakness. Pilot research conducted in 2023 engaged representatives from nonprofit organizations and university faculty involved in public administration and policy programs. The findings highlight educational priorities essential for preparing public administration employees to adapt to the evolving governance landscape driven by digital transformation, that could help cover the gap between the theoretical concept of open governance and its real implementations.

Keywords: education, open governance, universities, non-profit organizations

JEL classification: H00, H11

Introduction

The term "governance" generally refers to the institutional mechanisms involved in public policymaking and the implementation of policy decisions with public participation. It is

associated with theories and problems of social coordination and the establishment of its rules. These theories abandon the previous emphasis on the importance of the hierarchical role of the state and highlight the role of the market and networks (Bevir, 2011). It is based on the relationship with citizens and other relevant stakeholders that can influence public policy or are influenced by public policy. This relationship operates within a framework of legitimately established rules that are effectively realized when government policies reflect the social, political, and economic values of these actors (Klimovský, 2014; Musso, 2014).

Openness of the government is integrated into the principles of transparency, accountability, and participation into the management of public administration and public policy decision-making. Implementing open governance practices requires educating public administration employees and developing their skills. However, this is only possible when educational opportunities adequately meet demand. The situation becomes more challenging in the absence of a strategic approach to public administration employee education, as seen in the Slovak Republic. Although the concept of open governance is relatively broadly accepted in management of public administration in the Slovak Republic, it differs significantly in the theory and real implementation. This is largely due to limited knowledge of open governance principles and an insufficient educational system for public administration employees. This gap can be partially covered by study programs oriented towards the public administration which incorporate also the issue of open governance in public sector and should be based on the newest research outputs. These study programs provided by universities or non-profit organizations can help to educate the potential future employees with relevant theoretical knowledge in new trends in public administration.

In the paper we aim to examine the current state of education in open governance in the Slovak Republic, as offered by universities and non-profit organisations, and identify its strengths and weaknesses in the current study offer. The presented research results can be seen as a starting point for the further development of study programs. From this point of view, the paper presents unique research results based on the pilot research among these institutions in cooperation with the Plenipotentiary of the Government of the Slovak Republic for the Development of Civil Society.

The paper is divided into three main chapters. The first chapter presents the theoretical review on open governance. The second chapter explains the methodology used in the research. Subsequently, the research findings about the offer of study programs in open governance are presented. In conclusion, we summarize the research results in a form of SWOT analysis based on the critical analysis of the research results and identify the recommendation how to develop the education in open governance in Slovakia.

Literature review

The concept of public governance reflects a growing emphasis on involving diverse stakeholders in public policy, guided by participatory principles (see Kickert et al., 1997; Pierre, 1998; Piore & Peters, 2000; Rhodes, 2000; Bevir et al., 2003; Bevir, 2011; Berry et al., 2004).

Participatory democracy has emerged as a driving force for the implementation of smart initiatives, as community engagement—including businesses, citizens, and non-profit organizations—is essential for their development. Such participation plays a crucial role in implementing smart activities, delivering public services, and contributing to economic and

developmental projects (Borseková et al., 2017). Smart government implements smart transformation with the active integration of various stakeholders in public policy decision-making processes via traditional and modern tools with support of IT technologies and reflecting the insights from behavioural economics and evidence-based policy (Meijer et al., 2019).

Contemporary technological advancements substantially lower the transaction costs associated with stakeholder collaboration, thereby facilitating innovative models of cooperation commonly referred to as "open governance." Open government strategies and initiatives are grounded in the principles of transparency, integrity, accountability, and stakeholder participation (OECD, 2017). Openness is reflected in the extent to which citizens can monitor and influence governmental processes through access to information and participation in decision-making arenas (Meijer et al., 2012).

Open governance represents emerging models of collective engagement designed to tackle complex public policy challenges, enhance societal knowledge, and reform conventional public service delivery. These innovative, collaborative frameworks integrate a diverse network of digitally interconnected stakeholders, reshaping the government's role to be less conspicuous yet more flexible and responsive. Governments embracing open governance principles become more accessible, responsive, and accountable to citizens, fostering stronger relationships and delivering numerous benefits to all participants.

The main features of open governance (Meijer et al., 2019) include radical openness, which encompasses open data, interactive communication with citizens, and a culture of transparency (Noveck, 2015; Pyrozhenko, 2017). It emphasizes citizen orientation through various forms of citizen-to-citizen (C2C) facilitation, unofficial democratic practices, and citizen science initiatives (Bason, 2017). Another key aspect is connected intelligence, characterized by decentralized decision-making, the absence of traditional leadership structures, and the utilization of big data. Digital altruism is a crucial factor in the co-creation of public value, the development of shared public resources, and the establishment of data-sharing communities. Additionally, crowdsourced deliberation plays a fundamental role in fostering inclusive, equitable, and participatory decision-making processes. Enabled by advanced technologies, these open and asynchronous discussions enhance collective engagement and democratic discourse. The open governance paradigm addresses how stakeholder cooperation dynamics have evolved, placing a strong emphasis on citizens and emerging forms of collaboration such as citizen science, large-scale co-production, and crowdsource deliberation, all driven by advancements in information technology.

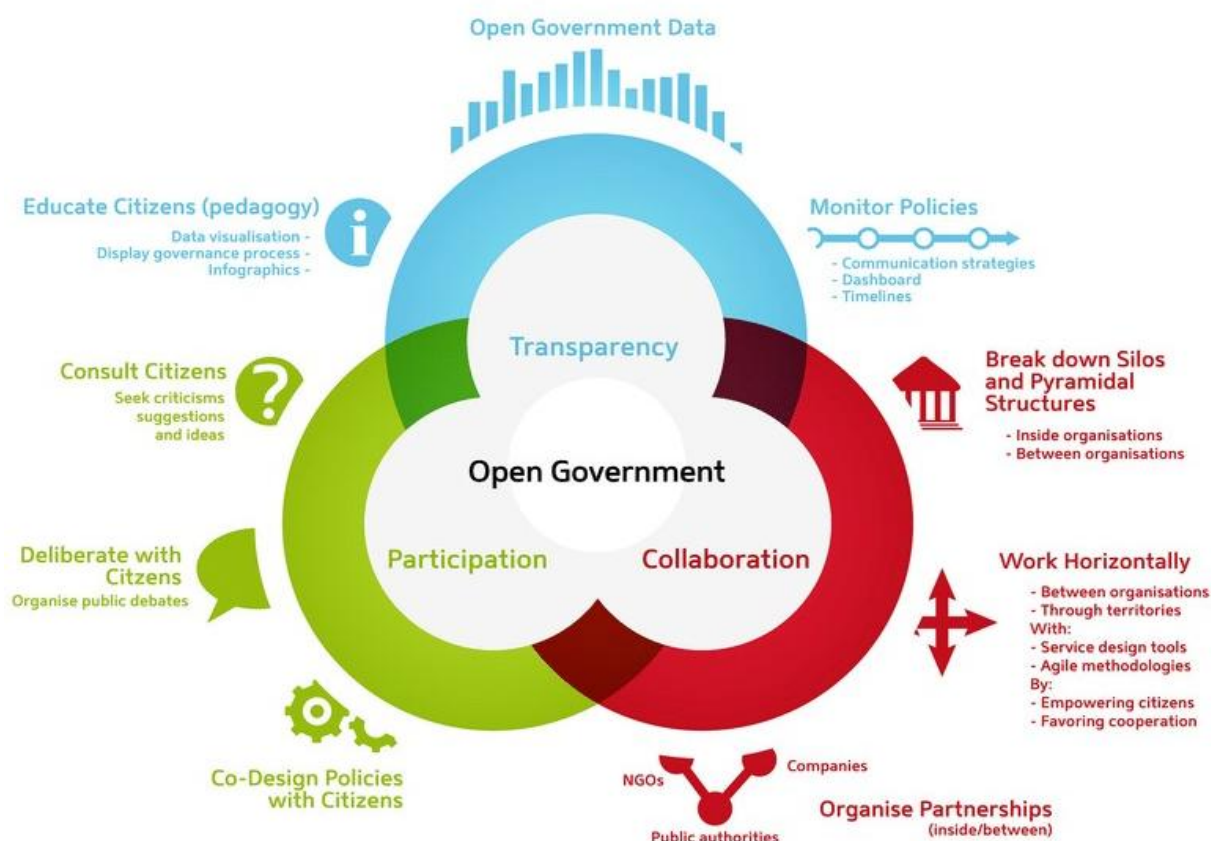
In public policy, the open governance approach fosters increased trust in institutions, though not without challenges (Kim & Lee, 2012; Parent et al., 2005; Tolbert & Mossberger, 2006; Warren et al. 2014; Kumagai & Iorio, 2020). By empowering citizens, it aims to make governing structures more democratic and inclusive (Poisson, 2021).

According to Millard (2016), the open governance framework is composed of three fundamental components: open data, open services, and open processes. Open data represents critical public sector assets that facilitate collaboration, co-creation, and informed policymaking. These data resources are essential for enabling transparent and participatory governance. Open services are characterized by highly personalized approaches that integrate behavioral insights and design thinking throughout each stage of service delivery. This approach ensures user-centricity and adaptability in public service production.

Open processes emphasize the active participation of all legitimate stakeholders in policy development, decision-making, and public sector arrangements, thereby contributing to the enhancement of public value. In this framework, the government functions as a platform for fostering innovation, supporting societal development, and addressing pressing societal challenges. The role of information and communication technologies (ICTs) is viewed expansively, serving as a pivotal enabler for the public sector to operate more innovatively and responsively within the scope of its mandate and resources, ultimately better meeting societal needs.

Even all international recognized organizations (e. g. OECD, UNESCO, World Bank) declare the strong support of implementation of open governance principles, the Open Government Partnership (OGP) has played a key role in shaping countries' open government agendas. (OECD, 2023). "The international initiative Partnership for Open Governance is a multilateral association whose goal is to ensure the transparency of governance, strengthen the involvement of citizens in public affairs, fight against corruption and support the use of new technologies in public governance. The basic principle that the initiative emphasizes is the cooperation of a larger number of stakeholders. The initiative was created by the signing of a public governance declaration by the eight founding members (Brazil, Indonesia, Mexico, Norway, the Philippines, South Africa, Great Britain and the United States of America) in Brazil in April 2011, who at the same time presented and declared the implementation of national open governance action plans in their countries. Since 2011, 76 national governments have joined the declaration, more than 100 local government and thousands of civil society organizations" (Open Government Partnership, 2023). The fundamental principles to which member countries commit upon joining the initiative in the realm of public policy and governance include transparency, citizen participation, accountability, and openness through the use of modern technologies. In practical terms, this commitment primarily entails ensuring public access to administrative data and information on government activities, fostering stakeholder engagement in addressing public policy issues, establishing and adhering to regulations that promote responsible governance, and guaranteeing free access to technologies and data through an open data system. The key pillars of open government, as defined by the Open Government Partnership (OGP), along with their interconnections, are illustrated in Figure 1.

Figure 1: Open government pillars



Source: OGP, 2022

The practical implementation of open governance principles necessitates the engagement of skilled and competent public sector employees. Given the rapid evolution of new technologies, which are increasingly integrated into participatory and co-production tools, continuous education and training should be prioritized by public administration management.

Education constitutes a critical element of organizational personnel management, shaping and preparing employees who are responsible for delivering public services. The ongoing professional development of both employees and elected representatives is essential for the effective adoption and application of open governance practices. Employees not only serve as agents driving and facilitating transformations within the public sector but also function as subjects directly influenced by these changes (Vaňová, 2006).

Methodology

The paper aims to map the current state of art in education of open governance issue in the Slovak Republic within the study programs delivered by the universities and non-profit organizations. Based on the analysis the strengths and weaknesses of the current study offer are identified and the recommendations on its further development are proposed.

The main sources of the secondary data belong monographs, studies or programs issues of open governance processed by method of abstraction. The secondary data were used in definition of

the theoretical framework as well as in designing of questionnaire used in the primary research. The survey consists of 10 questions (open, closed or semi-closed) and identification questions. Data collection was conducted from 31.5.2023 to 20.6.2023 electronically via Qualtrics Survey and shared via email.

The respondents consisted of representatives of NGOs and universities in the Slovak Republic, represented by 19 respondents. Due to the inability to estimate the size of the target group because of imperfect information about the subjects, we cannot say whether the sample is representative. But we use the database of universities delivering the study programs in the public administration in Slovak Republic (13 universities) as well as the database of non-profit and public organizations delivering the education in various topics of public administration management with the Plenipotentiary of the Government of the Slovak Republic for the Development of Civil Society. From this reason, the research is unique. It is the first of its kind and has not yet been conducted in conditions of Slovak Republic.

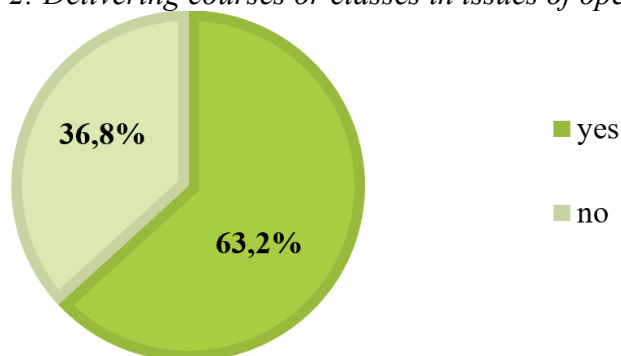
To process the data collected, we used fundamental mathematical and statistical methods. For testing and data analysis we used the Microsoft Excel application. Based on the evaluation of the research results as well as regarding our previous research on quality of public administration education in Slovakia (Vitálišová et al., 2019; Nemec et al., 2021) we transformed the research findings into the SWOT analysis, which identifies the strengths, weaknesses, opportunities and threats for the further development of study programs in issues of open governance.

Research results and discussions

The research results on the current state of open governance education in the Slovak Republic, within study programs and courses offered by universities and nonprofit organizations are based on the findings of our questionnaire survey. These results provide insight into the present landscape of open governance education in the country. We will present them by individual questions in the survey.

The first question was whether the institution/organization provides education in issues of open governance. Issues of open governance include the following: participation in public policy making, participation in the legislative process, participatory processes, civic participation, digital tools for participation, networking of collaborating actors, access to and publication of information. It also contains open data, methods and techniques for building public awareness of open government, building trust, transparency of processes, communication, co-creation of public services, integrity and ethics in public administration, monitoring and evaluation of public policies, open government (in general). We found that 63,2% of the NGOs and universities that participated in this research provide this education, see Figure 2.

Figure 2: Delivering courses or classes in issues of open governance

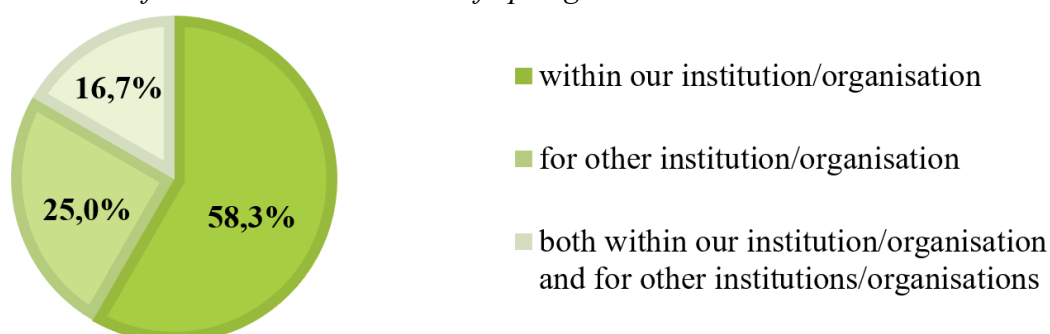


Source: own elaboration

The reasons why 36,8% of the institutions or organizations that participated in this research do not provide education in issues of open governance were mainly: they do not have the capacity to create new courses; they do not have the finances to do so, or it is a time and capacity consuming to obtain these finances; it is not their focus or a part of their agenda.

In the context of provider, we found that most of these education courses in the environment of NGOs and universities are provided within the institution or organization (58,3%), followed by providing it for other institutions (25%), as you can see in Figure 3.

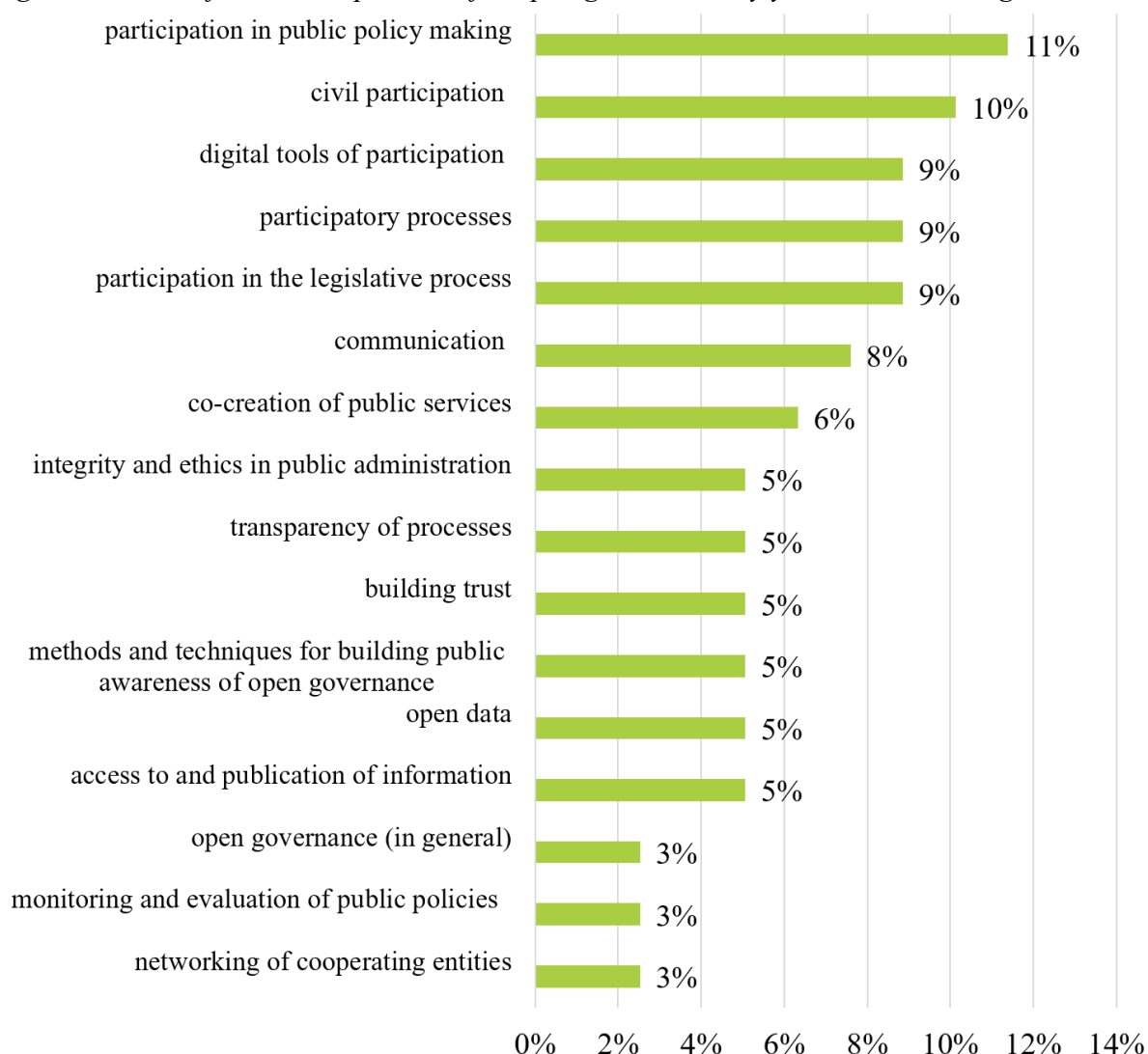
Figure 3: Provider of the education in issues of open governance



Source: own elaboration

Subsequently, we research what are the priorities in education of open governance. The respondents focus mainly on participation in public policy making (11%), civic participation (10%), digital tools of participation, participatory processes and participation in the legislative process (9%). Other less frequently indicated areas of education by the NGOs and universities can be seen in figure 4.

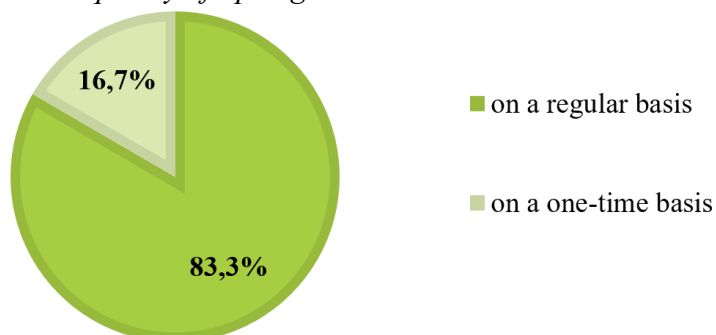
Figure 4: Areas of education provided for open governance by your institution/organization



Source: own elaboration

In terms of the frequency of providing education in issues of open governance by institutions/organizations, we found that there are 83,3% of those that educate regularly and 16,7% of those that educate on a one-time basis in the environment of NGOs and universities, see Figure 5.

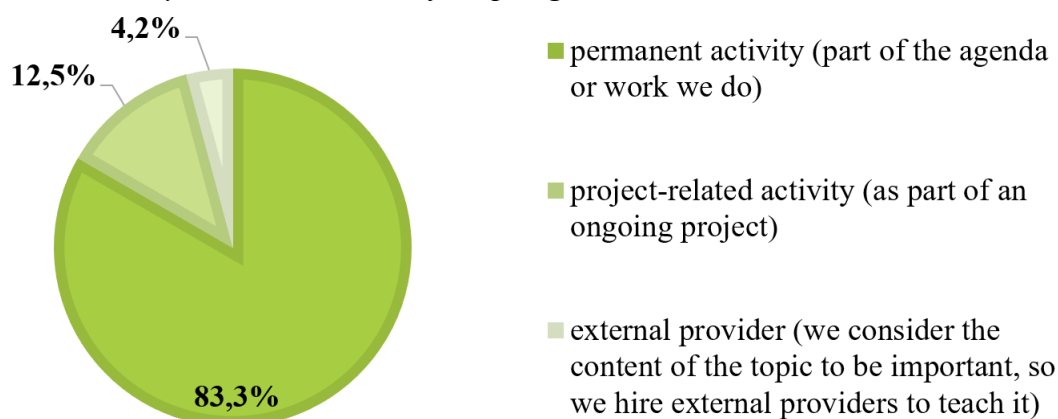
Figure 5: Frequency of open governance courses



Source: own elaboration

Next question was oriented on why how the education courses are delivered. The most frequently chosen option was that the education courses are permanent activity (83,3%) of the NGOs and universities, as a part of the agenda or work that they do, the second most frequent option was project-related activity (12,5%), and the least frequent option, indicated by 4,2% of respondents, was external provider, see *Figure 6*.

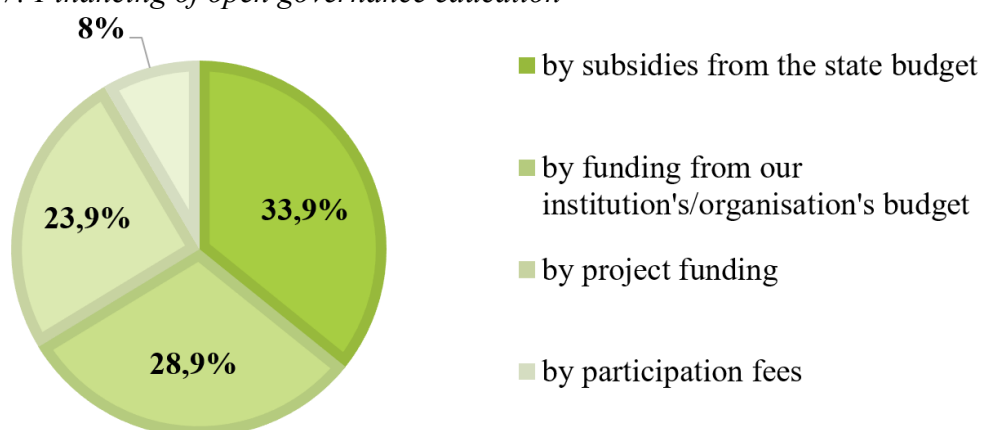
Figure 6: The way how the education for open governance is delivered



Source: own elaboration

As a part of the research, we also asked respondents about the method of financing education to employees or students provided by NGOs and universities. We found that most often, and in 33,9% of cases, this education is funded by subsidies from the state budget, as you can see in *Figure 7*. This is followed by funding from our institution's/organization's budget (28,9%) and by project funding (23,9%). The least indicated ways of funding education were by funding from an external institution/organization (3,9%) and by funding from sponsors (1,3%).

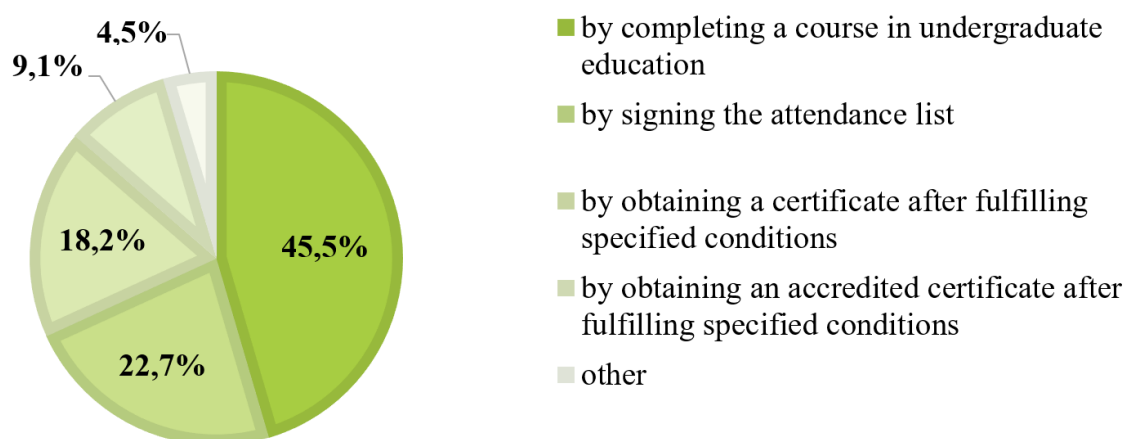
Figure 7: Financing of open governance education



Source: own elaboration

In terms of completing education, we found that the most common way of completing this education in open governance delivered by NGOs and universities is by completing a course in undergraduate education (45,5%), which is applicable to institutions such as universities. 22,7% of respondents become graduates of education by signing the attendance list and 18,2% of respondents by obtaining a certificate after fulfilling specified conditions, as you can see in *Figure 8*. Under the option “other”, which was chosen by 4,5% of the respondents, the respondents indicated a combination of signing the attendance list and completing e-learning.

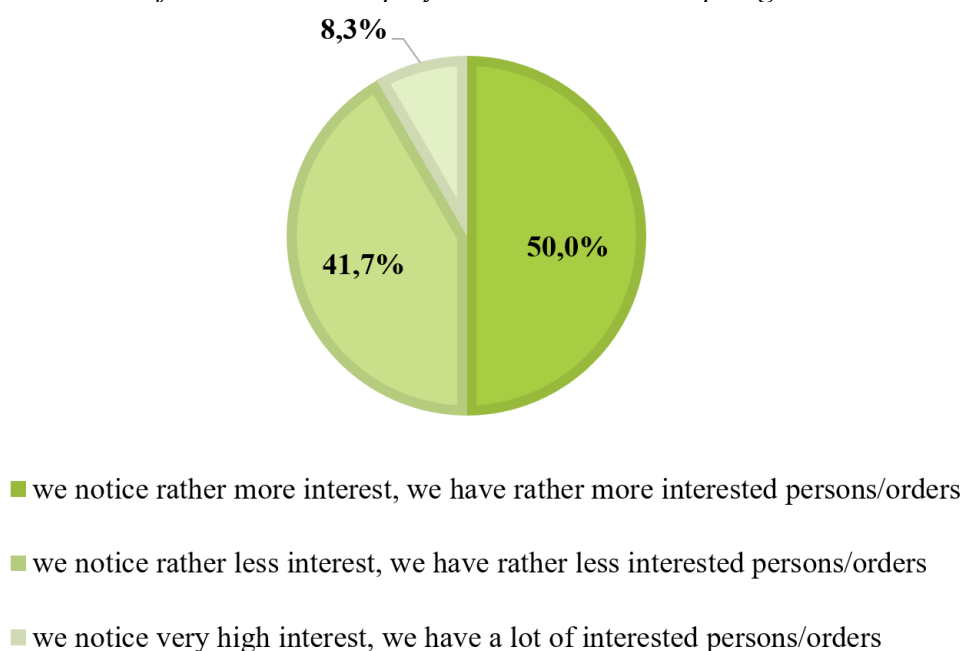
Figure 8: Completing the open governance education



Source: own elaboration

In the penultimate question of the survey, we explore the interest of employees or students in education in issues of open governance. As you can see in *Figure 9*, 50% of respondents indicated rather more interest, but 41,7% indicated rather less interest. Very much interest in this education was indicated by 8,3% of respondents.

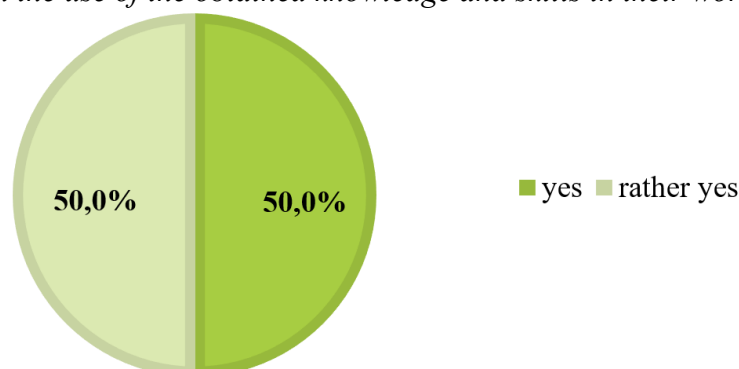
Figure 9: Interest of students and employees in education in open governance issues



Source: own elaboration

The last question explores the opinion of respondents if there is an impact of open governance education on the work performance of educated employees or abilities and skills of students. 50% of the respondents indicated the option yes and equally 50% of the respondents indicated rather yes, see *Figure 10*.

Figure 10: Impact of open governance education on the performance of employees/students and on the use of the obtained knowledge and skills in their work



Source: own elaboration

The research findings on the state of education in open governance within the Slovak Republic provide significant insights into the current offerings by universities and non-profit organizations, as well as the challenges and opportunities in this domain. The survey results indicate that 63.2% of universities and non-profit organizations provide education related to open governance. This demonstrates a considerable level of engagement in the field but also highlights that over one-third of institutions do not offer such education. The primary reasons cited for the lack of provision include limited financial and human resources, as well as the misalignment of open governance with institutional priorities. These findings align with prior studies on the barriers to integrating modern governance principles into public administration curricula (Meijer et al., 2019; OECD, 2017).

The survey revealed that most educational initiatives in open governance focus on public policy participation (11%), civic engagement (10%), and digital tools of participation (9%). However, there is a notable gap in areas such as ethical considerations, transparency, open data, and methods for monitoring and evaluation. This suggests that while existing programs successfully introduce fundamental participatory governance concepts, they may not sufficiently equip students and employees with practical skills necessary for implementation. Especially in the areas which are very fast moving forward (open data and their visualisation) and in monitoring and evaluation which are inevitable for the further progress in public administration. It is a contradiction to the recommended comprehensive and complex approach to this topic (Kim & Lee, 2012; Poisson, 2021).

The research results showed that open governance education is predominantly provided as a permanent activity (83.3%) within organizations, rather than as project-based training (12.5%). This finding implies that institutions recognize the long-term significance of governance education. However, the predominance of state funding (33.9%) and internal institutional funding (28.9%) indicates a dependency on public financial support, which may limit the sustainability of these programs.

By the research results, there is an interest in open governance education among students and employees. Furthermore, the study found that 50% of respondents believe education in open governance positively impacts work performance, while the remaining half view the impact as moderate. These findings emphasize the need for stronger linkages between theoretical education and practical applications in governance (Berry et al., 2004; Tolbert & Mossberger, 2006) and fostering these issues in the curricula of the study programmes and courses for the students and employees in public administration.

Based on the presented results, our previous research on quality of public administration education in Slovakia (Vitálišová et al., 2019; Nemec et al., 2021) and scientific discussion of these results with theoretical framework, we have created a SWOT analysis illustrated in Figure 11, where we present the specific strengths, weaknesses, opportunities as well as threats that we have identified.

Figure 11: SWOT analysis of education of open governance in the Slovak Republic delivered by universities and non-profit organizations

Strengths	Weaknesses
- the open governance is a regular part of the course's curricula, as well as a part of education focus of the institutions in survey, - orientation on the participation topics, - courses provided based on cooperation with the external institutions what merge theoretical knowledge with the practice, - interest of employees and students in topics of open governance,	- weak focus on ethical issues, transparency, open data, methods and tools of monitoring and evaluation, - lack of feedback about the placement of graduates in practice or utilization of gain knowledge in job,
Opportunities	Threats
- the existence of The Office of the Plenipotentiary for the Development of the Civil Society and their activities, - the existence of demand from the side of students and employees in public administration, - the existence of supporting projects within the Recovery plan,	- the lack of support/recognition of importance of the study programs/courses oriented on the public administration from the state, - low recognition of the value and need to educate on these topics within the system of education in universities, - low awareness and low promotion of the issue of open governance.

Source: own elaboration

The SWOT analysis highlights as strengths that open governance is frequently integrated into curricula and is a part of focus of education. There's an emphasis on participatory topics, and courses often involve collaboration with external institutions, which combines theoretical knowledge with practical application. Notably, there's a reported interest among employees and students in open governance topics. However, the analysis identifies a weak focus on critical areas of open governance such as ethical issues, transparency, open data, and methods and tools for monitoring and evaluation. Additionally, there's a lack of feedback on graduate placement in relevant jobs or how effectively they use their acquired knowledge.

From the external environment to the opportunities for the further development belong the existence of The Office of the Plenipotentiary for the Development of the Civil Society and its activities in the field of open governance. It also stresses the increasing demand from students and public administration employees for education in this area. Furthermore, the availability of supporting projects within the Recovery Plan is identified as a favourable opportunity. To the obstacles in further development belong the lack of support or recognition from the state for study programs and courses focused on public administration, the low recognition of the value

and need for education on these topics within universities. Finally, there's a threat posed by low awareness and promotion of open governance.

Conclusions

The aim of the paper was to examine the current state of education in open governance in the Slovak Republic, as offered by universities and non-profit organizations, and identify its strengths and weaknesses in the current study offer. The paper presents the original findings of the research realized in cooperation with the Plenipotentiary of the Government of the Slovak Republic for the Development of Civil Society. It provides a unique foundation for understanding the current landscape of open governance education in Slovakia.

The research confirms the gap between theoretical knowledge and real-world governance practices, so the first step in developing this issue should be strengthening collaboration between academic institutions, non-profits, and government bodies. In this context, we recommend strengthening the conceptual strategy of open governance implementation. The state should be the main actor in fostering education in issues of open governance in public administration employees and students (e.g. in explaining why this education is important, how this education should be implemented, publishing various recommendations or publications for this education). The state can be represented in this case by partnership of Ministry of Education of the Slovak Republic and The Office of the Plenipotentiary for the Development of the Civil Society of the Slovak Republic, which educate the stakeholders from the public sector, business, politics and media, as well as the general public, to better understand the need for and importance of civil society as well as importance of open governance, to feel part of it and to communicate with it more intensively. An essential component of this conceptual strategy should include a marketing communication plan aimed at increasing awareness of open governance and highlighting the significance of education in this field. This approach would enhance motivation and, as a result, encourage the planning and implementation of such educational initiatives for employees, university students, and members of non-profit organizations.

The subsequent phase of the strategy should encompass initiatives aimed at enhancing stakeholder networking by establishing a platform that facilitates the alignment of educational demand and supply in the field of public administration, with a particular focus on open governance. This platform would serve as a comprehensive hub, integrating information on educational opportunities for institutions, employees, and students, while also connecting prospective learners with education providers. As it could be seen from SWOT analysis, one of the threats was the lack of recognition of importance of the study programs oriented on the public administration from the state. Our recommendation would reduce this negative aspect as well as low awareness and low promotion of the issue of open governance.

Beyond improving awareness and communication, the platform would play a crucial role in the strategic planning of educational programs, ultimately contributing to a higher number of professionals equipped with expertise in open governance. Additionally, it would foster collaboration among education providers, enabling them to engage practitioners and subject-matter experts as guest lecturers in institutions or organizations through dedicated courses or lecture modules.

Furthermore, the platform could function as a valuable networking tool for scientific and research communities, facilitating connections among academics and citizens interested in open governance education. To enhance its effectiveness, we recommend utilizing open data to collect information for future platform upgrades. This approach would allow for the development of clearer visualizations regarding potential education recipients and providers, enabling a more precise identification of educational needs based on factors such as geographic location, group size, and cost.

Moreover, financial support from the state should be encouraged, particularly through grant schemes that address the emerging demand for open governance education. Such funding mechanisms would not only support the development of new educational initiatives but also strengthen partnerships and networks established through the platform. This measure would reinforce one of the strengths identified in the SWOT, namely demand from students and employees.

Even the research has its limits in the number of respondents (because we do not have the exact list of institution that deliver the education in open governance), as well as the situational aspect that the research characterizes only the situation in time of research conducting, but it can be a good starting point for the further research steps. From the future perspective, the research in this area should be oriented on the long-term impact of open governance education on public administration performance and investigation of best practices in integrating digital tools and participatory mechanisms into curricula. Additionally, comparative studies with other European nations could provide valuable insights into effective models of governance education.

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FINANCE

TRACK 1: Navigating Financial Markets and Monetary Flows

PREFACE

FINANCE – TRACK 1: NAVIGATING FINANCIAL MARKETS AND MONETARY FLOWS

This track delves into the intricate mechanisms and critical forces shaping financial markets and monetary dynamics in modern economies. It explores how global financial conditions, central bank actions, and market interconnectedness influence currency valuations, banking sector stability, and the transmission of risk throughout the economic system. The papers within this section collectively provide an in-depth look at the complex interactions that determine financial stability and efficiency, offering crucial insights for understanding systemic behavior and informing policy decisions in a volatile global landscape. They focus on analyzing the behavior of financial markets and the impact of monetary factors on economic stability and decision-making, thus contributing to achieving the defined aim and scope of the Odyssey conference.

Árokszállási and Kiss assess the robustness of the uncovered interest parity paradox for the Hungarian Forint, revealing the influence of central bank balance sheets and external funding conditions on currency depreciation. Milosheska Gavrovska and Slaveski conduct an empirical study on the drivers of deposit growth in North Macedonia, identifying key bank-specific and macroeconomic factors impacting bank deposits. Primorac and Badovinac examine the long-term relationship between sovereign risk and household borrowing costs in Eurozone countries, highlighting the heterogeneous effects across different economies. Vlah Jerić, Zoričić and Čorak perform a network analysis of CROBEX, offering two snapshots of the market structure during distinct periods and revealing shifts in market integration and interdependence.

THE ROBUSTNESS OF THE UNCOVERED INTEREST PARITY (UIP) PARADOX FOR THE HUNGARIAN FORINT

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Abstract

We assess HUF/EUR rate depreciations after the global financial crisis using a Bayesian Model Averaging model. Uncovered interest parity (UIP) paradox occurs when the currency depreciates under an increasing real interest rate premium. We show that such movements are not only driven by the real UIP but also by the size of the central bank balance sheet and implied volatility on the EUROSTOXX market, which signs a strong exposure towards external funding conditions. We also find evidence that the FX debt of Hungarian companies better partially describes this depreciation. The Hungarian central bank's sole instrument against such depreciation was the structure of its balance sheet. Thus, this paper makes a new contribution to the debate on currency valuation impact on emerging markets while highlighting the importance of the instantaneous nature of the UIP paradox.

Keywords: currency, uncovered interest rate paradox, emerging markets

JEL classification: C33, E44, H63

Introduction

Due to its pivotal role in indirect monetary interventions, the real uncovered interest rate parity (UIP) is one of the most widely used variables in currency pricing (Krugman et al., 2022). However, there are various reasons why applying a standard real UIP model yields misleading results about currency depreciation – with paradoxical implications for emerging open and small economies. The real UIP paradox became widely described by the literature in 2020 (Egilsson, 2020; Hassan & Zhang, 2021), highlighting the fact that increases in real interest spreads have a poor or even adverse effect on the depreciation of an emerging currency, which hinders the efficiency of central banks indirect interventions.

We contribute to the currency valuation literature by implementing one method to identify and select the relevant variables for pricing with a Bayesian Model Averaging (BMA) method, then analyze the chosen set of variables as a main model with a Vector Autoregression (VAR) model. Employing an empirical variable selection approach with BMA allows us to consider variables besides the ones included in the classical international Fisher model. Our analysis focuses on the following key factors: firstly, the assessment of a real UIP paradox; secondly, to evaluate how other variables (like the implementation of central banks' unconventional instruments) and the inflationary spike of the early 2020s affected such valuation process. We base our analysis on monthly data between 2007 and 2024 by focusing on the changes in the Hungarian Forint

against the Euro (HUFEUR) as the first currency is still considered an emerging one (Bubák et al., 2011). Applying BMA in the context of currency valuation is a novel approach and addresses a gap in the current literature.

Our key findings are as follows: First, the real UIP paradox biases the Hungarian Forint, regardless of the econometric method or the sample period. Second, the Hungarian National Bank (MNB) balance sheet changes were relevant, while the European Central Bank (ECB) was proven irrelevant, highlighting some monetary autonomy of the former. However, the currency is highly affected by changes in the European risk sentiment, as the implied volatility on the stock market made the highest contribution to the changes.

Our paper is structured as follows: section two identifies the variables potentially influencing the exchange rate through a literature review. Section three discusses the data used and the BMA and VAR models. Section four explains estimation results in detail, and robustness checks are concluded. The last section concludes the paper.

Theoretical background

Central banks face many challenges in the 21st century as they try to maintain price stability, support economic growth, and preserve financial stability. However, there is a loss of independence and growth of shadow banking as a threat in a complex and uncertain renewing environment. The economic situation in the last decade and the exogenous shocks stacking on each other make it difficult to diagnose the leading causes and find a reliable solution. Central banks have limited room to cut interest rates when the economy is weak because nominal interest rates cannot fall much below zero. This constraint reduces the effectiveness of conventional monetary policy and forces central banks to rely on unconventional tools, such as quantitative easing and forward guidance, which are less well-understood and more controversial (Brunnermeier, 2023). Monetary interventions are typically used to smooth exchange rate fluctuations, prevent currency misalignments, or defend a fixed exchange rate regime. The effectiveness of these interventions depends on various factors, including the intervention's size, timing, and communication, as well as market expectations and the monetary policy stance of the central bank (Bindseil & Fotia, 2021).

For this research, the most important is how central banks use various tools to stabilize the foreign exchange (FX) rate. It is described by Lafarguette & Veyrune (2021), that one of the key tools is foreign exchange interventions. This involves the buying or selling foreign currencies to influence the supply and demand dynamics. Such a procedure is designed to preserve financial stability in floating exchange rate arrangements by addressing market failures, such as the absence of a hedging solution for tail exchange rate risk in the market (i.e., high volatility). This can be done in a sterilized way, which means offsetting the impact on the domestic money supply, or in an unsterilized way, which means changing the domestic money supply (Gopinath, 2023).

Central banks can adjust the policy interest rate or the money supply to influence the exchange rate. A higher interest rate or a lower money supply can appreciate the domestic currency by attracting capital inflows or reducing capital outflows. The monetary policies of central banks can be divided into two major parts: the Conventional Monetary policies and the Unconventional Monetary policies. The main instrument of the former is to set the short-term key policy interest rate, to achieve its economic objectives (namely maintaining price stability).

The key policy interest rate influences other interest rates in the economy through the different channels of the transmission mechanism, by affecting the cost of borrowing and saving.

Conventional policy instruments are no longer effective in stimulating economic activity during deflation periods when interest rates are near zero. The unconventional instruments include open market operations, standing facilities, and minimum reserves. Open market operations involve buying or selling securities in the market to affect the money supply and interest rates. Standing facilities allow banks to borrow or deposit money with the central bank at predetermined rates. Minimum reserves require banks to hold a certain amount of money with the central bank. These include quantitative easing (QE), where the central bank purchases securities in the market outside of government bonds. QE can lower long-term interest rates to stimulate economic growth and inflation. Other tools include forward guidance, where the central bank communicates its future policy intentions, and negative interest rates, where the central bank charges banks for holding excess reserves. They can impose restrictions on cross-border capital movements to stabilize the exchange rate. This can reduce the volatility of capital flows and limit the exposure to external shocks. (Kiss & Balog, 2018).

The central bank can choose an appropriate exchange rate regime to suit its objectives and circumstances. This can range from a fixed exchange rate, which means pegging the domestic currency to a foreign currency or a basket of currencies, to a floating exchange rate, which means letting the market determine the exchange rate. Furthermore, central banks face trade-offs between inflation management and financial stability. Interest rate hikes to fight inflation could destabilize financial markets or increase financial vulnerabilities. Therefore, central banks need to balance these objectives and risks, coordinate with other regulators and policymakers, and decide how to use their lender-of-last-resort function in a crisis (Krugman et al., 2022).

Central banks have to take into account the global context of their policies, as their actions can have significant spillover effects on other countries through interest rate differentials, capital flows, trade linkages, and exchange rate movements. Central banks have to deal with the challenges posed by the dollar's dominance as the world's reserve currency, the divergences in monetary policies among major economies, and the potential conflicts or cooperation among central banks in a crisis – to obtain foreign exchange liquidity for their banking system through swap lines (Kiss et al., 2020).

Central banks must be institutionally independent with full responsibility and accountability to maintain price stability. However, the rise of authoritarianism as a challenge to liberal democracies has put a lot of pressure on the affected central banks. The interference of politics in appointments and even removals of monetary council members can undermine their credibility.

As a member of the European Union, Hungary is obliged to adopt the euro as its currency upon meeting the convergence criteria. However, as of 2023, there is no target date for this transition, and the Hungarian forint is not part of the European Exchange Rate Mechanism (ERM II). Its +/- 15% fluctuation band was abandoned in early 2008. Hungary has been compliant with most of the crucial technical and Maastricht convergence criteria, including those concerning the inflation rate, budget deficit, long-term interest rates, and debt management before the Covid-19 pandemic. However, it still fails to meet the exchange rate stability requirement.

Euro adoption eliminates foreign exchange exposure from most foreign trade and external debt and provides additional institutional support (Sági & Ferkelt, 2020). On the one hand, the European Semester increases the fiscal credibility of the Member States, while the financial contingency funds (like the ESM and the Banking Union's Resolution Fund) can also reinforce resilience. Interest rate pass-through between the ECB and the Member States bank loans can be lowered by cross-country heterogeneity with a fragmented market as a result (Horvath et al., 2018). The Banking Union aims to ensure that the banking sector in the euro area and the wider EU is stable, safe, and reliable, thus contributing to financial stability. Supervision of the most significant cross-border banks promotes macro-prudence, and the Resolution Fund can be available for bank consolidation, and it can be extended with deposit insurance in the future (Mérő, 2017).

Since Hungary is highly exposed to foreign funding and had to be regularly supported by the IMF during global liquidity dry-ups (1982-1998, 2008-2013), the ESM's guarantee can be a powerful tool to cut sovereign spread. In conclusion, while Hungary's potential membership in the eurozone could bring about economic stability and increased foreign investment, it also requires serious economic measures and a commitment to deeper integration within the EU.

Empirical strategy

The standard international Fisher-rule model might not be sufficient to approximate the actual HUREUR valuation ($S_{t,i}$), due to the real UIP paradox, as the real interest spreads and the currency changes in the opposite direction. Therefore, this section will define the set of possible variables which could influence the currency changes, namely: nominal interest rates ($r_{t,i}$), inflation ($\pi_{t,i}$), central bank balance sheet structure ($\frac{L+S}{FX}_{t,i}$), unemployment ($Unem_{t,i}$), currency base swap ($CBS_{t,i-USD}$) and come global capital market indicators.

Real uncovered interest rate parity (UIP) and eurolization

Real uncovered interest rate parity (UIP) (1) suggests that the foreign exchange rate changes follow the purchasing power parity ($\pi_{t,i} - \pi_{t,EUR}$) and the uncovered interest rate parity (UIP) ($r_{t,i} - r_{t,EUR}$). The importance of inflation is underlined by the inflation-targeting monetary regime, which is followed by the sample EU Member States; therefore, funding conditions in the medium run must reflect on the changes of inflation, which can motivate cross-border capital flows and, therefore, trigger currency changes as well.

$$\Delta S_{t,i} = \alpha_1 \Delta((r_{t,i} - \pi_{t,i}) - (r_{t,EUR} - \pi_{t,EUR})) \quad (1)$$

Meanwhile, the UIP paradox means emerging currencies can even depreciate despite providing a premium. As Egilsson's (2020) cost-push effects suggest, a large interest rate differential is a common forerunner to depreciations, similar to Hassan & Zhang (2021), who suggested that different capital-to-output ratios cause violation of UIP, inefficiency of capital allocations, foreign currency borrowings ($FX\_debt_{t,HU} = \frac{FX \text{ denominated debt}_t}{HUF \text{ denominated debt}_t}$) and current account deficits. As in Hungary it is only legal to allocate FX denominated loans to companies, this study used only corporate FX debt. In the combined case of an emerging, small, and open economy, even a floating regime must be managed within a dirty floating regime – while the central bank must also consider the UIP paradox. Evenngary moved away a lot from FX-

denominated external funding of its public debt during most of the 2010s, as an open and small economy, its external debt is still relevant (Tóth, 2024).

$$\Delta S_{t,i} = \alpha_1 \Delta(r_{t,i} - \pi_{t,i}) - (r_{t,EUR} - \pi_{t,EUR}) + \alpha_2 \Delta(FX\_debt_{t,i}) \quad (2)$$

Unconventional monetary policy

First, central banks were using their balance sheets much more actively in the second half of the 2010s (especially after the ECB introduced its quantitative easing monetary policy in 2014), meaning that we should not just consider the sovereign premium, but the ratio of the lending (L) and securities (S) in the central bank's balance sheet to their foreign exchange reserve (FX) ratio as well, to highlight their relative conservatism in funding (2). This is also necessary since most of the accumulated securities are government bonds from the secondary market, which indirectly impacts the sovereign spread as well (Kiss & Balog, 2018).

$$\Delta S_{t,i} = \alpha_3 \Delta\left(\frac{L+S}{FX}_{t,i}\right) + \alpha_4 \Delta(S_{t,i} + L_{t,i} + FX_{t,i}) \quad (3)$$

Central banks in the European Union must follow an inflation-targeting system. However, for an open and small economy, inflation can be affected more by the exchange rate pass-through rate – even if it seems weaker than during the 1980s (Frankel, 2011). The other problem of open and small economies is their limited monetary autonomy; therefore, it is harder for the monetary policy to focus on inflation since they are more exposed to global liquidity changes or the monetary policy of key central banks (the ECB in our case) (Landau, 2011). Small and open economies can be in the “fear of floating” stage, meaning the interest rate policy is set by indirect foreign exchange interventions to smooth exchange rate fluctuation regardless of the de jure floating status (Calvo–Reinhart 2002; Mackiewicz-Lyziak, 2016).

Flight to safety

In case of a severe negative economic shock (or an insufficient amount of risk-free assets), the demand for high-quality assets increases (Horváth & Szini, 2015). Such portfolio rebalancing effect can appear when investors' expectations are drastically changing, and they are selling their high-risk (or high-beta) assets and buying low-risk (low-beta) assets, even closing their positions in carry trade currencies in favor of safe haven currencies (Lyócsa et al., 2019). The implied volatility of the Eurostoxx index ($Vol_{t,i}$) can represent the presence of systemic risks and portfolio rebalancing sentiments on the European markets. Gold purchases ($XAU_{t,EUR}$) represent another indicator of the flight to safety; the Brent crude oil spot price (Oil_t) is assumed to be a good indicator for economic shocks and a benchmark for expectations about global economic growth.

$$\Delta S_{t,i} = \alpha_5 \Delta(Vol_{t,Eurostoxx}) + \alpha_6 \Delta(XAU_{t,EUR}) + \alpha_7 \Delta(Oil_t) \quad (4)$$

Macroeconomic growth

Since this study focuses on the usage of monthly data, Balance of Payments statistics could not be tested as they are available quarterly. However, the changing level of unemployment can be a good indicator of changing expectations about the economic output while it covers all economic sectors (Bošnjak, 2021).

$$\Delta S_{t,i} = \alpha_8 \Delta(Unem_{t,HU}) + \alpha_9 \Delta(Unem_{t,EZ}) \quad (5)$$

USD liquidity scarcity

Currency basis swaps ($CBS_{t,i-USD}$), especially the 1-year EUR-USD basis swap, are a good indicator of the international US liquidity scarcity as it is negative. Since the implementation of US swap lines among the key central banks in December 2007, this indicator has rarely been positive (Kiss et al., 2020). A similar HUF-USD indicator was also added to the analysis.

$$\Delta S_{t,i} = \alpha_{10} \Delta(CBS_{t,EUR-USD}) + \alpha_{11} \Delta(CBS_{t,HUF-USD}) \quad (6)$$

Data and methods

The paper applied a two-step method to identify and assess the main model's variables. First, a pairwise BMA model was estimated on every subset of the macroeconomic, funding, and liquidity environments to identify the variables with the most contribution to the changes of the currency. Then, once all the relevant variables were selected based on their high PIP values, the main model was formed and tested again with a BMA estimation. Once the model was validated, a VAR model was estimated on a reduced (2007-2019) sample and on the entire sample.

Data

In this section, we introduce the variables from the main model after they were selected using the BMA method. All the names, their shortened signs in the tables and graphs, as well as their sources, are presented in Table 1. As the basic statistics in Appendix 1 suggested, all the input variables in the main model had no unit root at their first differences, and their cross-correlations were lower than 0.6 to avoid any bias from multicollinearity.

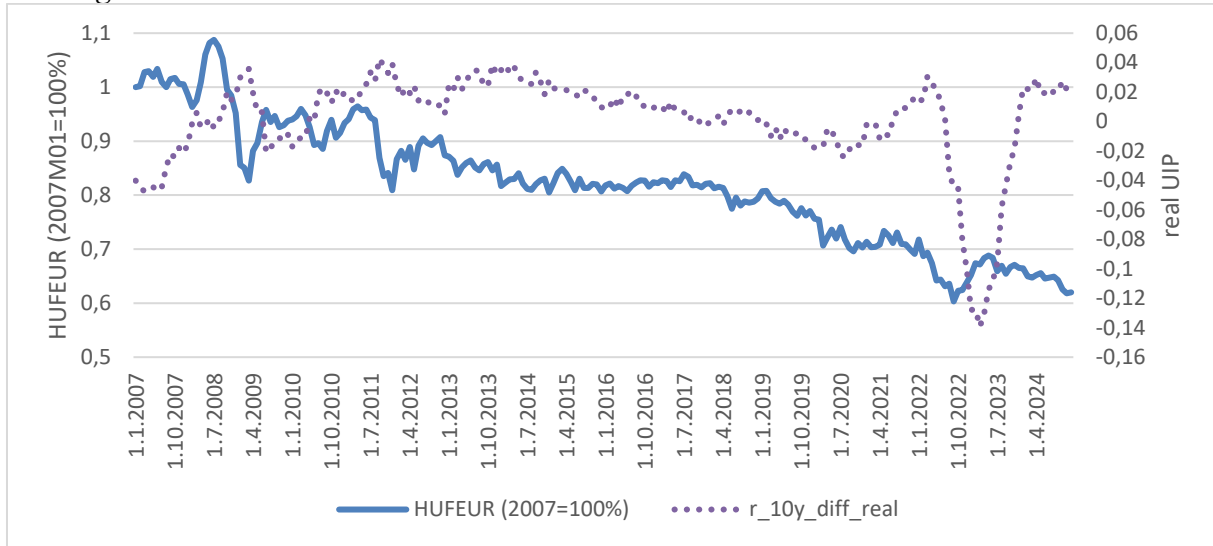
Table 1: Source of data for the variables

group	Name	sign	Source
currency	HUF-EUR exchange rate	HUREUR	Refinitiv Eikon
Eurolisation	Foreign exchange debt ratio	FX debt ratio	MNB
	Foreign asset ratio	Foreign asset ratio	MNB
UIP	The real sovereign spread between 10Y yields	r_10y_diff_real	Refinitiv Eikon
	The real sovereign spread between 3M yields	r_3M_diff_real	Refinitiv Eikon
CB balance sheet	Loans and Securities to foreign exchange reserve ratio at the MNB	LSFX_MNB	MNB
	Total Assets of the MNB	TA_MNB	MNB
	Total Assets of the ECB	TA_ECB	ECB
	Loans and Securities to foreign exchange reserve ratio at the ECB	LSFX_ECB	ECB
Macroeconomy	Unemployment in Hungary	Unemp_HU	Eurostat
	Unemployment in the Eurozone	Unemp_EZ	Eurostat
Liquidity	EUR-USD currency base swap 1Y	EURUSDCBS1Y	Refinitiv Eikon
	HUF-USD currency base swap 1Y	HUFUSDCBS1Y	Refinitiv Eikon
External	Implied volatility of the Euro Stoxx index	Volatility_Eurostoxx	Refinitiv Eikon
	Brent crude oil spot price in EUR	Brent	Refinitiv Eikon
	Gold price in EUR	XAUEUR	Refinitiv Eikon

Source: Authors' collection

Figure 1 focuses on the clear presence of the real UIP paradox: whenever there was a sudden depreciation, the real 10Y sovereign spread increased a lot, while it became more relaxed or even negative during calmer periods when the Hungarian Forint was not the subject of depreciation pressure.

Figure 1: The relationship between the real 10Y sovereign spread (UIP) and the HUF EUR exchange rate



Source: Authors' edition

Methods

Bayesian Model Averaging (BMA)

In this section, we briefly summarize the methodology of Bayesian model averaging (BMA), following Gross & Zahner (2021), to account for our model uncertainty problem in currency pricing and to assess and evaluate every feasible model combination from our predefined dataset. First, we specify the foreign exchange rate as the dependent variable y . Then, we choose a set of independent variables in each group (Z), which can potentially influence y . The BMA estimation will evaluate all possible $j = \{1, \dots, 2^k\}$ linear combinations of the regressors via Bayesian techniques to compute the vector of average coefficient ($\hat{\beta}_{BMA}$) from the posterior probabilities ($\hat{\beta}^j$), weighted by the posterior model probability (w): $\hat{\beta}_{BMA} = \sum_{j=1}^{2^k} \hat{\beta}^j w^j$. With the observed model space M_j and coefficients β_j , by applying Bayes rule, the posterior probability will be:

$$p(y, M_j) = \frac{p(\beta_j, M_j)p(M_j)}{p(M_j)} \quad (7)$$

Then, by aggregating the posterior distributions over the whole model space using an aggregation weight (w^j), a weighted average of all individual posterior probabilities is computed to obtain one full posterior distribution: $p(y) = \sum_{j=1}^{2^k} p(y, M_j)p(y)$, which allows us to analyze coefficients across all the models. Finally, to identify the relevant variables, we analyze the posterior inclusion probability (PIP) and rank the most relevant (PIP>0.15)

regressors based on their fit: $PIP_h = p(y) = \sum_{\beta_h \neq 0} p(y)$. The prior parameter is a fixed value $g = \max(n, p^2)$, which will be in our main model's case $g = 214$.

Vector Autoregression (VAR)

The vector autoregressive (VAR) model is a statistical model that captures the linear relationship between multiple time series variables. Each variable is modeled as a function of its own past values and the past values of the other variables in the system.

The structural version (8) of the reduced VAR form includes a time lag 'p' and three variables with structural coefficients 'A' and 'A^S', is essential for our analysis (Lütkepohl, 2006).

$$A y_t = A_1^S y_{t-1} + \dots + A_p^S y_{t-p} + B u_t, \text{ where } \varepsilon_t = A^{-1} B u_t \text{ and } S = A^{-1} B \quad (8)$$

where y_t is a k-dimensional vector of endogenous variables at time t, A_i are k-by-k matrices of coefficients, and ε_t is a k-dimensional vector of error terms. The error terms are assumed to have zero mean, constant variance, and no serial correlation.

It's possible to consider several parameter restrictions. For instance, Cholesky's method allows for the application of short-term restrictions to delineate the order of shocks. The identification matrix rates (see Table 2) the implied volatility of the Eurostoxx index as the most influential variable, as its shocks will affect all the other variables. The ratio of FX-denominated corporate debt to HUF-denominated corporate debt (FX_DEBT_RATIO) highlighted the eurolisation of the non-financial lending market, which can reduce transmission efficiency. The total assets (TA) and the balance sheet structure (LSFX ratio) of the central bank reflect the usage of unconventional instruments and the potential changes in the foreign exchange reserve (direct intervention). The long-term real sovereign spread (R_10Y_DIFF_REAL) or real UIP should capture the presence of indirect interventions. Finally, the foreign exchange rate, which has been floating since 2008, affects both the domestic inflation environment and the value of foreign exchange-denominated loans.

Table 2: Our identification matrix for the main model

	VOL.	FX_DEBT_RATIO	TA_MNB	LSFX_MNB	R_10Y_DIF F_REAL	HUFEUR
Volatility Eurostoxx	β_{11}	0	0	0	0	0
FX_DEBT_RATIO	β_{12}	β_{22}	0	0	0	0
TA_MNB	β_{13}	β_{23}	β_{33}	0	0	0
LSFX_MNB	β_{14}	β_{24}	β_{34}	β_{44}	0	0
R_10Y_DIFF_REAL	β_{15}	β_{25}	β_{35}	β_{45}	β_{55}	0
HUFEUR	β_{16}	β_{26}	β_{36}	β_{46}	β_{56}	β_{66}

Source: Authors' edition

Impulse response function (IRF) occurs when a VAR system is shocked, the IRF shows how each of the other endogenous variables will respond to the shock. It indicates what is the impact of an upward unanticipated one-unit change in the “impulse” variable on the “response” variable over the next several periods. It shows which variables will increase or decrease, in which lags, and by which magnitude.

Variance decomposition is a crucial aspect of Vector Autoregressive (VAR) models. It quantifies the proportion of the forecast error variance for each variable that can be attributed

to exogenous shocks to other variables. In other words, it indicates how much information each variable contributes to the other variables in the autoregression.

Results

In the following section, we discuss the main results of our explorative and model-specific BMA analysis to validate the variable set, which will be later estimated within a VAR model. First, to explore which variables should be included into the main model, we applied the BMA model in a pairwise selection. This was able to assess each variable's impact on the change on the FX rate. Here, we are looking for the variables from each group with relatively high PIP values (higher than 0.5), but also testing their cross-correlation with each other to avoid the inclusion of multicollinearity into the main model (variable with higher correlation than 0.6 and lower PIP will be excluded).

As Table 3 summarizes, the FX debt ratio, the real 10Y bond yield spread (representing the UIP, as it had a strong correlation with its 3-month counterpart with lower PIP), the balance sheet structure and size of the MNB, and the implied volatility of the Eurostoxx index will be included. Neither the unemployment macro data nor the USD liquidity shortage benchmarks were added.

Table 3: Pairwise BMA regression results

group	variable	mean	(std)	PIP	Correlation
Eurolisation	FX debt ratio	-0.0210	0.0224	0.5358	0.0652
	Foreign asset ratio	0.0011	0.0080	0.0902	
UIP	r_10y_diff_real	-0.0035	0.0010	0.9992	0.7440
	r_3M_diff_real	0.0014	0.0012	0.6701	
CB balance sheet	LSFX_MNB	0.0692	0.0239	0.9467	-0.3252
	TA_MNB	0.0000	0.0000	0.9457	
	TA_ECB	0.0000	0.0000	0.1913	0.7139
	LSFX_ECB	0.0000	0.0004	0.1509	
Macroeconomy	Unemp_HU	0.0000	0.0003	0.0369	0.2706
	Unemp_EZ	0.0000	0.0003	0.0362	
Liquidity	EURUSDCBS1Y	0.0000	0.0000	0.0557	-0.0280
	HUFUSDCBS1Y	0.0000	0.0000	0.0445	
External	Volatility_Eurostoxx	-0.0005	0.0001	1.0000	-0.3010
	Brent	0.0000	0.0001	0.3783	0.1435
	XAUEUR	0.0000	0.0000	0.1063	

Source: Authors' estimation (Stata 18)

Second, the main model was estimated again with a BMA model (see Table 4) both before the Covid-19 pandemic to represent the low inflation period after the global financial crisis of 2008 and then on the entire sample. All variables maintained the same positive or negative signs for their impacts, as well as their PIP remaining also similar. The real 10-year bond spread (which represents the real UIP in the model) had a negative impact, highlighting the presence of the UIP paradox, which was described by previous literature for emerging economies. Similarly, the accumulation of foreign currency-denominated debt in the corporate sector also contributed

to the depreciation of the forint. This result provides the input variables for our vector autoregressive model.

Table 4: BMA regression results on the main models

	2007-2019			2007-2024		
	Post mean	(Std. dev.)	PIP	Post mean	(Std. dev.)	PIP
real UIP	-0.004	0.001	1.000	-0.002	0.001	0.986
TA MNB	0.000	0.000	1.000	0.000	0.000	1.000
Volatility Eurostoxx	0.000	0.000	0.996	0.000	0.000	1.000
L+S/FX MNB	0.005	0.017	0.212	0.005	0.012	0.240
FX debt ratio	-0.001	0.006	0.193	-0.002	0.007	0.198

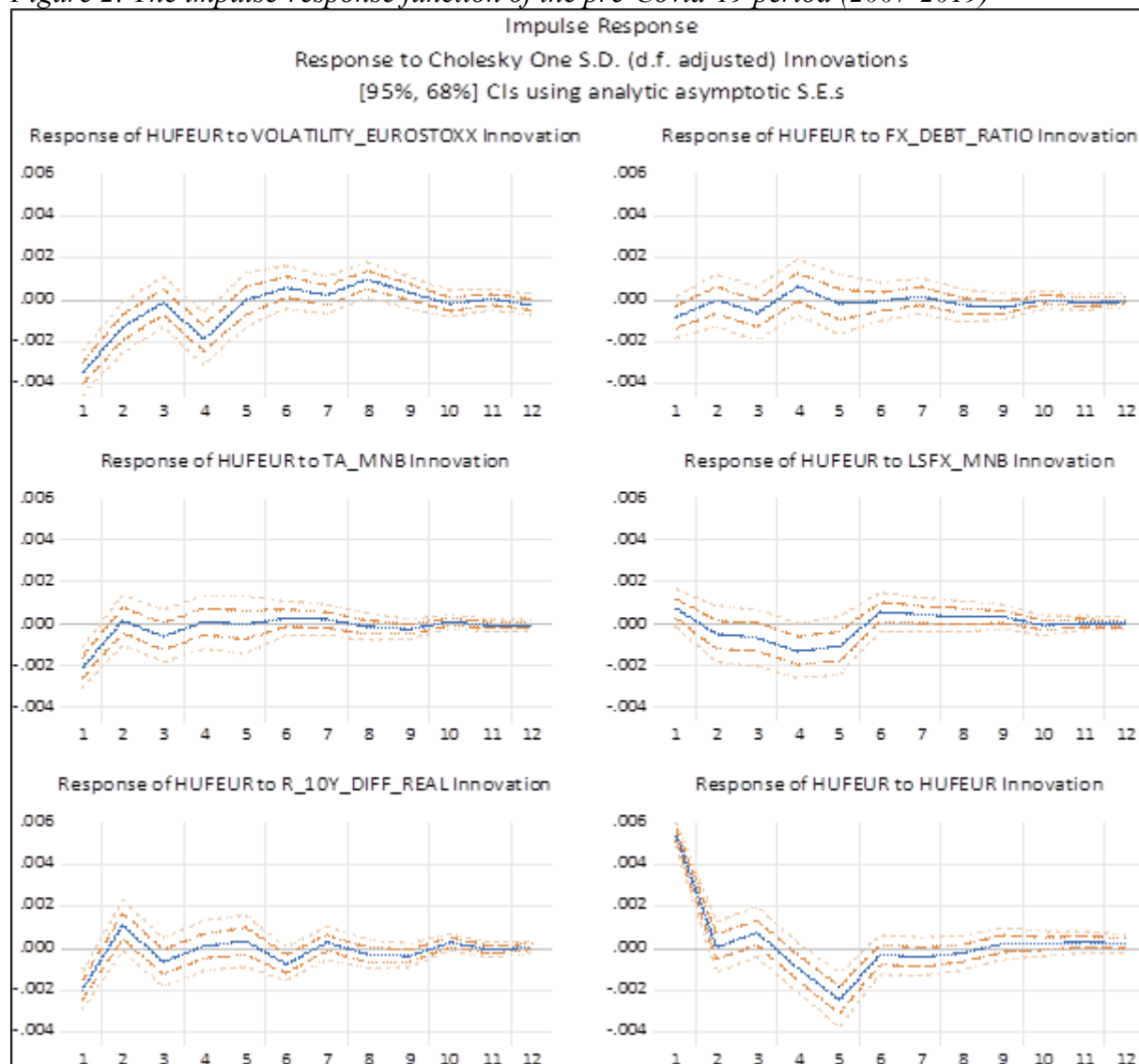
Source: Authors' estimation (Stata 18)

As the third step of the analysis, we estimated two VAR models with Cholesky decompositions on the variable set, provided by the BMA estimations. First, we studied the period between the global financial crisis and COVID-19, which was characterized by a low-inflation environment and the introduction of unconventional monetary instruments.

Our intuition was right, as the shocks from most of the variables had an instantaneous impact on the exchange rate in the first and second months only (Figure 2). An increasing implied volatility on the EUROSTOXX market contributed to the depreciation of the Forint for 4 months, showing the relevance of global risk sentiments, by describing 24-28% of the exchange rate's variance (The variance decompositions are visible in the Appendix 2.). While an increasing central bank total asset volume was interpreted by the market as a sign of monetary easing for one month only (with 8% relevance), an increased lending or security purchase activity (represented by the LSFY ratio) supported appreciation in the first month (within the 68% confidence interval), but later in the 3-5 months it promoted the depreciation (again, within the 68% confidence interval).

The real UIP paradox was visible with this approach as well, as the shock had a clear instantaneous negative impact in the first month (with 8% relevance). Meanwhile, the foreign exchange debt ratio had a negative impact but within the 68% band only. As we can see, the mobilization of domestic savings and indebtedness in domestic currency as efficient, and the monetary policy was mainly represented by the interest rates, not by the balance sheet.

Figure 2: The impulse-response function of the pre-Covid-19 period (2007-2019)



Source: Authors' estimation (Eviews 14)

The second VAR estimation studied the entire dataset, with the sudden drop in inflation during 2020, then with the inflationary spike of the 2022-2023 years, which resulted in even a negative real interest premium in the benchmark assets.

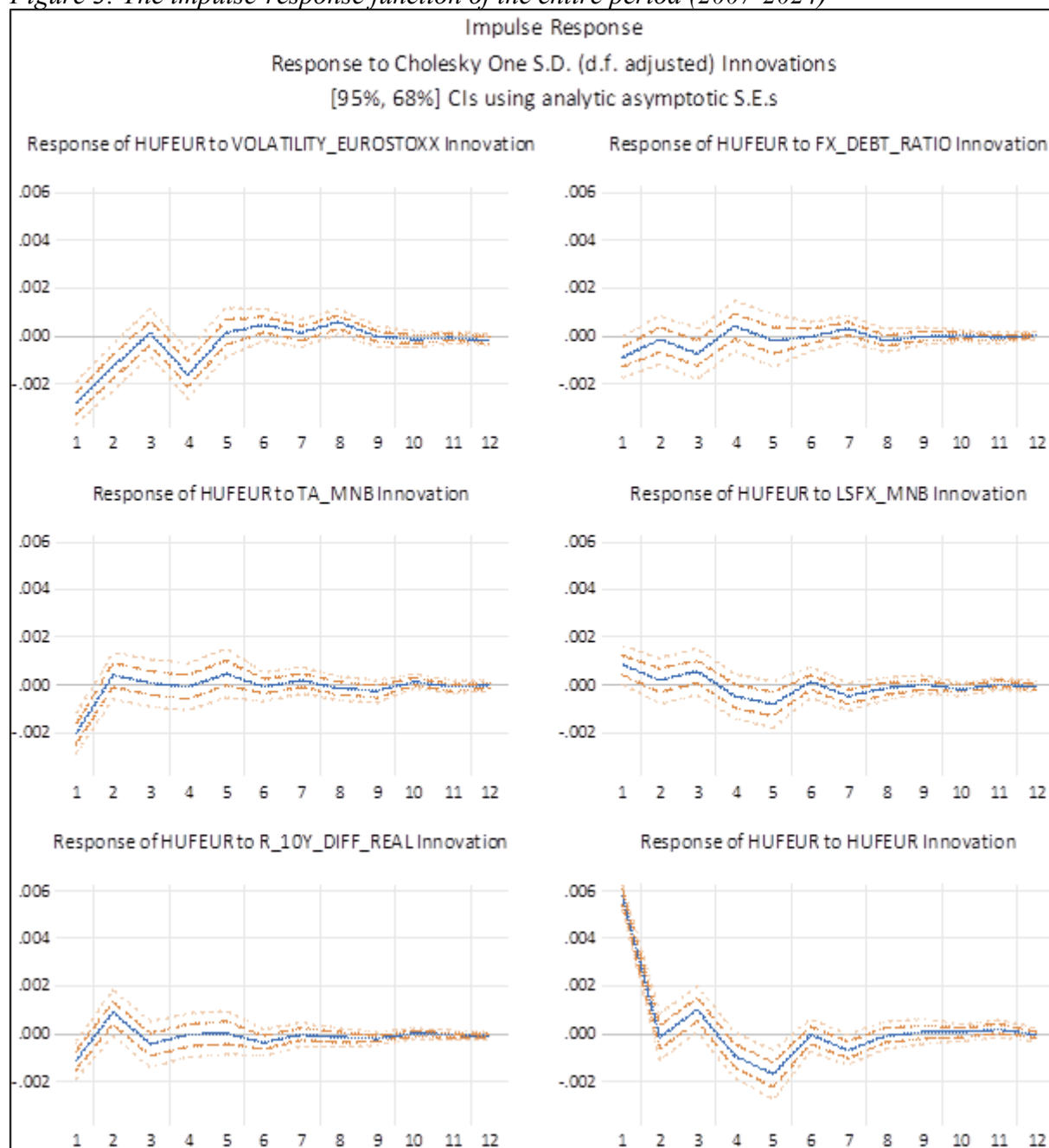
The majority of the shocks were still derived from the implied volatility on the EUROSTOXX market but with a bit lower 16-22% relevance (Figure 3). Similarly, an increasing central bank total asset volume was interpreted by the market as a sign of monetary easing for one month only (with 9% relevance), but now an increased lending or security purchase activity (represented by the LSFY ratio) supported clearly the appreciation in the first month (but with 1.5% relevance only).

The real UIP paradox was visible with this approach as well, as the shock had a clear instantaneous negative impact in the first month – however, its relevance dropped to 3% only. Meanwhile, the foreign exchange debt ratio maintained its negative impact but within the 68% band only. These results suggest that the UIP paradox is still present in the valuation of the Hungarian Forint, underlining its emerging nature. Our main findings about the persistence of

the real UIP paradox were robust across different econometric model specifications (both under BMA and VAR) and the different time sets as well.

From an empirical perspective, an improvement in the estimation was reached by using the BMA method by identifying the clearly relevant variables, which provided a more suitable VAR model. The separation between the pre- and post-COVID-19 periods surprisingly did not lead to a further substantial improvement in the empirical model, as results remained highly similar to each other.

Figure 3: The impulse-response function of the entire period (2007-2024)



Source: Authors' estimation (Eviews 14)

Conclusion and discussion

Over the last decade, the standard real UIP model (or the international Fisher rule), using the real interest spreads to approximate foreign exchange rate changes, has maintained its substantial explanatory power. Even if central banks started to rely more on the structure and size of their balance sheet during their operations, instead of focusing on their key policy rates solely.

To sum up all periods since the global financial crisis and the introduction of the floating regime in 2007, our results can confirm that the real uncovered interest rate parity paradox still accounts for the pricing of the Hungarian Forint. This divergence from the standard real UIP assumptions must indicate why the country is still considered by many investment banks and rating agencies as an emerging economy.

In this paper, we mainly attribute to the currency valuation literature with our two-step econometric approach, when the variable set of the main model's VAR was supported by a pre-selection with a BMA estimation. This approach enabled us to assess and evaluate a wide set of variables, representing different aspects of macroeconomics, funding, liquidity, and sentiment conditions that we derive from the literature. This approach has not been applied previously in the context of the Hungarian Forint and, therefore, addresses a gap in the literature.

Our key findings are the following: First, our results indicate that the real UIP paradox is present during the pricing of the Hungarian Forint, indicating that it should be still considered as an emerging economy. This result seems to be in accordance with Egilsson (2020) and Hassan & Zhang (2021). Second, we highlighted that there were no significant changes in the pricing model during the first half of the 2020s, even if the inflation environment was completely different. Further analysis could extend the model with more emphasis on the non-linearities of the variables by putting a higher focus on their signs.

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Appendix 1: Statistics of the variables in the main model

Table A1: Basic statistics of the first differentials of variables in the main model (2007-2024)

	VOL.	HUFEUR	FX DEBT RATIO	TA MNB	LSFX MNB	R 10Y DIFF REAL
Mean	0.0049	-0.0007	0.0019	117.6599	0.0020	0.0289
Std. Dev.	5.2625	0.0074	0.0337	528.8900	0.0240	0.8568
Skewness	0.8189	-0.6255	9.4689	0.9000	0.2698	-0.2927
Kurtosis	6.5153	6.5816	115.9021	5.3718	8.1769	7.4188
Jarque-Bera (p)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ADF (p)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Authors' estimation (Eviews 14)

Table A2: Cross-correlations of variables in the main model (2007-2024)

	VOL.	HUFEUR	FX DEBT RATIO	TA MNB	LSFX MNB	R 10Y DIFF REAL
VOL.	1.00	-0.38	0.16	0.13	0.03	0.11
HUFEUR	-0.38	1.00	-0.18	-0.44	0.18	-0.29
FX DEBT RATIO	0.16	-0.18	1.00	0.21	-0.10	0.02
TA MNB	0.13	-0.44	0.21	1.00	-0.33	0.13
LSFX MNB	0.03	0.18	-0.10	-0.33	1.00	-0.03
R 10Y DIFF REAL	0.11	-0.29	0.02	0.13	-0.03	1.00

Source: Authors' estimation (Eviews 14)

Appendix 2: Variance decompositions of the VAR models

Table A3: Variance decomposition (2007-2019)

Period	S.E.	VOL.	FX DEBT RATIO	TA MNB	LSFX MNB	R 10Y DIFF REAL	HUFEUR
1	0.01	24.17	1.37	8.56	1.13	7.98	56.80
2	0.01	25.96	1.29	8.12	1.52	9.61	53.51
3	0.01	24.97	1.99	8.41	2.21	10.02	52.39
4	0.01	27.97	2.36	7.57	4.57	9.03	48.50
5	0.01	25.06	2.18	6.78	5.68	8.25	52.06
6	0.01	25.04	2.15	6.74	6.02	8.87	51.19
7	0.01	24.92	2.17	6.74	6.26	8.89	51.03
8	0.01	25.71	2.24	6.65	6.32	8.85	50.23
9	0.01	25.66	2.40	6.68	6.42	8.96	49.89
10	0.01	25.65	2.40	6.68	6.41	9.03	49.82
11	0.01	25.62	2.41	6.68	6.41	9.03	49.86
12	0.01	25.65	2.41	6.67	6.40	9.02	49.84

Source: Authors' estimation (Eviews 14)

Table A4: Variance decomposition (2007-2024)

Period	S.E.	VOL.	FX DEBT RATIO	TA MNB	LSFX MNB	R 10Y DIFF REAL	HUFEUR
1	0.01	16.82	1.62	9.02	1.46	2.58	68.49
2	0.01	19.26	1.58	8.85	1.45	4.04	64.82
3	0.01	18.52	2.52	8.50	1.99	4.21	64.25
4	0.01	21.79	2.64	7.96	2.24	3.94	61.42
5	0.01	20.47	2.54	7.85	3.16	3.70	62.28
6	0.01	20.70	2.52	7.81	3.17	3.89	61.90
7	0.01	20.45	2.64	7.78	3.51	3.84	61.78
8	0.01	20.89	2.67	7.75	3.52	3.83	61.33
9	0.01	20.86	2.67	7.85	3.52	3.88	61.23
10	0.01	20.86	2.67	7.88	3.56	3.88	61.16
11	0.01	20.84	2.67	7.88	3.56	3.88	61.17
12	0.01	20.87	2.67	7.88	3.56	3.88	61.14

Source: Authors' estimation (Eviews 14)

DRIVERS OF DEPOSIT GROWTH IN NORTH MACEDONIA: AN EMPIRICAL STUDY

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Abstract

This article seeks to examine the influence of bank-specific variables and macroeconomic factors on the growth of bank deposits in the Republic of North Macedonia. The study employed the Autoregressive Distributed Lag (ARDL) bounds testing approach, using quarterly data from 2006Q1 to 2024Q1. The empirical results confirm the presence of cointegration among the variables. Furthermore, the analysis indicates that loans, remittances, and foreign exchange reserves have a statistically significant impact on deposit growth. On the other hand, the real change in GDP, weighted interest rates on deposits, CPI and the real change in net salaries do not result in a statistically significant change in deposits, in either the short or long term. These findings have significant policy implications for decision-makers involved in monetary policy planning, especially in North Macedonia. Additionally, these results may provide valuable insights for other researchers interested in conducting further studies on this topic.

Keywords: total deposits, total loans, remittances, foreign exchange reserves, ARDL bounds testing approach

JEL classification: E5, E51, F24, E59, C32

Introduction

Most of the money in the modern economy is in the form of bank deposits. As a result, any increase in deposits tends to attract the attention of researchers. Economic theory has featured diverse opinions on the money creation process since its inception. One approach, based on the concept of the money multiplier, views money as being determined by monetary authorities via changes in the monetary base. In line with monetarists and Friedman's theory of money (Friedman & Schwartz, 1963, 1982), the bank lends funds that clients had previously deposited physically. Once a loan is approved, it generates an entry on the deposit obligation. Bank money is created during this process when the bank transfers the existing physical cash deposits to clients. Known as "deposits creating loans," this process aligns with an *exogenous view of the money supply*.

However, the modern theory of money challenges the notion that monetary authorities independently control the money supply and emphasizes the active role of commercial banks in creating money. In the modern monetarist view of bank money creation, when the bank

grants a loan to a client, it credits the client's account with an amount equal to the loan size. This process creates bank money, without the need for physical cash in the accounting process. Known as "loans create deposits" this process aligns with an *endogenous approach to the money creation process* (McLeay et al., 2014a & 2014b).

In brief, the authors favoring the exogeneity view believe that changes in the money supply determine variables such as the price level, interest rates, or real output. On the other hand, the authors holding the endogeneity view argue that the money supply is influenced by these same factors. The endogenous money approach has seen increasing support in macroeconomics. Considering all of this, identifying the factors driving changes in deposits proves to be challenging.

The aim of this study is to understand the trends in deposit growth, specifically in the Republic of North Macedonia. This study examines the underlying reasons for the increase in deposits in recent years. This study enhances the literature by offering two distinct contributions. First, as far as we are aware, no empirical study has examined the reasons behind deposit growth in the Macedonian economy. As a result, this research presents pioneering work in this area. The results of this study provide value to banks, policymakers, and researchers by: informing banks (both commercial banks and the Central Bank) of the factors influencing deposit growth; providing policymakers with insights into macroeconomic factors that drive deposit growth; and enhancing researchers' understanding by exploring the relationship between bank deposits and various factors. Secondly, we break down the factors influencing deposit growth into short- and long-run determinants through the Autoregressive Distributed Lag (ARDL) model.

The structure of the paper is outlined as follows: In Section 2, we provide stylized facts about deposit growth and monetary policy in North Macedonia. Section 3 provides a literature review of relevant studies. The Methodology, data analysis and empirical model of the study are presented in Sections 4. In Section 5 we discuss the empirical results. Finally, section 6 presents the concluding remarks from the research performed.

Stylized facts about deposit growth and monetary policy in North Macedonia

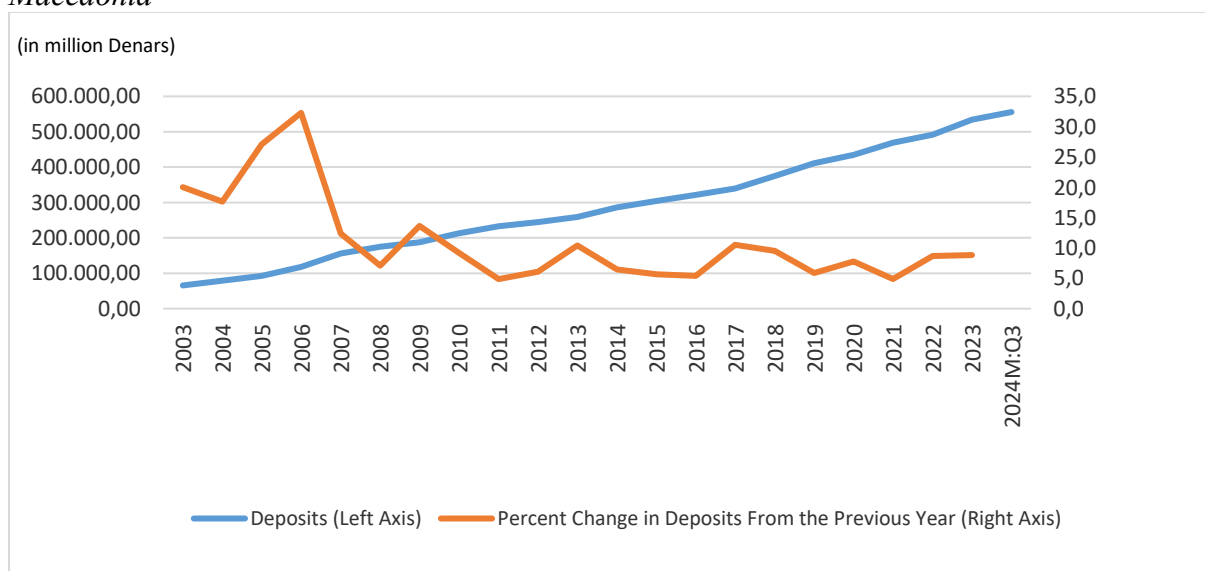
The Republic of North Macedonia is a small, open economy marked by low and stable inflation, typically ranging from 2% to 3%. However, between 2021 and 2023, inflation surged dramatically, reaching nearly 20%, driven by a series of crises, including the COVID-19 pandemic, the energy crisis, and the war in Ukraine. Despite this, the country has seen a recent decline in unemployment. Furthermore, a key aspect of the Macedonian economy is the substantial inflow of remittances, which constitute a significant portion of the total foreign exchange inflows in the country's balance of payments and play a crucial role in supporting foreign exchange reserves and maintaining exchange rate stability.

The Macedonian banking system is characterized by low degree of international financial integration, a simple structure of financial instruments, a consistent increase in loan demand from both households and firms.

Given that the Republic of North Macedonia operates under a fixed exchange rate regime, the monetary base is primarily influenced by the foreign exchange interventions of the NBRNM, aimed at defending the exchange rate, irrespective of lending.

In recent years, deposits in North Macedonia have experienced strong growth, with an average growth rate of 11.28 percent between 2004 and 2023. In comparison, nominal GDP growth during the same period was 5.9 percent. The factors driving bank deposits in Macedonia are worth exploring, especially considering the impact of bank deposits on economic growth.

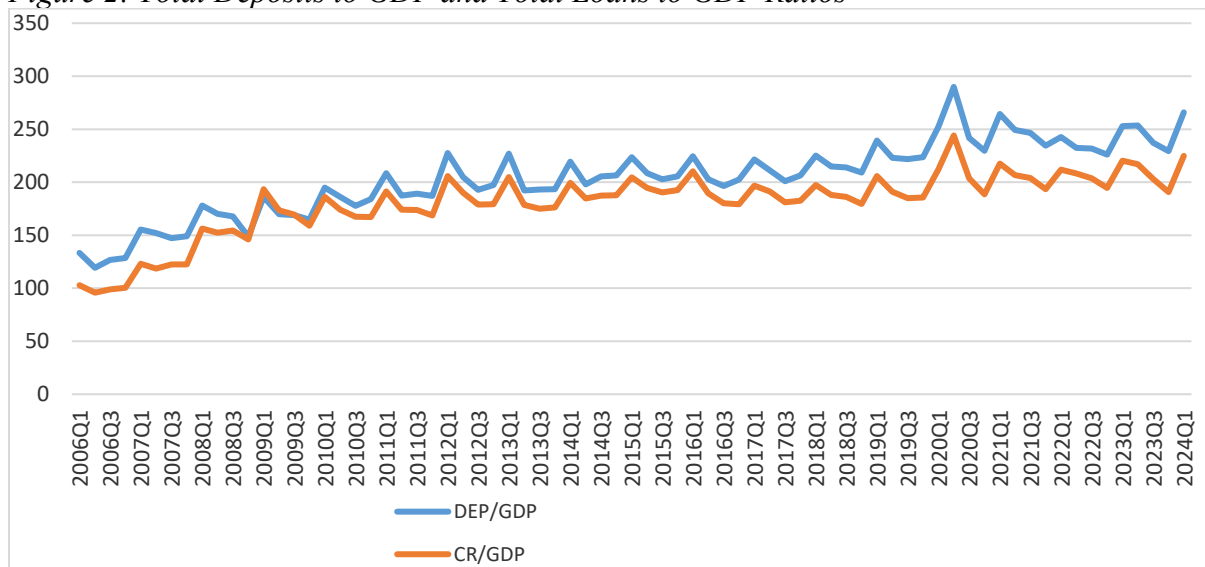
Figure 1: Total Deposits and Year-Over-Year Change in Deposits in the Republic of North Macedonia



Source: *www.nbrm.mk* and Author's calculation

The increase in deposit balances was driven by changes in consumer behavior, fiscal and monetary responses following the Great Financial Crisis (GFC), the COVID-19 pandemic, the global energy crisis (2021-2023), political instability, a higher personal savings rate, and other factors. As shown in Figure 2, the ratio of total deposits to nominal GDP increased from 133% in 2006:Q1 to 290% in 2020:Q2, then declined and continued to hovered around 230%.

Figure 2: Total Deposits to GDP and Total Loans to GDP Ratios



Source: *www.nbrm.mk* and Author's calculation

In the years leading up to the Great Financial Crisis (GFC), alongside the rise in the ratio of bank credit to GDP (shown by the red line), the ratio of deposits to nominal GDP also increased. Following the GFC, the deposits-to-GDP ratio continued to rise, partly due to the expansion of banks' balance sheets, driven by both the increase in reserves and credit within the banking system. Additionally, banks, in response to new liquidity regulations, sought to hold more stable forms of funding, including deposits. After the onset of the COVID-19 pandemic in 2020, the deposits-to-GDP ratio surged to over 290 percent, then declined and continued to hover around 230-260%. During this period, the Macedonian economy faced high core and headline inflation.

The NBRNM's policy response involved several measures, starting with interventions in the foreign exchange market, which helped manage liquidity in circulation (selling foreign exchange reserves led to the creation of deposits). The policy response then shifted to raising interest rates, not only on the basic interest rate but also on overnight loans, overnight deposits, and seven-day deposits. Additionally, the NBRNM adjusted the mandatory reserve requirement multiple times and implemented other measures aimed at gradually tightening monetary policy. For instance, a countercyclical protective layer was introduced. Furthermore, changes to the reserve requirement were made to signal to banks to adjust their interest rate policies, encouraging them to offer more favorable interest rates on denar savings. The increase in interest rates on bank deposits was thus a direct response to central bank measures.

Other significant macroeconomic trends during the period included the growth of private transfers (especially the rise in net inflows in the foreign exchange market) and the growth of net salaries.

Literature Review

Various scholars have sought to understand the growth of bank deposits by analyzing the factors that drive it.

Johnny & Prince (2020) explained the key macroeconomic drivers of bank deposits, including interest rates, inflation, unemployment rates, economic growth, exchange rates, and government policies. Their findings suggest that while some factors, such as interest rates and inflation, have a clear and direct impact on deposit levels, others, like government policies and exchange rates, may exert more complex effects. Additionally, the unemployment rate, economic growth, and GDP also influence deposit levels.

According to the review of the analyzed literature, researches in this area have not been found in Macedonian literature. Additionally, the number of research on this topic for European emerging economies is limited.

Using Ordinary Least Squares (OLS) methodology, Corovei & Socol (2019) examined the potential impact of macroeconomic indicators on the deposit growth rate in the Eurozone from January 2003 to June 2019. The authors conducted specific tests for multicollinearity and stationarity and incorporated robust standard errors to address heteroskedasticity in their panel data. The macroeconomic variables included in their analysis were: GDP annual growth rate, inflation rate, harmonized unemployment rate, interest deposit rate for deposits with a maturity of less than one year, interest deposit rate for deposits with a maturity greater than one-year, short-term debt securities, long-term debt securities, and listed shares. The authors concluded

that, except for the unemployment rate, all the other variables positively influenced the growth rate of household deposits.

Nguyen, T.A.N. (2022) examined the impact of institutional quality on bank deposit growth, alongside bank-specific and macroeconomic variables, in European transition economies. The author employed the Generalized Method of Moments (GMM) to analyze panel data covering the period from 2000 to 2017. The results indicate that institutional quality enhances the positive effect of deposit mobilization on bank deposit growth. More specifically, the rule of law was found to have a positive correlation with bank deposits. Additionally, macroeconomic factors such as broad money supply (M2) and economic growth (rGDP) were identified as significant drivers of bank deposit growth. Furthermore, bank-specific factors, including bank efficiency and branch expansion, were found to have no influence on bank deposit growth.

Yakubu & Abokor (2020) used quarterly data from 2000 to 2016 on the Turkish banking system to examine the relationship between bank deposits and six explanatory variables, including bank stability, bank efficiency, branch expansion, broad money supply, GDP growth, and inflation. Their analysis revealed that the GDP growth rate had a negative and statistically significant effect on deposit growth, while the inflation rate had a positive and statistically significant impact on bank deposit growth.

There is also a literature focused on the empirical analysis of deposit growth in the USA. Using VAR and VECM methodologies, Matteo & Enrico (2017) conducted an analysis of the United States from 1959 to 2016, testing several propositions of the endogenous money theory. Specifically, they demonstrated that in the United States during this period, bank loans influence bank deposits, which, in turn, determine the monetary base.

It is important to note that while reviewing the available literature in this area, we came across a large number of studies that analyze the impact of various factors (money supply, exchange rates, inflation rates, deposit interest rates, GDP growth, bank investment, the number of bank branches) on deposit levels in Asian countries such as Ethiopia (Tenaw, 2020), Ghana (Ngula, 2012; Larbi-Siaw & Lawer, 2015), Zimbabwe (Mashamba et al., 2014), Nigeria (Eriemo, 2014), etc. Due to the distinct characteristics of the banking system and economic conditions, this group of countries does not serve as a benchmark for the Macedonian economy, although their findings still provide valuable explanatory insights.

Focusing on the Republic of North Macedonia, this study strives to close this gap by integrating both bank-specific and macroeconomic factors into a single model to examine the factors affecting bank deposit growth in North Macedonia.

Methodology

In this research, we apply the ARDL model to investigate the impact of the total loans of the non-government sector (CR), remittances (REM), foreign exchange reserves (FR), economic growth (RGDP), weighted interest rates on deposits (IR), consumer price index (CPI), and the real change in net salaries (RSAL) on total deposits growth (DEP) in the Republic of North Macedonia in the long-run. After establishing cointegration, we proceed to estimate the error correction model (ECM), often referred to as the short-run model. The ARDL procedure involves two key steps: examining stationarity and cointegration.

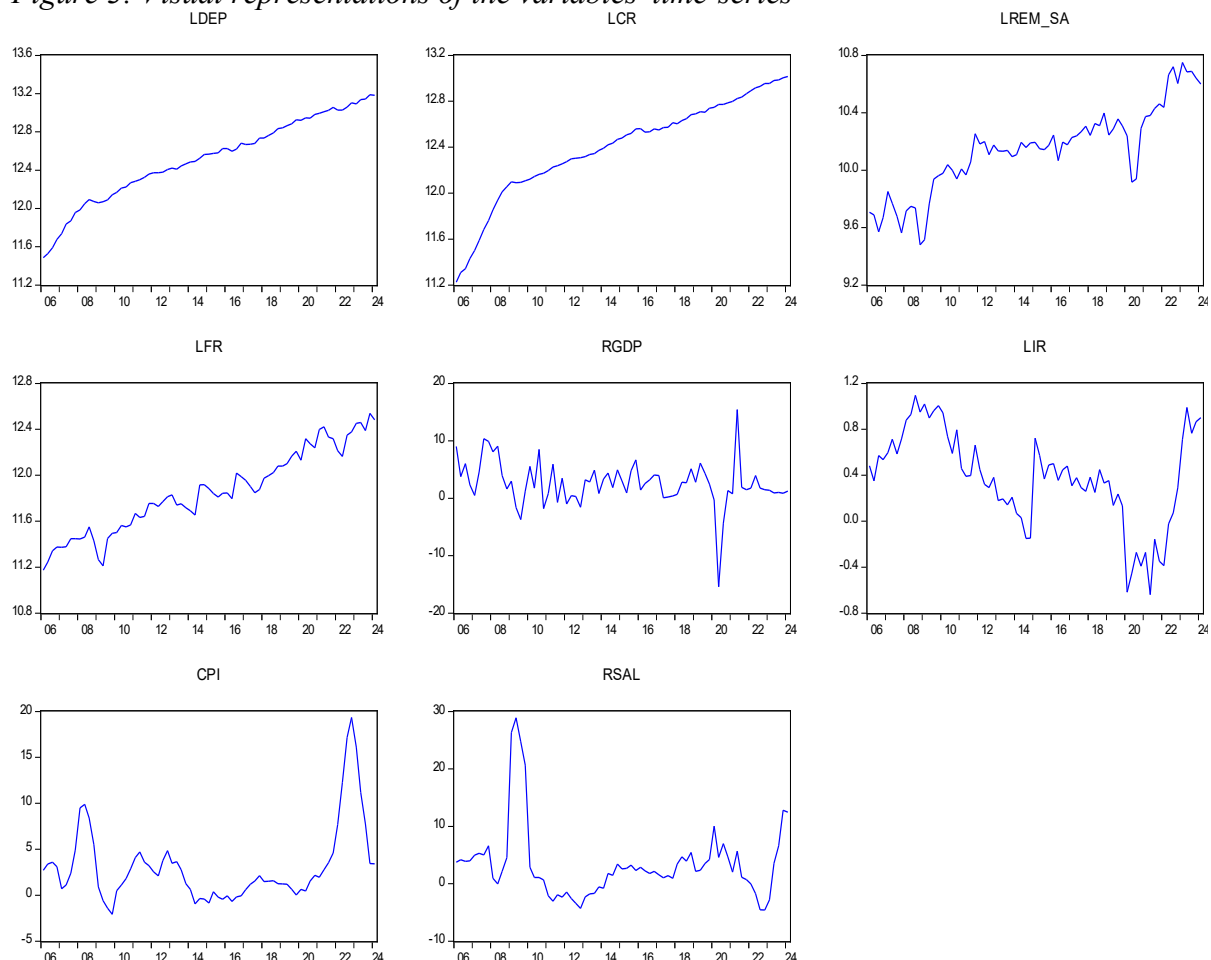
Preliminary data analysis

The variables' data are quarterly, covering the period from 2006Q1 to 2024Q1. We obtain the data on total deposits, total loans, remittances, foreign exchange reserves, economic growth, weighted interest rates on deposits, consumer price index, and the real change in net salaries from The National Bank of The Republic of North Macedonia (2024a, 2024b, 2024c) database. Total deposits (DEP), total loans (CR), remittances (REM) and foreign exchange reserves (FR) are in million Denars. Economic growth (RGDP), weighted interest rates on deposits (IR), consumer price index (CPI), and the real change in net salaries (RSAL) are in %. The Eviews 10 software is used to generate all of the empirical results and graphs.

The time series of remittances are seasonally adjusted. Since all variables, (except, economic growth, consumer price index and the real change in net salaries) take on positive values, they are expressed in logarithmic form.

We begin our empirical analysis by visual representations of the variables' time-series (Figure 3) to assess their time series properties, as ensuring stationarity is essential to avoid spurious results.

Figure 3: Visual representations of the variables' time-series



Source: Authors

Visual examination of time series plots reveals that most variables are non-stationary due to their trends and changing levels, i.e. they exhibit unit roots, meaning they are not of order one

integration, and therefore not stationary at the levels. Only series RGDP seems as potential stationary series. Even though the series (RGDP) has strong cycles. These cycles are aperiodic, meaning that they do not repeat at regular intervals. Figure 3 illustrates that the variables experience structural breaks at various periods. As highlighted in Perron (1989), it is crucial to consider this situation when performing unit root tests to avoid drawing incorrect conclusions. The statistics of the variables employed in the study are summarized in Table 1.

Table 1: Descriptive statistics

	LDEP	LCR	LREM SA	LFR	RGDP	LIR	CPI	RSAL
Mean	12.51840	12.39581	10.13826	11.85393	2.594215	0.379763	3.088713	3.311355
Median	12.56773	12.47975	10.17485	11.83987	2.332818	0.384227	1.964697	2.245355
Maximum	13.18860	13.01534	10.74972	12.53938	15.41255	1.095113	19.34858	28.91171
Minimum	11.48470	11.22398	9.480711	11.17327	-15.41616	-0.640599	-2.100000	-4.568237
Std. Dev.	0.434718	0.435070	0.301054	0.358554	3.911245	0.412804	4.176586	6.358817
Skewness	-0.442033	-0.840449	-0.125139	0.094475	-0.637228	-0.480292	2.037787	2.291761
Kurtosis	2.462740	3.268155	2.690420	2.066149	9.076909	2.789294	7.346783	9.060199
Jarque-Bera	3.255256	8.812698	0.482040	2.761164	117.2655	2.941658	107.9938	175.6097
Probability	0.196395	0.012200	0.785826	0.251432	0.000000	0.229735	0.000000	0.000000
Sum	913.8432	904.8942	740.0933	865.3366	189.3777	27.72272	225.4761	241.7289
Sum Sq. Dev.	13.60654	13.62856	6.525614	9.256367	1101.444	12.26928	1255.959	2911.288
Observations	73	73	73	73	73	73	73	73

Source: Authors

According to Table 1, all the variables have positive mean values. In addition, the volatility, as indicated by the standard deviation, is greater for RGDP, CPI, and RSAL than for the other variables. The JB-test outcomes reveal that, except for RGDP, CPI, and RSAL, all variables are normally distributed.

Empirical model

This research focuses on analyzing the short-run and long-run impacts of loans, remittances, foreign exchange reserves, economic growth, weighted interest rates on deposits, consumer price index, and the real change in net salaries on total deposits growth in the Republic of North Macedonia, by using the quarterly data over the period of 2006 – 2024.

Firstly, we establish the long-run model of total deposits growth. Using the seasonally adjusted and logarithmic values of the variables as it was explained before, we present the long-run model of total deposits growth as follows:

$$LDEP_t = \alpha_0 + \beta_1 LCR_t + \beta_2 LREM\_SA_t + \beta_3 LFR_t + \beta_4 RGDP_t + \beta_5 LIR_t + \beta_6 CPI_t + \beta_7 RSAL_t + u_t \quad (1)$$

where all factor proxies have been defined earlier, except for u , that represents the error term. t denotes the study period, and α_0 represents the intercept. The coefficients β_1 to β_7 represent the explanatory factors in the model.

Stationarity and cointegration

The initial step in the ARDL analysis involves performing a unit root test. For the ARDL Bounds testing approach to be applicable to cointegration, each variable must be $I(0)$ or $I(1)$, and not $I(2)$. We test the integration order of the variables through traditional unit root tests, including the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests (Table

2). The null hypothesis for both tests states that the variables are non-stationary and contain a unit root. If the test statistic exceeds the critical value, we reject the null hypothesis of non-stationarity.

Table 2: Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests

At Level								
Intercept					Trend and Intercept			
Variable	ADF		PP		ADF		PP	
	t-Statistic	Probability	t-Statistic	Probability	t-Statistic	Probability	t-Statistic	Probability
LDEP	-1.3552	0.5988	-3.9960*	0.0025	-3.2451***	0.0852	-7.7683*	0.0000
LCR	-1.6880	0.4327	-4.5217*	0.0004	-6.0931*	0.0000	-5.1757*	0.0003
LREM SA	-1.4692	0.5435	-1.0555	0.7289	-3.4964**	0.0473	-3.4897**	0.0481
LFR	-0.1858	0.9346	-0.8614	0.7949	-4.5291*	0.0027	-4.5291*	0.0027
RGDP	-5.3359*	0.0000	-6.1750*	0.0000	-5.7968*	0.0000	-6.3030*	0.0000
LIR	-2.0917	0.2486	-2.0731	0.2560	-2.0848	0.5452	-2.1391	0.5154
CPI	-2.0944	0.2476	-2.6329***	0.0912	-2.1721	0.4968	-2.7086	0.2365
RSAL	-2.8820***	0.0528	-3.0812**	0.0325	-2.8487	0.1857	-3.0370	0.1296
At First difference								
LDEP	-2.9983**	0.0407	-7.0913*	0.0000	-2.7509	0.2209	-7.8122*	0.0000
LCR	-2.9377**	0.0464	-4.1193*	0.0017	-2.8298	0.1921	-5.0376*	0.0005
LREM SA	-7.7502*	0.0000	-16.0438*	0.0001	-7.6836*	0.0000	-15.8133*	0.0001
LFR	-5.5679*	0.0000	-12.0041*	0.0001	-5.5394*	0.0001	-11.8727*	0.0001
RGDP	-5.8133*	0.0000	-17.7945*	0.0001	-5.8228*	0.0000	-17.6372*	0.0001
LIR	-10.0561*	0.0001	-10.0977*	0.0001	-7.2108*	0.0000	-10.1288*	0.0000
CPI	-3.6557*	0.0070	-4.2887*	0.0010	-4.0732**	0.0109	-4.2613*	0.0061
RSAL	-5.4203*	0.0000	-6.9817*	0.0000	-5.5968*	0.0001	-6.9532*	0.0000

*, **, *** Indicates stationarity at the 1%, 5%, and 10% significance levels, respectively.

Source: Authors

As Perron (1989) demonstrated, ignoring structural breaks in time series reduces the ability to reject a unit root when the stationary alternative is valid. Since the time series plots of the variables display structural breaks, and traditional unit root tests fail to account for these breaks, we also employ the two structural breaks unit root tests by Lee and Strazicich (2003) to verify the results of the traditional tests. In the LS unit root tests, the null hypothesis indicates that the series has a unit root with two level breaks. The null hypothesis can be rejected if the computed LS test statistic exceeds the table's critical value.

Once the necessary conditions for applying the ARDL Bounds approach are met, we move forward with its implementation. The ARDL Bounds approach is an innovative method for linear cointegration, introduced by Pesaran & Pesaran (1997), Pesaran & Smith (1998), Pesaran & Shin (1999), and Pesaran et al. (2001). It offers significant benefits compared to other cointegration approaches, such as, estimation of both short-run and long-run parameters in one model, solves issues of endogeneity, it can assess whether cointegration exists among variables that exhibit different integration orders, such as I(0), I(1), or fractional integration, and finally, it is suitable for small sample sizes (Jebli & Belloumi, 2017) and provides unbiased long-run estimates (Odhiambo, 2008).

The ARDL model is derived as follows:

$$\Delta \left[\sum_{i=0}^p \sum_{j=0}^q \sum_{k=0}^r \sum_{l=0}^s \sum_{m=0}^n \sum_{o=0}^t \sum_{p=0}^u \sum_{v=0}^w \right] \text{RSAL}_{t-i} + \delta_1 \text{LDEP}_{t-i} + \delta_2 \text{LCR}_{t-i} + \delta_3 \text{LREM\_SA}_{t-i} + \delta_4 \text{LFR}_{t-i} + \delta_5 \text{RGDP}_{t-i} + \delta_6 \text{LIR}_{t-i} + \delta_7 \text{CPI}_{t-i} + \delta_8 \text{RSAL}_{t-i} + \rho \text{ECM}_{t-i} + e_t \quad (2)$$

In this context, Δ represents the difference operator; α_0 is the intercept; α_1 to α_8 are the short-run coefficients, while δ_1 to δ_8 are the long-run coefficients; e_t is the error term; n denotes the optimal lag length of the variables; ρ is the coefficient of the error correction term (ECM); and ECM_{t-1} refers to the error-correction term with one-period lag.

The long-run relationship among the variables is assessed using the F-test in a bound test, where the null hypothesis posits no such relationship, and this hypothesis is tested against the alternative. By utilizing Equation (2), we can derive the subsequent hypothesis.

$H_0: \delta_9 = \delta_{10} = \delta_{11} = \delta_{12} = \delta_{13} = \delta_{14} = \delta_{15} = \delta_{16} = 0$ (no cointegration).

$H_1: \delta_9 \neq \delta_{10} \neq \delta_{11} \neq \delta_{12} \neq \delta_{13} \neq \delta_{14} \neq \delta_{15} \neq \delta_{16} \neq 0$ (cointegration).

The outcome of the tests is determined by comparing the computed F-statistic with the lower bound $I(0)$ and upper bound $I(1)$ critical values, as specified by Pesaran et al. (2001). If the calculated F-statistic surpasses the upper $I(1)$ critical value, the null hypothesis is dismissed, indicating cointegration among the variables.

Empirical results

Based on the unit root test results in Table 2, all variables are stationary at their first difference ($I(1)$), satisfying the ARDL Bounds testing approach's requirement that variables not be $I(2)$. Additionally, Lee & Strazicich's unit root test results are presented in Table 3. We can conclude that the break dates align with periods of major economic, financial, and political upheavals, or the times following these disturbances, in the Republic of North Macedonia.

Table 3: Lee & Strazicich's (2003) unit root test outcomes, which incorporates two structural breaks.

Level					
Two shifts in levels					
Variables	Test Statistics	Lag	1 st break date	2 nd break date	Critical value (%5)
LDEP	-6.21*	4	2010Q1	2017Q2	-6.19
LCR	-6.40*	2	2010Q2	2016Q3	-6.18
LREM SA	-5.46	1	2012Q1	2021Q2	-5.92
LFR	-4.80	8	2012Q4	2019Q4	-6.38
LRGDP	-7.35*	3	2013Q1	2022Q1	-6.15
LIR	-5.24	7	2012Q2	2019Q3	-6.15
CPI	-7.05*	5	2013Q4	2021Q3	-6.15
RSAL	-5.80	4	2008Q3	2010Q2	-6.11
First Difference					
Variables	Test Statistics	Lag	1 st break date	2 nd break date	Critical value (%5)
LDEP	-7.02*	8	2015Q2	2021Q3	-6.19
LCR	-7.23*	4	2008Q3	2017Q3	-6.18
LREM SA	-7.91*	2	2019Q4	2021Q4	-6.11
LFR	-8.10*	1	2019Q2	2021Q4	-6.11
LRGDP	-10.46*	7	2019Q4	2020Q4	-6.11
LIR	-10.16*	0	2008Q3	2009Q3	-6.11
CPI	-8.88*	3	2008Q3	2011Q1	-6.11
RSAL	-12.31*	3	2008Q3	2010Q4	-6.11

* Indicates stationarity at the 5% significance level.

Source: Authors

The unit root test results confirm that the highest level of integration for all variables in the study is I(1), so we can proceed with analyzing the presence of cointegration between the variables using this method and we first determine the optimal lag length for the ARDL model based on the Schwarz Information Criterion (SC). According to the results, the ideal lag length is 1. The corresponding ARDL model is ARDL(1, 1, 0, 0, 0, 0, 0, 0) and Table 4 provides the outcomes of the diagnostic tests for this model.

Table 4: The results of diagnostic testing for the ARDL (1, 1, 0, 0, 0, 0, 0, 0) model

Test	Calculated Statistics	Probability
Breusch-Godfrey Autocorrelation	1.1372	0.3275
Breusch-Pagan-Godfrey Test	1.5605	0.1473
Jargue-Bera Test of Normality	1.1229	0.5704
Ramsey RESET Test	0.4630	0.6450
Coefficient Stability Tests		
CUSUM: Stable*		
CUSUMQ: Stable*		

* Shows statistical significance at the 5% significance level.

Source: Authors

Table 4 reveals that the model is free from autocorrelation and heteroscedasticity, the errors are normally distributed, the functional form is properly specified, and the coefficients of the model remain stable.

Table 5 displays the findings from the ARDL Bounds tests. The bounds test has two basic critical values: lower bound I(0) and upper bound I(1); which are used to determine the final outcome of the test. The null hypothesis of the test is “H₀: There is no cointegration between the variables”. If the F-test statistic obtained from the ARDL test Equation exceeds the upper bound I(1), H₀ is rejected.

Table 5: Results of the ARDL bounds tests

k	F-Statistic	1% Critical Values	
7	5.319239	I(0)	I(1)
		2.17	3.21

Source: Authors

Given that the computed test statistic of 5.3192 exceeds the upper bound critical value of 3.21, we reject the null hypothesis of no cointegration and conclude that cointegration exists between LDEP and LCR, LREM_SA, LFR, RGDP, LIR, CPI, and RSAL. The short-run and long-run coefficient estimates are shown in Table 6.

Table 6: Short-run and long-run coefficient estimates

Short-term Coefficients and Error Correction Model				
Variable	Coefficient	Standard Error	t-Statistics	Probability
LDEP(-1)	-0.319050*	0.075744	-4.212223	0.0001
LCR(-1)	0.187420*	0.061842	3.030625	0.0036
LREM_SA	0.039679**	0.017143	2.314639	0.0240
LFR	0.140340*	0.028875	4.860271	0.0000
RGDP	-0.000219	0.000599	-0.365033	0.7163
LIR	-0.003152	0.007205	-0.437433	0.6633
CPI	-0.001240	0.000643	-1.928043	0.0584
RSAL	0.000184	0.000403	0.456177	0.6499
D(LCR)	0.711183*	0.146398	4.857872	0.0000
CointEq(-1)*	-0.319050*	0.043397	-7.351893	0.0000

Long-term Coefficients				
Variable	Coefficient	Standard Error	t-Statistics	Probability
LCR	0.587431*	0.069877	8.406642	0.0000
LREM SA	0.124366**	0.060522	2.054890	0.0441
LFR	0.439869*	0.068286	6.441529	0.0000
RGDP	-0.000686	0.001893	-0.362346	0.7183
LIR	-0.009878	0.021820	-0.452709	0.6523
CPI	-0.003886	0.002180	-1.782467	0.0796
RSAL	0.000576	0.001263	0.456145	0.6499
C	-1.213361	0.359397	-3.376106	0.0013

*, ** Indicates stationarity at the 1% and 5% significance levels, respectively.

Source: Authors

Deposits are determined by a linear function of their own lagged values and the lagged values of other time series.

According to the results in Table 6, the effect of deposits lag value (-1), loans and its lag value (-1), remittances and foreign exchange reserves, on deposits is statistically significant in the short-run. In the long-run, loans, remittances and foreign exchange reserves, have a statistically significant effect on the deposits.

Consistent with the findings of McLeay et al. (2014a, 2014b) and Matteo & Enrico (2017), our results indicate a significant positive effect of loans on deposit growth. This suggests that an increase in loans triggers bank deposit growth, as the approval of a loan creates a matching deposit in the borrower's bank account, effectively creating new money. Moreover, our results emphasize a notable positive impact of foreign exchange intervention on deposit growth. This is particularly evident in the Republic of North Macedonia, where foreign exchange reserve interventions play a crucial role in stabilization policies.

In the case of North Macedonia versus Eurozone (Corovei & Socol, 2019) or Turkish economy (Yakubu & Abokor, 2020), the Consumer Price Index (CPI) shows a negative effect on deposit growth, though this result is statistically significant at the 10% level.

Furthermore, economic growth, the weighted interest rates on deposits, and the real change in net salaries do not show a statistically significant effect on deposits, neither in the short term nor in the long term. These results differ from those of Corovei & Socol (2019), Nguyen (2022) and Yakubu & Abokor (2020), who observed that deposit interest rates and economic growth have positive influence on bank deposit growth.

Based on the long-run elasticity estimates, a 1% increase in the LCR leads to a 0.59% increase in LDEP; a 1% increase in LREM_SA results in a 0.12% increase in LDEP; a 1% increase in LFR leads to a 0.44% increase in LDEP; and a 1% increase in CPI causes a 0.003% decrease in LDEP in the long-run.

In the short-run, a 1% increase in LDEP results in a 0.32% decline in LDEP with a quarter's delay; a 1% increase in LCR leads to a 0.71% and 0.19% increase in LDEP with a quarter's delay; a 1% increase in LREM_SA causes a 0.04% rise in LDEP; a 1% increase in LFR results in a 0.14% increase in LDEP; and a 1% increase in CPI decreases LDEP by 0.001%.

The lag value of the error correction term (ECTt-1), also known as the speed of adjustment term, is found to be negative and statistically significant (-0.319050). This coefficient indicates

the speed at which the system returns to equilibrium after a shock in the long-run relationship. Based on the estimated value of the ECTt-1, we can conclude that approximately 31.905% of the deviation from the long-run equilibrium is corrected each quarter, indicating a relatively slow adjustment process.

Table 6 displays the contribution of each factor to deposits. It is worth noting that while these factors explain a significant portion of the variation in deposits, they do not account for the entire variation.

Conclusion

Identifying the key factors influencing deposit growth is crucial, particularly for the Central Bank to develop effective policies and strategies. This study examines both the short- and long-run determinants of bank deposit growth in the Republic of North Macedonia.

The developments in deposits from the first quarter of 2006 to the first quarter of 2024 were influenced by various factors. The most significant of these were the Central Bank's management of foreign exchange reserves, credit activity of the commercial banks towards households and firms, and growth in remittances, all of which played a key role in driving total deposit growth.

We provide several recommendations based on the findings. First, since commercial banks' lending activities to firms and households, as well as remittances and foreign exchange reserve interventions, significantly influence deposit growth, efforts to strengthen financial stability should combine macroprudential regulation with an acknowledgment of the positive impact that broader access to bank deposits can have on financial stability. Second, considering that the demand for bank loans and remittances are a significant source of money, monetary policies may use foreign exchange reserve interventions as the most effective measure when tends to reduce liquidity in the real economy. This study focuses on one country, and we encourage future studies that considers panel studies and explores additional factors that could impact bank deposits.

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WHAT DOES IT HAVE TO DO WITH ME? – SOVEREIGN RISK AND HOUSEHOLD BORROWING COSTS

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Abstract

This paper aims to examine the long-term relationship between sovereign risk (measured with government bond yields) and household borrowing costs in ten Eurozone countries from 2012 to 2024. Changes in yield fluctuations are often widely discussed in public discourse, even though their broader implications remain insufficiently clarified. This raises the question of their actual impact on the households. Using the Johansen cointegration method, the study identifies significant long-term connections between sovereign risk and bank lending rates, highlighting the heterogeneous effects across countries. The findings suggest that in some economies (e.g., Spain, Italy, Luxembourg), higher sovereign risk increase household borrowing costs, whereas in others (e.g., Germany, France, Croatia), the relationship is inverse. The results provide crucial insights for policymakers, emphasizing the need to account for country-specific factors when assessing the transmission of sovereign risk to the banking sector.

Keywords: public debt; government bonds; loans; active interest rates; Eurozone

JEL classification: H31, H63, H74, E62, G21

Introduction

The yields on government bonds serve as a measure of a country's sovereign risk and, as such, represent an indicator of the broader economic and financial market conditions. Over the past two decades, Europe has witnessed structural shift in bond yields – ranging from very high levels at the beginning of the period when Sovereign Debt Crisis in Euro Area peaked, through Draghi's quantitative easing that drove yields to historic lows, to the recent resurgence observed in the latter part of the period that came with normalization of monetary policy. The market reaction to macroeconomic outlook changes is very quickly reflected in government bonds yield fluctuations and therefore is often widely discussed in public discourse, even though their broader implications remain insufficiently clarified. This raises the question of their actual impact on the households.

During periods of expansive monetary policy, such as was the case in Euro Area until few years ago, there is a risk that macroeconomic fundamentals and their impact on financing conditions might be overlooked or neglected. The objective of this study is to examine the existence of long-term relationships between sovereign risk and household lending rates in ten selected

Eurozone member states. Also, this paper's methodological contribution lies in its application of the Johansen cointegration method to uncover long-term relationships between sovereign risk and household lending rates. This approach can offer a more nuanced perspective on cross-country heterogeneity than previous studies relying mainly on panel VAR or ARDL models. The findings could be valuable to fiscal policymakers in assessing the effects of utilizing the public debt, as one of the key fiscal policy instruments. As highlighted by Theobald & Tober (2020), among others, adverse changes in sovereign risk negatively affect financing conditions and economic activity in the private sector. Therefore, understanding and managing these effects seems crucial. Finally, findings reveal significant heterogeneity: in countries like Italy, Spain, and Luxembourg, higher sovereign risk is associated with higher household borrowing costs, while in Germany, France, and the Netherlands, the relationship is inverse. In other words, these results underscore the complexity of sovereign risk transmission in the Eurozone and highlight the importance of country-specific financial and policy conditions.

Theoretical Framework and Literature Review

Public debt, as the ultimate manifestation of a country's accumulated fiscal deficits, is one of the fundamental instruments of fiscal policy in sovereign economies. In the same time, public debt financing cost is one of the key macroeconomic indicators. Government securities form the backbone of every developed financial market and serve as the foundation of the financial asset portfolio pyramid – both for individual and institutional investors (Leko & Stojanović, 2018). The primary and most common method of long-term government borrowing is through the issuance of bonds. Bonds are debt securities that establish a credit relationship between the bond issuer as the debtor and the bondholder as the creditor (Orsag, 2015). Various types of bonds exist, classified based on different criteria; however, government bonds are most commonly coupon bonds, traded on regulated financial markets. Specifically, bond markets facilitate both the issuance and trading of bonds and play a crucial role in allocating surplus capital (Saunders & Cornett, 2006). The yields on government bonds directly influence the price of these financial instruments (Orsag, 2015).

Table 1 shows the annual long-term interest rates of bonds of selected countries. Just a brief overview reveals significant heterogeneities among countries. Until mid-2020, there was a noticeable decline in interest rates, with countries like Germany, Luxembourg, and the Netherlands recording the lowest rates – even negative from 2019 to 2021. On the other hand, countries such as Italy, Spain, and Croatia had significantly higher rates, reflecting a higher risk premium and weaker market confidence. In the following period, interest rates surged, driven by the ECB's increase in reference rates aiming to curb inflation. However, substantial differences among countries remain visible. Italy and Spain recorded the largest rate increases, indicating the sensitivity of their financial markets to changes in monetary policy. Germany and Luxembourg, on the other hand, remained among the countries with the most stable and lowest rates. In the same time Croatia, despite reducing borrowing costs after joining the eurozone in 2023, still has higher rates compared to other countries. Even though in 2024 a partial stabilization is observed, differences among countries persist. These trends clearly demonstrate how changes in monetary policy and risk perception influence the borrowing costs of individual eurozone countries.

Table 1: Government long-term interest rates over time, 2011 – 2024

	AT	DE	ES	FR	HR*	IT	LU	NL	SI	SK
2011	3,32	2,61	5,44	3,32	6,54	5,42	2,92	2,99	4,97	4,45
2012	2,37	1,5	5,85	2,54	6,13	5,49	1,82	1,93	5,81	4,55
2013	2,01	1,57	4,56	2,2	4,68	4,32	1,85	1,96	5,81	3,19
2014	1,49	1,16	2,72	1,67	4,05	2,89	1,34	1,45	3,27	2,07
2015	0,75	0,5	1,73	0,84	3,53	1,71	0,37	0,69	1,71	0,89
2016	0,38	0,09	1,39	0,47	3,48	1,49	0,25	0,29	1,15	0,54
2017	0,58	0,32	1,56	0,81	2,77	2,11	0,54	0,52	0,96	0,92
2018	0,69	0,4	1,42	0,78	2,17	2,61	0,56	0,58	0,93	0,89
2019	0,06	-0,25	0,66	0,13	1,29	1,95	-0,12	-0,07	0,28	0,25
2020	-0,22	-0,51	0,38	-0,15	0,83	1,17	-0,41	-0,38	0,08	-0,04
2021	-0,09	-0,37	0,35	0,01	0,45	0,81	-0,36	-0,33	0,07	-0,08
2022	1,71	1,14	2,18	1,7	2,7	3,16	1,73	1,38	1,89	2,07
2023	3,08	2,43	3,48	2,99	3,8	4,28	2,97	2,79	3,4	3,65
2024	2,84	2,32	3,15	2,97	3,31	3,71	2,76	2,62	3,11	3,47

*Croatia joined the Eurozone in 2023

Source: Eurostat

Speaking of banks, credit represents a fundamental banking product with far-reaching implications for the economy, as confirmed by numerous studies. For instance, Korkmaz (2015) examines the effects of bank lending on inflation and economic growth in Eurozone member states, concluding that while lending significantly impacts economic growth, it does not influence inflation. Other studies, such as those by Levine & Zervos (1998) and Dritsaki & Dritsaki-Bargiota (2005) also provide evidence of the positive effects of banking activities on economic growth. Conversely, research by Leitão (2009) and Kudar (2024) acknowledges a correlation between banking activities and economic growth but highlights potential negative effects. Regardless, the critical role of credit in the economy is undeniable. Finally, when discussing credit, it is essential to mention its core component - interest rates. The cost of using borrowed funds, or the price of a bank loan, is the active interest rate, which depends on the principal, maturity, and interest rate level (Leko & Stojanović, 2018).

The following section presents an overview of existing research and findings. Even a brief review reveals that literature on this topic is relatively scarce, particularly concerning Croatia. Only a few studies are available, primarily focused on developments related to the Eurozone sovereign debt crisis. For example, Zoli (2013) investigates how volatility in Italian government bond spreads influences banks' financing costs and corporate lending conditions in the short term. The study finds that an increase in Italian government bond spreads significantly raises yields on Italian bank bonds, which are then quickly transmitted to corporate lending rates (30-40% within three months and 50-60% within six months), consequently slowing credit growth. Similarly, Neri (2013) demonstrates that changes in required bond yields significantly increase banks' active interest rates in Italy, Spain, Portugal, and Greece (countries referred to as the "periphery"), whereas these effects are absent in countries like Germany and France. The study covers ten Eurozone countries – Italy, Spain, Portugal, Greece, Germany, France, Belgium, Austria, the Netherlands, and Finland – over the period from 2003 to 2012.

Furthermore, Albertazzi *et al.* (2014) examine how fluctuations in government borrowing costs affected the Italian banking sector from 1991 to 2011. The study focuses on the transmission

channel of risk from government bonds to the banking sector, driven by changes in spreads between Italian and German government bond yields. Among other findings, the study highlights the impact on active interest rates, showing that wider spreads significantly increase lending rates for both businesses and households. During the crisis, the spread transmission effect was stronger for corporate loans (around 50 basis points for a 100 basis point increase in the spread) than for household mortgage loans (around 30 basis points).

Theobald & Tober (2020) attempt to quantify the transmission effects of changes in Eurozone government bond spreads on private sector borrowing costs, accounting for asymmetric and heterogeneous effects across countries. Specifically, they examine how government bond spreads influence private sector interest rates in ten Eurozone countries from 2003 to 2017. Their findings indicate substantial heterogeneity across countries; however, in all cases, an increase in the spread leads to higher active interest rates.

Finally, one of the most recent studies – and the only one to date that includes Croatia – is the research conducted by Havolli (2023). The author investigates how government borrowing costs influence private sector lending conditions and macroeconomic outcomes in eight transition economies from 2003 to 2016, employing panel vector autoregression (VAR), models and impulse response functions. The findings suggest that a one-percentage-point increase in required government bond yields raises corporate borrowing costs by 0.59 percentage points and household borrowing costs by 0.50 percentage points within two years. Additionally, the study identifies a spillover effect on the broader economy, with investment and GDP growth significantly declining in response to higher government borrowing costs. These effects are particularly pronounced in economies with weaker fiscal positions or greater exposure to external debt.

In the end, while prior studies such as Zoli (2013) primarily focused on short-term effects of sovereign risk on bank lending conditions, this paper explicitly emphasizes the long-term perspective. Short-term analyses may overlook structural relationships that persist across economic cycles and policy changes. By applying the Johansen cointegration method, this research addresses this gap and captures these enduring linkages. This approach not only adds depth to literature but also strengthens the policy relevance of the findings for long-term fiscal and monetary strategies.

Data and methodology

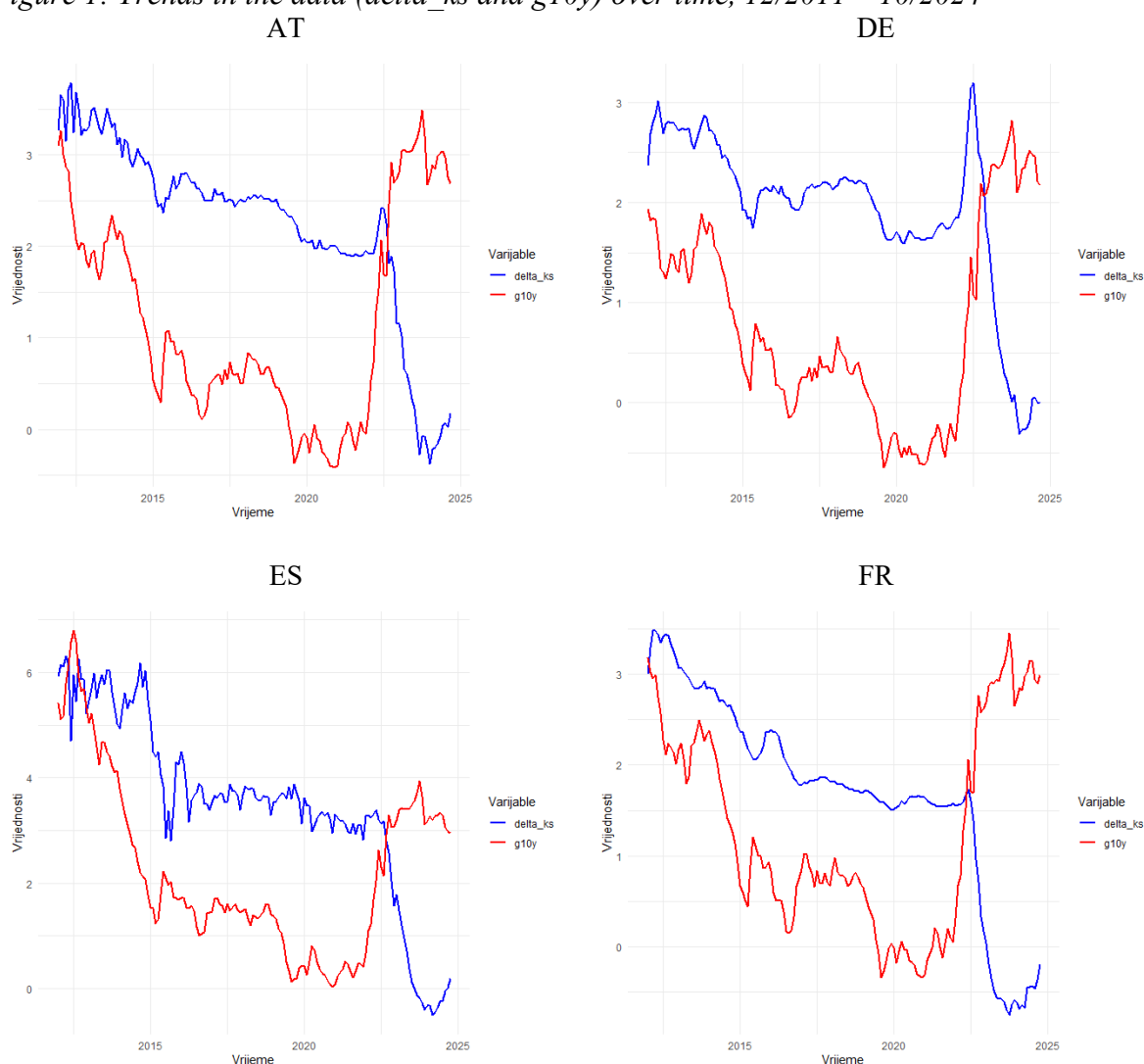
This study uses monthly data for ten selected Eurozone member states over the period from January 2012 to September 2024. To get a broader picture a set of ten eurozone countries are chosen. Those countries are heterogenous and represent both so-called core and periphery countries. The countries included in the analysis are Austria, Germany, Spain, France, Croatia, Italy, Luxembourg, the Netherlands, Slovenia, and Slovakia. The data were collected from the official websites of Eurostat and the European Central Bank (ECB).

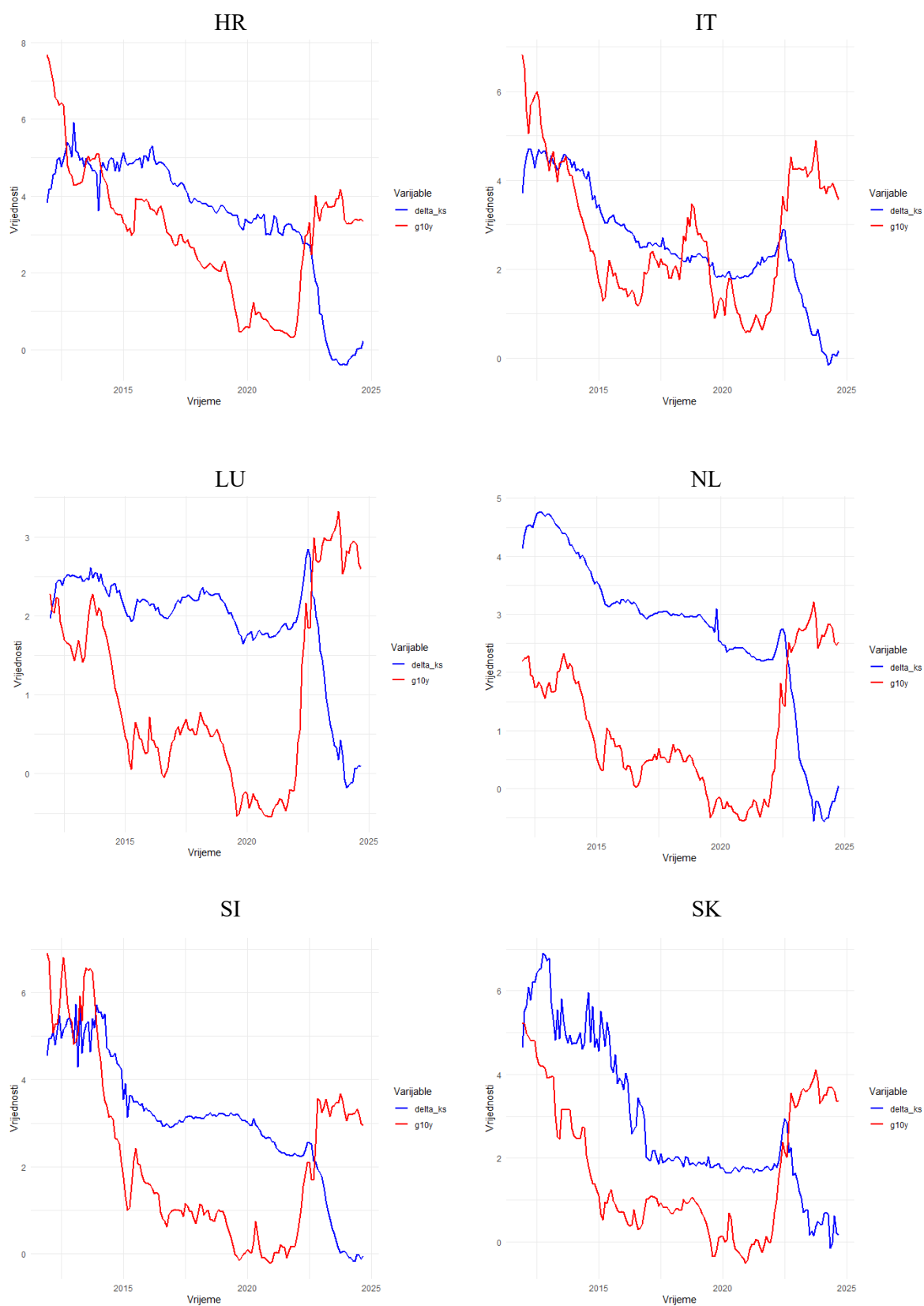
To isolate the effects of monetary policy reference rates, a variable representing the country's risk premium was constructed. This was calculated by subtracting the money market interest rate (Euribor-1m) from households active lending rates, as Euribor-1m serves as the benchmark rate for determining interest rates on new credit agreements. The sovereign risk is represented with the nominal interest rates on ten-year government bonds. Additionally, the control variables used in the analysis include the monthly inflation rate (HICP) and deposit interest rates for

households (passive interest rates), following the methodology of Theobald & Tober (2020). The dynamics of the risk premium (Δ_{KS}) and the sovereign risk (g_{10y}) over time for the selected countries are illustrated in Figure 1.

Analyzing the trends of the risk premium and sovereign risk over time across the ten Eurozone members reveal notable patterns and differences among countries. The most significant fluctuations are observed in Italy and Spain, where pronounced volatility in both variables is evident. In contrast, more stable trends are observed in countries such as Germany and the Netherlands, indicating lower risk levels and greater resilience to market shocks. Croatia and Luxembourg also exhibit interesting patterns in the movement of these variables, with differences in amplitudes and responses to key economic events. These findings show the heterogeneity of the Eurozone and underscore the importance of further investigating their correlation on the level of individual countries to maintain financial stability.

Figure 1: Trends in the data (Δ_{KS} and g_{10y}) over time, 12/2011 – 10/2024





Source: authors

In order to examine the long-term relationship between the specified variables, this study employs the Johansen cointegration method. Previous research has utilized various methods depending on the research objectives and the variables involved. For instance, Zoli (2013) and Havolli (2023) applied VAR model, while Neri (2013), Albertazzi *et al.* (2014), and Theobald & Tober (2020) used the autoregressive distributed lag (ARDL) method for testing critical values. Meanwhile, cointegration analysis has been employed in studies such as Eller & Reininger (2016).

Compared to other methods, such as ARDL or panel VAR models, the Johansen method has the advantage of allowing the analysis of multiple long-run relationships simultaneously. This is particularly useful in the context of different economic policies and structures within the euro area. However, although methodologically it covers heterogeneity across countries well, this method does not consider possible structural changes, such as an increase in the ECB's reference interest rates or Croatia's entry into the euro area in 2023. This can be one limitation of the research that must be acknowledged. This is why this should be an important direction for future research, where methods that take these turning points into account.

Before conducting the cointegration analysis, multicollinearity tests were performed. Multicollinearity arises when two independent variables in the model are highly correlated or approximately linearly dependent, leading to biased estimations. The results indicate no significant multicollinearity issues. In the second step, the data were log-transformed and differenced. Subsequently, stationarity tests were conducted on the first differences of the selected variables using the Augmented Dickey-Fuller (ADF) test. The ADF test is a unit root test that extends the original Dickey-Fuller (DF) test, first developed by Dickey and Fuller in 1979. It evaluates stationarity by comparing test statistics with critical values from the DF distribution (Jakšić *et al.*, 2020). The t-statistic and p-values from the ADF test are presented in Table 2. The results confirm that the variables are stationary in their first differences, $I(1)$, allowing for further analysis.

Table 2: Results of the ADF test (t-statistics and p-values) for the variables used in the model

Country	Variable	$z.lag.1$
AT	dln_delta_ks	-14.680*** (< 2e-16)
	$dln\_ks\_depoziti$	-8.100*** (1.88e-13)
	dln_hicp	-9.085*** (6.19e-16)
	dln_g10y	-8.066*** (2.28e-13)
DE	dln_delta_ks	-14.594*** (< 2e-16)
	$dln\_ks\_depoziti$	-8.059*** (2.37e-13)
	dln_hicp	-10.967*** (< 2e-16)
	dln_g10y	-9.490*** (< 2e-16)
ES	dln_delta_ks	-14.124*** (< 2e-16)
	$dln\_ks\_depoziti$	-7.145*** (3.72e-11)
	dln_hicp	-10.741*** (< 2e-16)
	dln_g10y	-8.423*** (2.84e-14)
FR	dln_delta_ks	-13.884*** (< 2e-16)
	$dln\_ks\_depoziti$	-8.293*** (6.03e-14)
	dln_hicp	-10.991*** (< 2e-16)
	dln_g10y	-9.046*** (7.45e-16)
HR	dln_delta_ks	-15.356*** (< 2e-16)
	$dln\_ks\_depoziti$	-8.782*** (3.65e-15)
	dln_hicp	-11.326*** (< 2e-16)
	dln_g10y	-10.261*** (< 2e-16)

Country	Variable	<i>z.lag.1</i>
IT	<i>dln_delta_ks</i>	-13.862*** (< 2e-16)
	<i>dln_ks_depoziti</i>	-8.154*** (1.38e-13)
	<i>dln_hicp</i>	-13.824*** (< 2e-16)
	<i>dln_g10y</i>	-7.923*** (5.11e-13)
LU	<i>dln_delta_ks</i>	-12.702*** (< 2e-16)
	<i>dln_ks_depoziti</i>	-14.183*** (< 2e-16)
	<i>dln_hicp</i>	-11.974*** (< 2e-16)
	<i>dln_g10y</i>	-8.744*** (5.35e-15)
NL	<i>dln_delta_ks</i>	-12.493*** (< 2e-16)
	<i>dln_ks_depoziti</i>	-8.123*** (1.6e-13)
	<i>dln_hicp</i>	-11.331*** (< 2e-16)
	<i>dln_g10y</i>	-8.713*** (5.27e-15)
SI	<i>dln_delta_ks</i>	-15.033*** (< 2e-16)
	<i>dln_ks_depoziti</i>	-9.042*** (7.97e-16)
	<i>dln_hicp</i>	-12.418*** (< 2e-16)
	<i>dln_g10y</i>	-9.553*** (< 2e-16)
SK	<i>dln_delta_ks</i>	-14.710*** (< 2e-16)
	<i>dln_ks_depoziti</i>	-9.937*** (< 2e-16)
	<i>dln_hicp</i>	-9.038*** (8.15e-16)
	<i>dln_g10y</i>	-10.054*** (< 2e-16)

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: authors

In this analysis, the Johansen cointegration method was applied to the variables in their levels, which is a common practice for capturing long-term relationships in time series that are not stationary. The lag length was chosen according to the Akaike Information Criterion (AIC), and the cointegration vectors were normalized to the risk premium variable to facilitate interpretation. This approach enables the focus of the research to find equilibrium relationships between variables, rather than short-term deviations.

Cointegration of two or more variables assumes that they maintain a long-term equilibrium relationship. When analyzing a set of variables with more than two components, the standard Engle-Granger approach becomes inadequate, and Johansen's method is used as an alternative. Johansen's method is one of the most commonly applied techniques in cointegration analysis, determining the number of cointegration relations based on the rank of the matrix (Bahovec & Erjavec, 2009). At the beginning, we assume a VAR model defined with n variables and a lag length of k :

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \dots + A_k Z_{t-k} + e_t. \quad (1)$$

The idea behind this method is to estimate a Vector Error Correction (VEC) model

$$\Delta \hat{Z}_t = \hat{\Gamma}_1 \Delta Z_{t-1} + \hat{\Gamma}_2 \Delta Z_{t-2} + \dots + \hat{\Gamma}_k \Delta Z_{t-k+1} + \hat{\Pi} Z_{t-k} \quad (2)$$

and calculate the eigenvalues $\hat{\lambda}_i$ of the estimated matrix Π ($\hat{\Pi}$). The eigenvalues, ordered in decreasing size with $\hat{\lambda}_1$ being the largest and $\hat{\lambda}_n$ the smallest, can be written as:

$$1 > \hat{\lambda}_1 \geq \hat{\lambda}_2 \geq \dots \geq \hat{\lambda}_n > 0. \quad (3)$$

The number of cointegration relations, or the rank of the matrix, is equal to the number of eigenvalues $\hat{\lambda}_i$ that are different from zero. In this analysis, two test statistics will be used to determine the number of cointegrated vectors: λ_{trace} and λ_{max} . The test statistic in the λ_{trace} test can be written as:

$$\lambda_{\text{trace}} = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \quad (4)$$

where T represents the number of observations, r is the number of cointegration vectors, n is the number of variables, and $\hat{\lambda}_i$ are the eigenvalues. Thus, the hypotheses for the test are defined as:

$$\begin{aligned} H_0: \lambda_{r+1} = \lambda_{r+2} = \dots = \lambda_n = 0 \\ H_1: \lambda_{r+1} \neq 0. \end{aligned} \quad (5)$$

On the other hand, the test statistic for the λ_{max} test can be written as:

$$\begin{aligned} \lambda_{\text{max}} = \lambda_{\text{max}}(r) = -T \cdot \ln \ln(1 - \hat{\lambda}_{r+1}), \\ r = 0, 1, 2, \dots, (n-2), (n-1) \end{aligned} \quad (6)$$

where $\hat{\lambda}_{r+1}$ represents the $(r+1)$ -th eigenvalue, and the hypotheses for the test are defined as:

$$\begin{aligned} H_0: \lambda_{r+1} = r \\ H_1: \lambda_{r+1} = r + 1. \end{aligned} \quad (7)$$

Results

The Johansen cointegration analysis for the selected countries revealed a varying number of long-term relationships among the variables. Most countries (Austria, Germany, Spain, France, Croatia, Italy, Luxembourg, and Slovakia) have three cointegration vectors, indicating strong long-term connections among the variables. On the other hand, the Netherlands and Slovenia have two cointegration vectors, which still suggests robust long-term relationships.

Furthermore, the results of the normalized cointegration vector, where the value of the risk premium is equal to one, indicate the existence of long-term relationships between risk premium and the sovereign risk. The values of the cointegration vector represent the impact of the risk on long-term equilibrium, with both the magnitude and sign of the coefficients being equally important. Positive coefficients (Spain, Italy, Luxembourg, Slovenia, and Slovakia) suggest that an increase in sovereign risk leads to an increase in the risk premium, while negative coefficients (Austria, Germany, France, Croatia, and the Netherlands) indicate an inverse relationship. The intensity of the effect varies across countries, with the strongest effect observed in Luxembourg and the weakest in Germany. The results are significant as they provide insight into the diversity of responses of Eurozone member states to changes. A more detailed presentation of the results of the analysis is shown in *Table 3*.

These findings underscore the complexity of sovereign risk transmission in the Eurozone and highlight the importance of country-specific financial and policy conditions. The results are particularly relevant for monetary and fiscal policymakers, as they emphasize the need to

monitor yield movements and consider their potential spillover effects on household credit markets.

Table 3: Results of the Johansen Cointegration Method

Country	Cointegration vector – value for g10y	r	Trace Statistic	0.05 Critical Value (Trace Statistic)	Max Eigen value	0.05 Critical Value (Max Eigen value Statistic)
AT	-0.44099696	0	319.33	53.12	135.26	28.14
		1	184.07	34.91	79.48	22.00
		2	104.59	19.96	54.88	15.67
		3	49.70*	9.24	49.70*	9.24
DE	-0.20291765	0	370.15	53.12	135.33	28.14
		1	234.81	34.91	114.09	22.00
		2	120.73	19.96	70.22	15.67
		3	50.50*	9.24	50.50*	9.24
ES	0.04832131	0	328.45	53.12	129.02	28.14
		1	199.43	34.91	97.27	22.00
		2	102.16	19.96	58.22	15.67
		3	43.93*	9.24	43.93*	9.24
FR	-0.03690827	0	348.80	53.12	129.12	28.14
		1	219.67	34.91	98.08	22.00
		2	121.60	19.96	65.13	15.67
		3	56.47*	9.24	56.47*	9.24
HR	-0.53430276	0	392.19	53.12	148.40	28.14
		1	243.79	34.91	111.11	22.00
		2	132.68	19.96	74.75	15.67
		3	57.93*	9.24	57.93*	9.24
IT	2.118979507	0	369.92	53.12	135.02	28.14
		1	234.90	34.91	122.41	22.00
		2	112.49	19.96	66.85	15.67
		3	45.64*	9.24	45.64*	9.24
LU	8.26224501	0	93.73	53.12	39.07	28.14
		1	54.29	34.91	27.19	22.00
		2	27.11	19.96	16.73	15.67
		3	10.38*	9.24	10.38*	9.24
NL	-0.18701377	0	100.83	53.12	44.40	28.14
		1	56.43	34.91	35.94	22.00
		2	20.49*	19.96	16.83*	15.67
		3	3.66	9.24	3.66	9.24
SI	2.86103146	0	126.91	53.12	62.38	28.14
		1	64.53	34.91	40.06	22.00
		2	24.47*	19.96	17.93*	15.67
		3	6.54	9.24	6.54	9.24
SK	0.11551094	0	361.57	53.12	138.13	28.14
		1	223.44	34.91	83.44	22.00
		2	140.01	19.96	77.39	15.67
		3	62.62*	9.24	62.62*	9.24

* rejection of the null hypothesis at $p = 0.05$

Source: authors

These results show that there are significant differences across countries in the way in which sovereign risk is transmitted to households' borrowing costs, which can be explained by the

different macroeconomic circumstances, the structure of their banking systems and the fiscal discipline of each country. In Italy, Spain and Luxembourg, where the cointegration vector has a positive sign, higher sovereign risk directly increases households' borrowing costs. This is mainly associated with higher public debt, more volatile economic conditions and higher bank exposure to domestic sovereign bonds – which strengthens the link between the state and the banking sector, as also pointed out by Zoli (2013) and Albertazzi et al. (2014). On the other hand, in Germany, France and the Netherlands the link is negative, which may indicate stronger fiscal positions and more diversified financial systems that can more easily absorb sovereign risk without greater spillover to households (Neri, 2013; Theobald & Tober, 2020).

Compared to previous studies, the intensity and direction of the impact in this paper confirm earlier findings for Italy and Spain, while the results for Germany and France are in line with findings showing greater resilience of core countries. However, a particularly interesting finding is for Luxembourg and Croatia, for which there have been almost no studies so far, and this paper provides new insights.

These differences suggest that policy recommendations will also depend on the specificities of each country. For countries that are particularly sensitive to changes in yields, such measures to strengthen the fiscal position, diversify funding sources of the banks as well as to reduce banks direct exposure to government bonds would be useful.

Conclusion

In conclusion, it is important to reiterate the key research motivations and results. The existing literature lacks studies on the effects of government debt price movements on active bank interest rates. This is especially true for Croatia, which, as shown in the literature review, has been addressed in only one study so far. On the other hand, given the recent developments in the public debt market, the need to understand the direction and strength of these effects is clear. Therefore, this research can serve not only the academic community but also policymakers – essentially the navigators of economic policies.

The Johansen cointegration analysis revealed varying numbers of long-term relationships among the variables for the Eurozone member states. Most of the analyzed countries exhibit strong long-term connections with three cointegration vectors, while the Netherlands and Slovenia have two, indicating significant relationships as well. The impact of sovereign risk on the risk premium varies in magnitude and sign of the cointegration vector. A positive relationship is observed in Spain, Italy, Luxembourg, Slovenia, and Slovakia, suggesting that an increase raises the risk premium. Conversely, a negative relationship is seen in Austria, Germany, France, Croatia, and the Netherlands, indicating the opposite effect. In terms of intensity, the effect is strongest in Luxembourg and weakest in Germany. These findings provide significant insights into the heterogeneous responses of European countries to changes in financial markets.

This research offers valuable insights into the relationship between sovereign risk and household lending's, highlighting the need for robust risk management and sound economic policies to mitigate the spillover effects of sovereign debt crises. Future analyses could explore the causes of heterogeneity among the countries, particularly in the case of Croatia.

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NETWORK ANALYSIS OF CROBEX: TWO SNAPSHOTS OF MARKET STRUCTURE

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Abstract

This study performs network analysis across CROBEX constituents during two time periods: 2008, during the global financial crisis, and 2023, in a more stable post-pandemic economy. The network is created from partial correlations of logarithmic stock returns followed by calculating key network properties such as density, clustering, assortativity, centrality and modularity. The results suggest that the 2008 network was more integrated and centralized, with higher clustering, shorter path lengths, and negative assortativity, implying a hub-and-spoke structure dominated by large stocks. In contrast, the 2023 network is more segmented, with increased modularity, positive assortativity, and less systemic interdependence, reflecting a shift toward more localized stock relationships. These findings are consistent with earlier research on financial networks during crises and also point to a long-term transition toward decentralized market structures. The study contributes to the literature on financial market interconnectedness and systemic risk by providing empirical evidence for Croatian stock market. Future study may investigate stock-level centrality patterns over time, assess network features as possible crisis indicators, and compare portfolio strategies based on central vs peripheral stocks. The findings highlight the significance of network-based techniques to analyzing market stability, risk assessment, and investment strategies.

Keywords: financial networks, systemic risk, market segmentation, stock market structure, CROBEX

JEL classification: G10, G14, C45

Introduction

In recent years, financial network analysis has gained a lot of attention, especially in the fields of risk assessment, market dynamics, and portfolio creation. Numerous tools, such as threshold networks, correlation-based networks, and methods based on random matrix theory, have been described for employing network science to analyze and assess financial markets. In financial network research, correlation-based networks are a popular method where stocks serve as nodes and edges connect them to show statistically significant relationships. One of the fundamental models was created by Mantegna (1999), who used correlation matrices to reveal the

hierarchical structure of financial markets. By using more potent filtering strategies to find significant correlations between assets, later research has improved this approach (Tumminello et al., 2005; Tumminello et al., 2010).

A relatively recent method for representing financial networks is the P-threshold approach. A technique for building stock networks that employs t-test-based filtering to guarantee that only statistically significant correlations are kept in the network was proposed by Xu et al. (2017). By eliminating the impact of market-wide fluctuations, which frequently mask the underlying relationships between individual stocks, this method provides a more reliable depiction of financial market structures.

Systemic risk and financial crises have also been studied using network analysis. Heiberger (2014) investigated how financial networks react to recessions and found that market structures brought on by crises become more integrated and centralized. Additionally, he noted that amid financial turmoil, a more densely linked network replaces the disassortative structure of stable markets. Conversely, Kenett et al. (2015) investigated the correlations and interconnection of global financial markets and their implications for financial stability.

The structural evolution of market interdependence among CROBEX index members across two time periods—2008, during the global financial crisis, and 2023, in a more stable post-pandemic economy—is examined in this paper using network analysis. In order to determine how stock return dependency has changed over time, the main goal is to construct and analyze correlation and partial correlation structures and underlying networks. The study's foundation is established financial network analysis technique, particularly systemic risk assessment and correlation filtering. This article employs conditional partial correlations to create networks by removing the impact of the overall market factor (CROBEX index returns in this case), in keeping with previous research emphasizing the need to distinguish between firm-specific dependencies and market-wide impacts. This method enables a more thorough analysis of stock relationships, exposing idiosyncratic interactions as well as possible changes in market segmentation, the transmission of systemic risk, and structural stability.

To achieve this, stock return dependencies are reflected using Spearman rank correlation coefficients, and only statistically significant connections are kept in the network using a P-threshold filtering technique created by Xu et al. (2017). Essential network characteristics like modularity, density, clustering, assortativity, and centrality metrics are gathered and compared between 2008 and 2023. The history of stock clusters and risk concentrations can be seen by using the community detection approach to analyze the evolution of market segmentation over time.

By combining visual and quantitative network analysis, this study contributes to existing understanding of market structure dynamics. It focuses on how financial crises change stock interdependencies and how markets recover from systemic shocks. The findings are meant to shed fresh light on how financial networks may be used to spot structural shifts, market instability, and opportunities for investment diversification.

The following section examines relevant literature on financial networks, systemic risk, and correlation-based market systems. The section on data and methodology follows, which describes dataset compilation, network development using partial correlations, and essential network metrics. The results section covers correlation analysis, network features, and market

segmentation between 2008 and 2023. The paper concludes by summarizing significant findings, their implications for market stability, and future research prospects.

Literature review

Finance studies have long researched risk-return tie and capital allocation under uncertainty. Fundamental theories such as mean-variance analysis (Markowitz, 1952) and the Capital Asset Pricing Model (CAPM) form the basis of modern investment analyses. The CFA Program Curriculum has been built on these foundational ideas. However, as mentioned in the discussion, empirical evidence increasingly shows that interdependencies among assets are more complex than traditional models imply. (CFA Institute, 2023)

Stock markets reflect both firm-specific fundamentals and broader market sentiment. Studies on market microstructure reveal that factors such as liquidity, trading volume, and price reversals influence stock return behavior. The study about impacts on the liquidity ratio (Bogdan et al., 2012) investigate the Croatian stock market. Specifically, the authors examine how key factors: market capitalization, the number of issued stocks and trading volumes influence the liquidity ratio, using Amihud's liquidity ratio as their main measure. Their analysis, based on the data from the Zagreb Stock Exchange, finds that larger companies by market capitalization tend to exhibit higher liquidity, also that an increased number of issued shares is positively correlated with higher liquidity. Furthermore, they claim that higher trading volumes are associated with improved liquidity, as they facilitate quicker and smoother conversion of stocks into cash. This understanding of liquidity and its determinants is vital for interpreting stock return behavior, especially in smaller markets where liquidity constraints are more severe. While the Bogdan et al. (2012) study focuses specifically on the Croatian market, another study (Avramov et al., 2006) investigates how liquidity, alongside trading volume, influences price reversals and return autocorrelations in a broader market context. Their findings indicate that stocks with high turnover, but low liquidity display the largest short-run reversals, but with smaller contrarian trading profits than the associated transaction costs.

Furthermore, (Zoričić et al., 2020) explore factor-based optimization of fundamentally weighted portfolios in the Croatian market. Their work applies principal component analysis to capture underlying risk factors. In-sample tests indicated that the factor-based optimization approach significantly improved portfolio performance relative to the benchmark. However, the out-of-sample tests showed poor performance, suggesting that although the model fit the historical data well, it did not translate into real-world gains when applied to new data. Also, they mention that such results are contrary to those in the developed markets.

Network analysis offers an alternative approach for modelling the interdependencies among financial assets. The study by (Namaki et al., 2011) uses Random Matrix Theory (RMT) to construct a financial market network that reflects only statistically significant correlations between stocks. The paper focuses on two key aspects. Threshold method for noise filtering and topological analysis of the filtered network. The authors first calculate the correlation matrix from stock return data. They then introduce a thresholding procedure designed to eliminate spurious correlations, that is correlations that arise simply due to noise rather than true interdependencies between individual stocks. A crucial step in their approach is the removal of the market effect, a common factor affecting all stocks, which ensures that the remaining correlations are reflective of genuine relationships. This method allows them to build a network where an edge between two nodes (stocks) is drawn only if the absolute correlation

exceeds a carefully chosen threshold. After applying the threshold, the paper examines the resulting network's structure by analyzing its degree distribution, clustering coefficients, and component numbers. One of the findings is that, over certain intervals, the degree distribution follows a power-law behavior. This indicates that a few stocks act as highly connected hubs, which can have significant implications on portfolio management.

Another study by (Millington & Niranjana, 2021) takes this a step further by exploring how using rank-based correlation measures can improve the construction of minimum spanning trees (MST), a network showing only the most important relationships, from stock return data. While traditional methods often rely on Pearson's correlation to gauge the relationships between stock returns, Pearson's approach assumes normality and is sensitive to outliers. In contrast, rank-based methods assess correlations based on the ranking of returns rather than their actual values. This makes them less vulnerable to extreme values and non-normal distributions that are common in financial data. The study finds that MSTs constructed using rank-based correlations tend to be more robust over time.

Noteworthy are the findings that portfolios constructed using peripheral stocks, those with lower degree of centrality, tend to outperform more central stocks (Mo & Chen, 2021). Furthermore, Li et al. (2019) use network filtering approach and peripherality measures for portfolio optimization shows significant advantages with respect to classical approaches. Chuulun (2017) examines the impact of financial connectedness of countries on international stock market co-movement using network analysis. Yan et al. (2024) propose return-on-equity networks for portfolio optimization reaching reached 13.20% compared with 6.02% of the Shanghai Stock Exchange (SSE) Composite Index. Moreover, survey on network analysis in economics and finance can be found in the work of Esmalifalak & Moradi-Motlagh (2024), while a broader perspective is given by Sutiene et al. (2024) who review literature on applications of artificial intelligence in portfolio management, including network analysis.

Research on other Central and Eastern European (CEE) stock markets and similarly small or emerging economies reveals patterns that are similar to those found in Croatia. Several studies show that, in times of crisis, stocks within these markets tend to become more interconnected, with a few dominant stocks emerging as central hubs. For example, a recent network study of the Polish stock market during the COVID-19 outbreak found that in the most "turbulent" period (early 2020) the correlation network took on a star-like shape, where many smaller stocks were closely tied to one or two highly connected firms. By contrast, in a calmer 2021 period that centralized pattern dissolved and the network became more evenly distributed (Tomeczek, 2022). Similar hub-and-spoke structures have been observed under stress in other small markets, which were relatively segmented from global markets before 2008, became highly integrated during the 2008–2009 crisis (Nikkinen et al., 2020).

Data and methodology

Two time intervals are taken into consideration: the first one relates to one of the two 2008 revisions, which took place between March 24 and March 20, 2008, and the second one corresponds to one of the two 2023 revisions, which took place between March 2023 and March 15, 2024. The historical daily stock prices of every security that was a part of the CROBEX at any point of time were used to create the dataset. This was accomplished by compiling an extensive collection of past prices using CROBEX composition data. To create a consolidated time series, stock prices are appended iteratively, guaranteeing that only stocks that are part of

the composition dataset are kept. To ensure consistency, stock metadata is assigned from the composition dataset and the final dataset is organized chronologically by date and stock symbol. The data is split- and consolidation-adjusted.

In order to monitor changes in stock composition over time, the dataset also includes information on CROBEX modifications. Based on these revisions, data extractions are carried out, capturing specified revision periods by filtering stock prices based on revision start and finish dates. Stocks having a high percentage of missing values are eliminated to guarantee the validity of the data (those traded at least 2/3 of the observed time interval are only kept). After processing, the dataset is put into a structured format that can be used for further analysis.

Daily logarithmic stock returns are computed upon which the network analysis is performed. Spearman rank correlation coefficients are computed between stock returns. However, the network construction is based on conditional partial correlations, which consider returns after removing market index effects (Xu et al., 2022). Namely, we calculate excess returns by removing the market return component using a linear regression model applied to each company using the market factor (CROBEX returns). Idiosyncratic (specific, residual) returns are computed representing the actual corresponding return of the stock. Correlation matrices were examined before and after market factor removal to demonstrate the influence of these changes. Then the network analysis is performed on the idiosyncratic returns by calculating Spearman rank correlation coefficients and proceeding with network construction and extraction of its key properties.

The foundation of network analysis methodology here is essentially the creation of an adjacency matrix by the application of a correlation criterion, which guarantees that only statistically significant relationships ($p\text{-value} < 0.05$) are included (Xu et al., 2022). After that, a weighted network representation is produced to provide more in-depth understanding of stock interactions. The edges are weighted to indicate correlation strength and colored to distinguish between positive and negative associations.

To examine network topological features, essential metrics such as graph density, structure, centrality measures and clustering/community related measures are generated. These measures, which are frequently employed in network analysis (e.g., Newman, 2010; Barabási, 2016; Xu et al., 2022; Battiston et al., 2012), highlight major entities, structural links, and network weaknesses, offering information about systemic stability and market behavior.

Graph density shows the ratio of actual connections to all possible connections, giving an overall sense of how interconnected the network is. Assortativity is the Pearson correlation between the degrees of node pairs connected by edges which indicates whether nodes tend to connect with others that have a similar number of links, revealing if highly connected nodes prefer one another. Clustering coefficients tell us how strongly nodes tend to cluster together, highlighting the presence of tightly knit groups. The average shortest distance between any two nodes in the network indicate higher efficiency in flow within the network.

Vertex centrality measures are computed to assess the influence of each stock within the network. Degree centrality, measures the number of direct links each node has, while strength centrality considers the weight of these links, reflecting not only the number but also the intensity of interactions. Betweenness centrality quantifies how often a particular node appears on the shortest paths between other nodes. Closeness centrality measures the average distance of a node to all others, showing how “quickly” a stock can connect to the entire network.

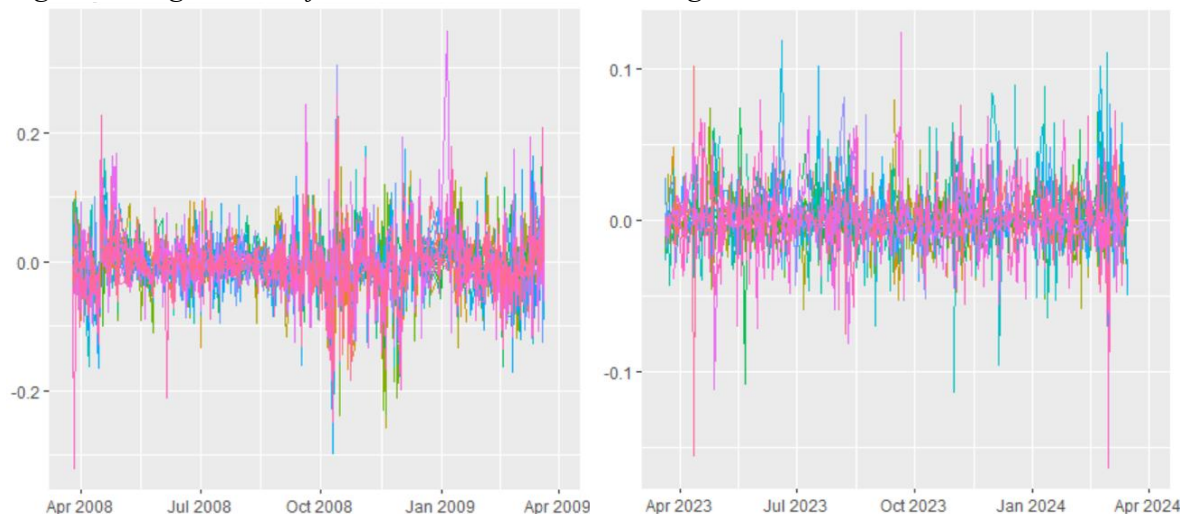
Meanwhile, eigenvector centrality evaluates a node's importance by considering the influence of its neighbors, emphasizing stocks connected to influential partners. The average values of these measures provide insights into the overall distribution of influence in the network.

The fast-greedy modularity optimization algorithm by Blondel et al. (2008) is used to find communities and identify cohesive stock groups. In this context, modularity scores indicate how well the network can be divided into distinct groups (clusters) where connections are dense within groups and sparse between them, while the community sizes are determined by counting the number of nodes in each group. Modularity compares the actual number of edges within communities to the expected number of such edges if connections were random. Maximum clique is the largest set of nodes where each node is directly linked to every other member of the group. It allows observing the stock moving more closely together than the rest of the market. While largest clique relates to the strongest mutual ties between a group of stocks, modularity indicates macro-level segmentation by relating to the degree to which the entire market network breaks into separate communities. All analyses, from pre-processing to network creation, were performed in R (R Core Team, 2024).

Results

Figure 1 depicts the log returns of CROBEX constituents in two panels, covering the period during which the observed revisions took place (from the first day of the initial revision to the last day of the final observed revision). The left panel shows the log returns for stocks listed in CROBEX during either of the two revisions in 2008, while the right panel shows logarithmic returns for stock listed in CROBEX during either of the two revisions in 2023. Different stocks are represented by different colors.

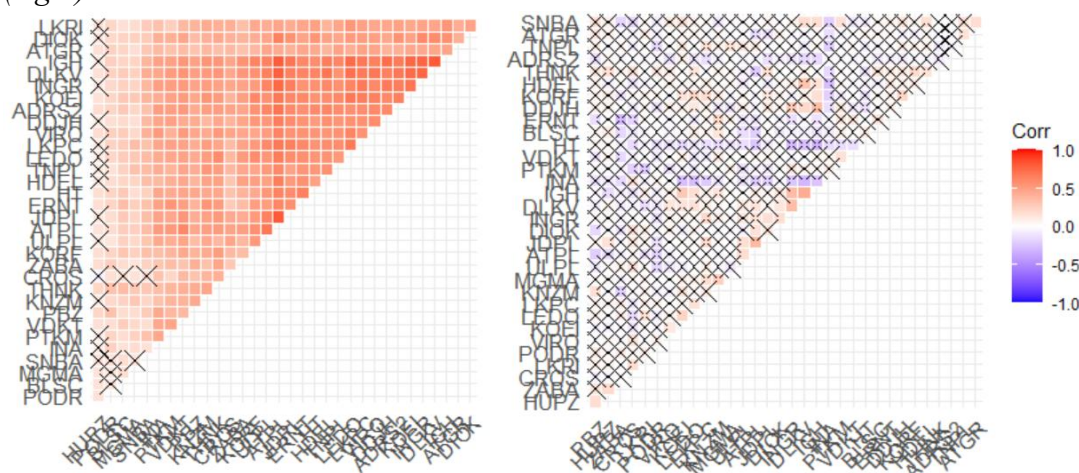
Figure 1: Log returns of CROBEX constituents during observed revisions



Source: authors

Figure 2 shows the log return correlation matrices for the 2008 CROBEX revisions. The left panel displays the original correlations before any changes, while the right panel displays the conditional partial correlations i.e. correlations after factor removal. This comparison demonstrates how factor removal alters the structure of return correlations, revealing more meaningful linkages between individual stocks by filtering out market-wide factors.

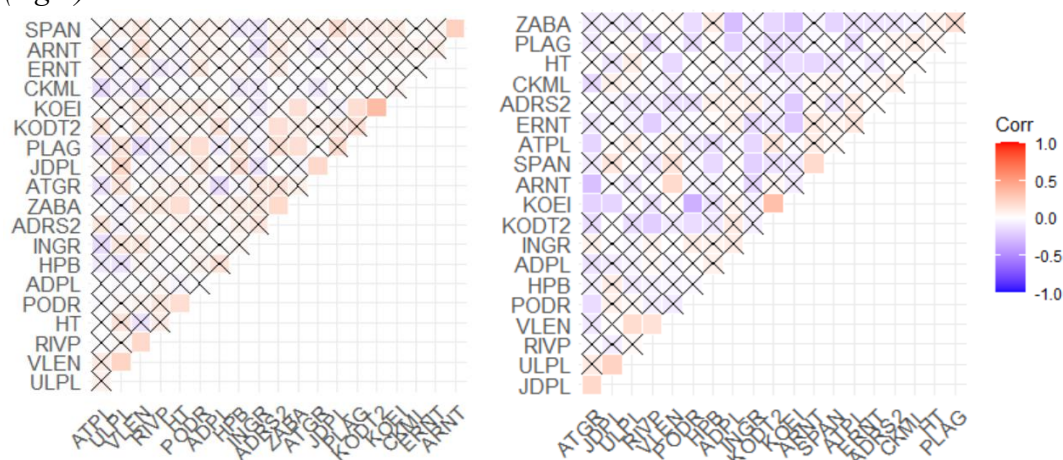
Figure 2: Log return correlations for 2008 revisions - original (left) vs. after factor removal (right)



Source: authors

Similarly, Figure 3 shows the log return correlation matrices for the 2023 CROBEX revisions. The left panel presents the original correlations without any changes, whereas the right panel displays the conditional partial correlations. Compared to the 2008 revisions, the 2023 correlation matrix shows less changes after factor removal, implying that market-wide effects played a less dominating role in driving stock return correlations.

Figure 3: Log return correlations for 2023 revisions - original (left) vs. after factor removal (right)



Source: authors

The disparity observed from Figure 2 and Figure 3 could be related to the broader economic situation in each period. The 2008 adjustments took place amid the global financial crisis, which was marked by increased systemic risk, liquidity limitations, and significant correlations across asset classes. Correlations tend to rise in times of crisis due to market fear, investor herd mentality, and systemic contagion effects. As a result, removing a common market factor in 2008 resulted in a more significant shift in the correlation structure.

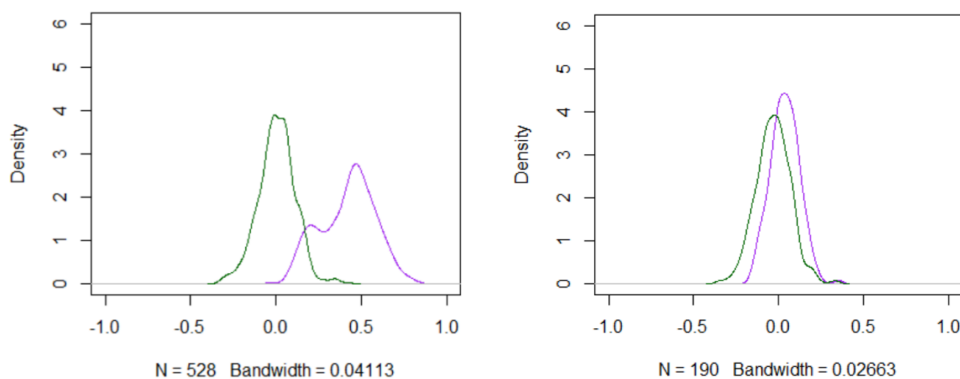
In contrast, the 2023 adjustments occurred in a relatively more stable market environment, with economic conditions defined by post-pandemic recovery, inflationary pressures, and sector-specific dynamics rather than an acute financial crisis. The fact that factor elimination had a

smaller impact in 2023 shows that stock return correlations were influenced by firm-specific or industry-specific attributes rather than systemic shocks. This discovery demonstrates how macroeconomic factors and market structure influence asset return dependency, with financial crises magnifying market-wide correlations and more stable periods allowing for greater differentiation between individual stocks.

Figure 4 provides an alternate perspective on the correlation structures presented in Figure 2 and Figure 3 by presenting kernel density estimates of log return correlations before and after factor removal for the 2008 and 2023 CROBEX revisions. Before factor removal, the correlation distribution for 2008 is heavily skewed toward higher positive values, with the large number of correlations concentrated in the top range. This shows that systemic market-wide effects were prominent, resulting in uniformly high co-movement among equities. In comparison, the 2023 distribution, while still concentrated on positive values, appears less skewed toward extreme correlations, indicating a more diverse correlation structure even before factor elimination.

Following factor removal, the impact varies between the two years. In 2008, factor removal dramatically altered the distribution, resulting in a leftward shift with a rather narrow shape. This shows that systemic variables were the primary driver of correlations prior to removal, and that once these influences were removed, correlation values went closer to zero while remaining relatively stable. In comparison, the 2023 correlation distribution is reasonably stable before and after factor elimination. The curves remain close together, with only a little movement, indicating that systemic forces played a minor impact in shaping associations. The fact that the distribution width does not change appreciably in both years implies that the heterogeneity of stock linkages was already established prior to factor removal, particularly in 2023.

Figure 4: Density plots of log return correlations before and after factor removal, with 2008 (left) and 2023 (right) CROBEX revisions



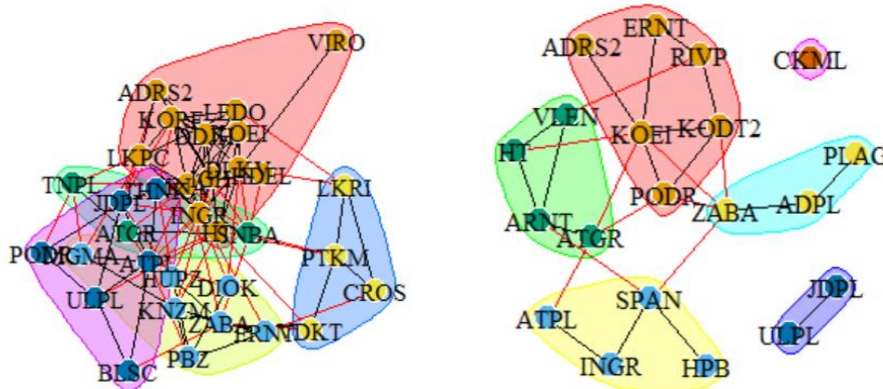
Source: authors

Overall, while the two years' correlation patterns differed before factor removal, they became more similar afterwards. The key difference between the periods is the level of systemic market-wide impacts, which were significantly stronger in 2008 due to the financial crisis, resulting in more uniform and closely clustered correlations before elimination. In contrast, correlations in 2023 were already more diversified, indicating a more stable and firm-specific correlation structure from the outset.

The following step entails analyzing networks constructed from the examined partial correlations (i.e., correlations after factor removal) to see if network properties change despite

the reported similarity in correlation structure and distribution properties after factor removal. Figure 5 show the network structure of CROBEX constituents for the 2008 and 2023 revisions with the modularity-based community structure, with stocks organized into market clusters in each period. The visual depiction enables a simple comparison of connectivity patterns, node centrality, and overall network architecture across the two periods. Following this, Table 1 provides a quantitative summary of key network properties, allowing for a more detailed interpretation of how network structures.

Figure 5: Network structures based on partial correlations for the 2008 (left) and 2023 (right) CROBEX revisions



Source: authors

Table 1: Network properties

Property	2008 revisions	2023 revisions
Network Size		
Number of Stocks	33	21
Filtered Stocks	33	20
Network Density		
Edge Count	109	27
Edge Density	0.206	0.142
Avg. Correlation	0.181	0.191
Network Structure		
Avg. Clustering Coefficient	0.387	0.190
Avg. Shortest Path Length	0.339	0.475
Degree Assortativity	-0.036	0.056
Centrality Measures		
Avg. Degree Centrality	6.606	2.700
Avg. Betweenness Centrality	16.818	9.550
Avg. Closeness Centrality	0.016	0.013
Avg. Eigenvector Centrality	0.339	0.283
Community Structure		
Modularity	0.289	0.400
Number of Communities	5	6
Avg. Community Size	6.60	3.33
Max Clique Size	6	4

Source: authors

Figure 5 combined with the metrics in Table 1 give a comprehensive picture of market interconnection, structural alterations, and systemic risk implications. The analysis shows differences in market connectedness between 2008 and 2023. Because the number of stocks in the network changed between the two periods (33 in 2008 and 21 in 2023), a direct comparison of the number of edges (109 in 2008 vs. 27 in 2023) is insufficient to infer changes in total

market integration. Edge density, which considers network scale, is a more trustworthy metric of connectedness. The edge density was higher in 2008 (0.206) than in 2023 (0.142), indicating that equities in 2008 were more likely to be directly related to other stocks in the network. This distinction shows that stock returns in 2008 had more direct dependencies, resulting in a more interconnected market structure, but equities in 2023 had less direct linkages, potentially reflecting a more selected and localized network of relationships.

Furthermore, the average shortest path length was shorter in 2008 (0.339) than in 2023 (0.474), implying that stocks in 2008 were more directly related to one another. In comparison, the longer shortest path length in 2023 indicates that interconnections were weaker and systemic repercussions were less immediate, supporting the idea of a more segmented market structure in the latter time.

The clustering coefficient, which quantifies the degree to which stocks form local interrelated groupings, was much larger in 2008 (0.387) than in 2023 (0.190). This suggests that in 2008, equities were more likely to form tightly connected clusters, allowing for more focused risk propagation within these groupings. The lower clustering value in 2023 indicates that stocks were less embedded inside closely related groups, reflecting fewer systemic linkages and a greater relevance for firm-specific determinants in stock interactions. Figure 5 shows cluster structures that support this observation, with 2008 displaying larger, more cohesive communities and 2023 exhibiting smaller, more fractured groups.

Modularity, which measures market segmentation, was higher in 2023 (0.400) than in 2008 (0.289), indicating that stocks in 2023 were more clearly divided into independent clusters, with less inter-cluster linkages. The number of observed communities climbed from 5 in 2008 to 6 in 2023, but the average community size declined from 6.6 in 2008 to 3.3 in 2023, indicating that market segmentation got more prominent in 2023, with stocks clustering into smaller, more isolated groupings. The larger, well-integrated communities in 2008 meant that systemic impacts were more prominent, whereas by 2023, the market had a more decentralized structure, with risk shared mostly inside smaller, localized communities rather than across the entire market.

The degree assortativity coefficient, which quantifies the likelihood of highly connected equities being associated with similarly connected stocks, shifted between the two periods. In 2008, assortativity was somewhat negative (-0.035), indicating that high-degree stocks were linked to lower-degree equities, establishing a hub-and-spoke structure in which a few dominating stocks played crucial roles in connecting weaker stocks. In 2023, assortativity increased somewhat (0.056), indicating that equities with comparable degrees of connectedness were more likely to be linked together. This shift implies that the market evolved from a hierarchical structure (in which central stocks linked weaker ones) to a more homogeneous network, in which similarly connected stocks formed more localized clusters.

Because network connectivity patterns changed between 2008 and 2023, centrality measurements, which represent how influential specific stocks were inside the network, also altered:

- Degree centrality, which measures the number of direct connections a stock maintains, was higher in 2008 (6.606) than in 2023 (2.700), implying that stocks in 2008 had more direct interactions with other stocks, resulting in a more linked network.
- Betweenness centrality, which identifies stocks that act as market intermediaries, was higher in 2008 (16.818) than in 2023 (9.550). This suggests that in 2008, specific stocks

played a larger role in promoting indirect linkages between otherwise weakly linked equities, whereas in 2023, the network structure was more scattered, diminishing the importance of individual intermediary stocks.

- Closeness centrality increased from 0.015 in 2008 to 0.122 in 2023, indicating that stocks in 2023 were, on average, more directly accessible within their respective communities. This shows that, while the overall network was more fragmented, intra-community links were stronger, allowing for local information flow inside stock clusters.
- Eigenvector centrality, which assesses how well a stock is connected to other influential stocks, was pretty consistent in both years (0.339 in 2008 and 0.282 in 2023). This shows that, despite less direct connectedness, the network's most significant stocks maintained a similar level of importance in both times. However, the minor reduction in 2023 may imply that dominating market leaders' roles weakened, supporting the conclusion that the industry got increasingly decentralized over time.

Discussion

The analysis of CROBEX members in 2008 and 2023 shows clear structural differences of the underlying networks, which align with observations from more developed markets and research on developing markets. The 2008 network exhibits high centrality levels combined with a high degree of density and clustering. These findings align with the results from Heiberger (2014) and Kenett et al. (2012), who examined financial networks during times of crisis and found that systems become more interconnected and significantly dependent on a small number of powerful players. The usual "hub-and-spoke" structure occurring in developed economies during the global financial crisis, is reflected in the negative assortativity and centralized structure found in 2008.

There is evidence from the literature that other emerging economies have experienced similar tendencies. Tomeczek (2022) showed that the Polish stock market had a highly centralized structure during the early stages of the COVID-19 crisis, resembling the 2008 CROBEX structure. Moreover, during the 2008–2009 recession, Nikkinen et al. (2020) observed an increase in systemic ties across a number of European frontier markets indicating a trend of crisis-driven integration beyond market maturity.

In 2023, the Croatian market obtained a new structure with lower centrality values, positive assortativity, and more modularity. This change also corroborates findings from developed markets, where decentralization is usually seen during times of more stability (Kenett et al., 2012). Similar trends have been noted in other markets (Xu et al., 2017), where financial networks tend to become more modular during stable or post-crisis periods, with community clustering becoming stronger.

However, the Croatian market also shows characteristics of less developed financial markets. Even during moments of higher connectedness, such as in 2008, the entire network remained less linked than networks of established markets like the S&P 500. Limited liquidity, low capitalization, and the significant influence of a few large companies are possible contributing factors (Bogdan et al., 2012). Furthermore, Zoričić et al. (2020) highlight how local market limits impact financial structure and behavior by showing that investment strategies that work well in developed countries frequently don't function as anticipated in Croatia.

Even in relatively small or illiquid markets, Namaki et al. (2011) suggest that removing common market factor may help reveal the underlying linkages among individual stocks, as also shown in applying this technique to CROBEX. Still, with fewer connections and less integration across stock clusters, total connectedness is still poor. This suggests that despite certain structural similarities with developed markets, the Croatian market still has a high degree of segmentation and limited opportunities for the transmission of systemic risk.

Finally, the finding that eigenvector centrality is similar in the two time periods points to the network's important stocks continuing to have an impact. This persistence could be a result of structural limitations in smaller markets, where a limited number of enterprises control trade activity and leadership turnover is less common than in established markets, where sectoral changes and competitive dynamics cause more regular reorganizations of power.

All things considered, CROBEX's evolution is influenced by unique traits of developing countries, such as unequal diversification, strong concentration, and limited liquidity, even if it shares some crisis-time behaviors and post-crisis structural elements with more established markets. When applying network analysis to financial systems, these results highlight the necessity of market-specific frameworks, particularly when considering systemic risk and market stability.

Conclusion

This study examined the network structure of CROBEX constituents between the 2008 and 2023 revisions, comparing market connectivity, clustering, and systemic risk dynamics. After removing market factors, networks based on partial correlations were used to identify important structural changes between the 2008 financial crisis and the more stable market of 2023. The 2008 network was more connected, clustered, and centralized, whereas 2023 showed more segmentation and weaker systemic dependencies. The shift in assortativity from negative in 2008 to positive in 2023 shows that the market structure has evolved from a hub-and-spoke system dominated by central stocks to a more uniform segmentation. This result is partially consistent with prior research emphasizing the importance of central stocks in crisis transmission, but it also shows that markets may grow less reliant on dominant intermediaries during stable periods, which has implications for both systemic risk monitoring and investment strategy design. The patterns observed here are consistent with previous research on financial networks during crises, in which systemic shocks increase stock co-movement.

These findings have practical implications for different groups. Monitoring network features such as modularity and centrality can assist regulators as early indicators of growing systemic risk or potential vulnerabilities in the financial system. For investors, the findings indicate that stock placement within the network (central vs. peripheral) may influence return patterns and risk exposure, particularly during times of market stress. For researchers, this study highlights the importance of network-based techniques for studying market dynamics, particularly in smaller or emerging markets where standard models may fall short due to illiquidity or concentration. Furthermore, the methodology used in this study can be used to build monitoring systems that use network measurements as market health indicators.

Several possibilities of additional research are opened up from this analysis. First, a stock-by-stock study of centrality measures would reveal which stocks have consistently served as key connections or intermediaries throughout time, assisting in the identification of potential market

leaders or risk amplifiers. Furthermore, evaluating the evolution of network features over multiple years, rather than just two specific revisions, would allow for a more dynamic examination of market transitions.

Furthermore, connecting network properties to previous financial crises could reveal whether specific network traits are accurate predictors of future market volatility, especially when applied to markets that have experienced multiple crisis episodes. If growing centralization or decreasing modularity routinely precedes downturns, such indicators could help regulators and investors develop risk management plans. Also, measures for positive and negative correlations could be examined separately.

Lastly, the options for building a portfolio should be considered. According to earlier research, portfolios made up of peripheral stocks perform better than those made up of central stocks (Mo & Chen, 2021). Evaluating whether portfolios weighted toward central or peripheral equities perform better than other market regimes may have useful implications for asset allocation models and investment strategies in light of the observed shifts in network segmentation. Taken together, these results underscore the significance of network-based methodologies in financial market analysis, namely in comprehending systemic risk, investment patterns, and structural shifts in various economic contexts.

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IT

TRACK 1: Digital Transformation and Technological Innovations

PREFACE

IT – TRACK 1: DIGITAL TRANSFORMATION AND TECHNOLOGICAL INNOVATIONS

In today's rapidly evolving landscape, information technology is a fundamental driver of change, reshaping industries and enabling new efficiencies across various sectors. This thematic section explores the cutting-edge applications and strategic implications of digital technologies, highlighting their role in enhancing operational processes, fostering sustainability, deriving critical business insights and influencing consumer behavior. The papers in this track collectively demonstrate the profound impact of IT on modern organizations, from automating tasks and improving customer experiences to leveraging data for strategic decision-making and transforming entire industries, such as tourism. These papers focus on the practical application and strategic impact of advanced information technologies across different business contexts, contributing to achieving the defined aim and scope of the Odyssey conference. They delve into how specific digital tools and approaches are transforming operations, decision-making, and market competitiveness, as well as influencing user experience and consumption patterns.

Bosilj Vukšić, Milanović, Suša Vugec, and Ivančić present a meta-review of robotic process automation (RPA), synthesizing current research trends and identifying future directions, particularly its integration with artificial intelligence and the challenges associated with its implementation. Jelušić, Mikulić and Pušeljic explore the knowledge, perception, and usage of new technologies in Croatian tourism demand, revealing how innovative technologies like mobile applications, IoT, VR, and AI are transforming consumption patterns and driving economic growth within the sector. Pranjić, Jaković and Jajić conduct a comprehensive analysis of digital transformation and sustainability in the Croatian hotel industry, examining how top-rated hotels leverage digital technologies to enhance guest experiences and operational efficiency. Stjepić provides a quantitative bibliometric review of business intelligence in consumer-oriented sectors, showcasing its increasing importance in providing quality information and insights for more efficient decision-making processes in industries like retail and wholesale.

ROBOTIC PROCESS AUTOMATION: A META-REVIEW AND FUTURE RESEARCH DIRECTIONS

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Abstract

Robotic process automation is a concept that emerged in recent years as both a new research field and a new technology that has attracted considerable attention due to its potential to increase process efficiency while reducing costs. This paper presents a meta-review of systematic literature reviews on robotic process automation published between 2020 and 2024 with the aim of providing a thorough synthesis of the current research landscape. Having this in mind, the authors seek to identify key research themes, evaluate current trends and outline potential future research directions. The findings suggest that while research dealing with robotic process automation has increased significantly, there are still some areas that have not been fully explored, particularly in terms of integration with artificial intelligence, hyperautomation and process mining. Additionally, the results point to challenges such as governance issues, resistance to automation and risks associated with process rigidity.

Keywords: robotic process automation, systematic literature review, intelligent automation, artificial intelligence, business process management

JEL classification: M15, I19

Introduction

Robotic Process Automation (RPA) is a technology that focuses on the automation of business processes that are repetitive and rule-based and typically require structured data for execution. So far, many benefits of its implementation in business practice have been recognized in the

literature, such as increased efficiency and quality of work, increased volume of tasks performed and focus on value creation, reduced need for human labor and manual work, ease of use and cost savings (Ivančić et al., 2019). Recently, the use of RPA has increased notably, driven by developments in artificial intelligence (AI) and process mining, which have broadened its functionalities beyond the simple automation of tasks. However, despite this rapid development, academic research on RPA is still fragmented. There are only a limited number of SLRs that can summarize the most important findings in this field. For example, in a study by Ivančić et al. (2019), which analyzed articles published up to March 2019 by searching the Scopus and Web of Science (WoS) databases, only one SLR was identified, indicating a significant gap in systematic reviews in this area. Subsequently, and in order to gain insight into the current situation of published RPA papers, we conducted a preliminary search of the Scopus and WoS databases for the term “robotic process automation”, which yielded 101 articles in Scopus and 65 articles in WoS between 2015 and 2019 (with more than half published in 2019), while the search between 2020 and 2025 yielded 977 articles in Scopus and 477 articles in WoS. These results indicate a growing research interest in RPA, and given the significant increase in literature on RPA after 2019, it was assumed that numerous SLRs were conducted. Therefore, this paper aims to: (1) identify the number of SLR articles published in the five-year period from 2020 to 2024, and (2) analyze the identified articles to systematize the key topics that SLR authors consider particularly important in the field of RPA. Accordingly, the following research questions are posed:

RQ(1): What are the SLRs primary research topics (meta-themes) in the field of RPA?

RQ(2): What common conclusions can be drawn regarding the status and trends of RPA for each of the previously defined research topics?

To answer these research questions, a qualitative study was conducted using the meta-review method. This article is organized as follows: First, an overview of related work is provided to establish a theoretical foundation. This is followed by a detailed description of the research methodology and the bibliographic data. The results of the meta-review are then presented, analyzed and discussed in order to answer the research questions. Finally, the article concludes with the key findings and offers guidelines for future research in the field of RPA.

Robotic process automation: theoretical background

By definition, RPA is “a transformative technology that involves deploying software robots or digital workers to perform repetitive, procedure-based activities within an organization’s digital environment” (Saatchi et al., 2024, p. 75). It exceeds traditional Business Process Management (BPM) by offering a fully automated solution that optimizes processes without the significant costs associated with previous approaches (Jindal & Gupta, 2024). In other words, RPA enhances BPM by automating repetitive, rule-based tasks, improving accuracy, reducing cycle times and increasing productivity and cost efficiency, while streamlining operations, minimizing human error and allowing employees to focus on more strategic activities without changing the existing IT infrastructure (Leshob et al., 2018; Santos et al., 2020).

The introduction of RPA brings numerous benefits, including reduced operational costs, increased efficiency and improved service quality. A study conducted at an Australian university has shown that RPA can provide strategic, managerial, organizational and operational benefits (Denagama Vitharanage et al., 2020). However, despite these benefits, there is little empirical evidence of the actual impact of RPA adoption. A study in the

automotive industry found that the expected benefits, such as shorter process times and better quality, are not always achieved (Wewerka & Reichert, 2020). These discrepancies between expected and actual outcomes point to the need for more in-depth research to quantify the effects of RPA implementation in different contexts.

Although RPA is increasingly recognized as a key technology within the broader framework of business automation, the academic community has not yet fully agreed on a comprehensive definition of this term, nor is the research on its application methodologically consistent (Plattfaut & Borghoff, 2022). The growing popularity of RPA has led to a large number of studies examining its technical and business aspects, but their thematic orientations and analytical perspectives differ considerably (Syed et al., 2020). While some authors focus on the technological features and architecture of RPA systems (Ng et al., 2021), others examine its impact on business processes, organizational structure, and the labor market (Pramod, 2022). This variety of approaches emphasizes the importance of a systematic review of the current state of knowledge to understand the prevailing research topics and identify any gaps in the literature.

Methodology and bibliographic data results

Research method and search strategy

The study was conducted as a meta-review, a special type of systematic review that includes only SLRs. This approach is particularly useful when relevant systematic reviews are available, as it allows for broader generalizability due to a larger sample size (Hunter & Schmidt, 2004). It provides a concise yet comprehensive summary of existing reviews on a particular topic (in this case RPA) and overcomes the challenge of balancing comprehensive coverage with precise focus (Grant & Booth, 2009). Although a meta-analysis usually involves the use of quantitative methods, such an approach was not feasible in this case due to the identification of only 11 SLRs. Therefore, content analysis was applied, which allows for a qualitative examination of a small to medium sized corpus of articles (10–110), in line with the recommendations of Kraus et al. (2022). Furthermore, Kraus et al. (2022) emphasize that from a qualitative perspective, researchers can perform content analysis or, more specifically, thematic analysis by subjectively organizing content into themes. This approach is in line with the aim of this study, which aims to systematize the key themes that SLR authors consider particularly important in the field of RPA. In line with the protocol for SLR outlined by Kitchenham et al. (2007), our literature search was conducted in three phases: (1) defining the SLR protocol, followed by searching and selecting relevant literature; (2) conducting a quality assessment and extraction of relevant articles; and (3) conducting a qualitative analysis and synthesis of accepted articles.

The data search was conducted on February 1, 2025 in the Scopus and Web of Science Core Collection (WoS) databases. These two databases were selected because they are among the largest international and multidisciplinary repositories of peer-reviewed studies and are recognized as highly valuable scientific resources by the National Council for Science, Higher Education and Technological Development (2022). The search strategy (Table 1) included the terms ("robotic process automation" OR "RPA") AND ("systematic literature review" OR "SLR") in the Title-Abstract-Keywords (TITLE-ABS-KEY) for Scopus or "Topic" for WoS fields to identify relevant research papers. As a result, 47 articles were found in Scopus and 20 articles in WoS. The predefined filters — such as language, year of publication and document type — were then applied to refine the selection of the most relevant studies.

Table 1: Search strategy (Scopus/Wos)

Search string component	Criteria
Search terms in “TITLE-ABS-KEY” / “Topic”	("robotic process automation" OR "RPA") AND ("systematic literature review" OR "SLR")
Time span	2020 – 2024
Document type	peer reviewed journal article
Language	English

Source: Authors' work

This step yielded 15 articles in Scopus and 7 articles in WoS (22 articles in total). As the field of RPA has attracted much attention from researchers in the last 5 years, resulting in an increasing number of published articles on this topic, only articles published in peer-reviewed journals were included in this study. The search was limited to SLR articles published after 2019 to gain insight into systematic RPA research published in the period after the review conducted by Ivančić et al. (2019).

In the second phase, duplicate entries were eliminated and articles that were not directly relevant to the research topic were excluded. The articles were reviewed by the authors, who checked whether the results obtained corresponded to the field of research. When analyzing the full texts of all 22 articles, 6 articles were found to appear in both Scopus and WoS, which reduced the number of articles for further analysis to 16. Of these, 5 articles were classified as irrelevant to the research, leaving 11 articles for coding.

Bibliographic summary

Table 2 shows the results of the bibliometric analysis. Of the 11 articles, one was published in 2020 and 2021, while most of the articles (4) were published in 2024. The articles were published in various journals, with the exception of 2 articles that appeared in the Business Process Management Journal. The research mainly focuses on business, management and economics (7 articles) and computer science (6 articles). To a lesser extent, research belonged to other fields: Decision Sciences (3), Engineering (2), Mathematics (1) and Social Sciences (1). A total of 583 articles were analyzed in 11 SLRs. The number of articles analyzed within each SLR ranged from 10 (ID 6) to 113 (ID 5). The searches spanned different time periods, with results varying depending on the sources used, the keywords used and other search criteria. While it is likely that there are duplicates within the sample of 583 articles, the aim of this study is not to compare the articles analyzed in the SLRs. Rather, the main aim is to identify the research focus of these studies and thus answer RQ1.

Table 2: Results of the literature search

ID	Authors	Year	Journal	Scopus / WoS	Research area	No. of articles reviewed & search time span
1	Syed, R; Suriadi, S; Adams, M; Bandara, W; Leemans, SJJ; Ouyang, C; ter Hofstede, AHM; van de Weerd, I; Wynn, MT; Reijers, HA	2020	Computers in Industry	S&W	Computer Science; Engineering	61 (-)
2	Ng, K.K.H., Chen, C.-H., Lee, C.K.M., Jiao, J.R., Yang, Z.-X.	2021	Advanced Engineering Informatics	S	Computer Science	63 (2011-2020)
3	Afriliana, N., Ramadhan, A.	2022	Journal of system and management sciences	S	Business, Management & Account; Computer Science; Decision Sciences; Engineering	42 (-)
4	Plattfaut, R., Borghoff, V.	2022	Journal of Information Systems	S	Business, Management & Account; Computer Science; Decision Sciences	82 (2015 – 2020)
5	Pramod, D.	2022	Benchmarking: an international journal	S	Business, Management & Account;	113 (-)
6	Billion, W., Mauritsius, T.	2023	Journal of Theoretical and Applied Information Technology	S	Computer Science; Mathematic	10 (2018 – 2022)
7	El-Gharib, N.M., Amyot, D.	2023	Data & Knowledge Engineering	S	Decision Sciences	32 (-)
8	Farinha, D; Pereira, R; Almeida, R	2024	Journal of information technology	S&W	Business, Management & Account; Computer Science; Social sciences	46 (-)
9	Moderno, OBD; Braz, AC; Nascimento, PTD	2024	Business Process Management Journal	S&W	Business, Management & Account;	40 (- 2022)
10	Murphy, L	2024	International Journal of Organizational Analysis	W	Business & Economics	65 (2020 – 2024)
11	Schlegel, D; Rosenberg, B; Fundanovic, O; Kraus, P	2024	Business Process Management Journal	S&W	Business, Management & Account;	29 (-)

Source: Authors' work

Meta-review: analysis and discussion

Overview of research meta-themes

In the third phase, after a bibliometric analysis, a qualitative approach was used to analyze the content of 11 articles. Through the content analysis, the articles were coded and classified according to research meta-themes (Table 3).

Table 3: Research meta-themes

Meta-theme	SLRs Research questions, goals and/or objectives	ID
RPA definitions	ID 1: What is Robotic Process Automation (RPA)?	1;
	ID 4: What is the definition of RPA (investigation and consolidation of definitions for RPA within the academic literature)?	4
RPA technologies	ID 1: What are the current and future technologies for RPA?	1;
	ID 2: What is the role of RPA in intelligent automation?	2;
	ID 7: How are process mining techniques applied to accelerate and improve robotic process automation implementation? / Which tools are used to apply both process mining and robotic process automation in an integrated way?	7
RPA in practice	ID 1: How to identify where to deploy RPA?	1;
	ID 3: In which business areas is RPA been implemented? / What kind of business processes are suitable for RPA?	3;
	ID 4: Investigation of feasibility of RPA (situations or features of situations mentioned within the academic literature, indicating the use of RPA as feasible for solving business problems)	4;
	ID 5: What are the industries that leveraged RPA technology and what is the extent of the adoption of RPA in various industry domains?	5;
	ID 8: Investigation of the criteria to assist decision-makers in evaluating which business processes are suitable for RPA.	8
RPA initiative	ID 1: What is an effective RPA methodology?	1;
	ID 3: What factors determine the success of RPA in DT initiatives?	3;
	ID 4: Investigation of best practices for introducing and implementing RPA in organizations mentioned in the academic literature.	4;
	ID 6: Does SDLC involvement can provide benefits during the development of RPA? / Which criteria does the SDLC framework impact the critical success factors (CSFs) the most?	6;
	ID 11: What are the prerequisites for a company to successfully implement RPA? / Which maturity criteria should a company meet before undertaking RPA projects? / What are the challenges of implementing RPA in a company? / What are the barriers that may prevent the adoption of RPA? / What factors contribute to the failure of an RPA project? / What factors contribute to the success of an RPA project?	11
RPA benefits	ID 1: What are the benefits that companies have realised because of RPA? / What is the potential of RPA?	1;
	ID 4: Investigation of the advantages of RPA listed in the academic literature, especially compared to other more traditional forms of process automation.	4;
	ID 5: How RPA adoption has picked up in various domains and what are the benefits?	5;
	ID 9: How can the RPA implementation help improve IS/IT resources management? / How can the implementation of RPA promote the generation of CAs?	9;
	ID 10: The impact of automation (e.g. RPA) on employment. Does workplace automation lead to job displacement? / Does augmentation alongside automation positively influence employment? / Does augmentation alongside automation positively influence productivity? / What successful approaches are being followed to enable augmentation?	10
RPA disadvantages, challenges and risks	ID 4: Investigation of the disadvantages of RPA listed in the academic literature, especially compared to other more traditional forms of process automation. / Investigation of the risks of RPA implementation mentioned in the academic literature.	4,
	ID 5: What are the RPA implementation challenges in the industry and how industries can overcome them?	5,
	ID 7: What are the challenges encountered when combining process mining with robotic process automation?	7
RPA as part of other initiatives	ID 3: How is the research trend and the relations of RPA with DT? / What are the roles of RPA technology in DT initiatives?	3,
	ID 9: How can the RPA implementation support the creation of AI capabilities?	9

Source: Authors' work

In defining these meta-themes, the authors first identified the research questions, aims and/or

objectives presented in the selected articles and developed a predefined list of themes on this basis. The authors then read the articles several times and systematically coded the relevant sections of text according to the defined themes. The coding process was carried out independently by the pairs of researchers. The results were then compared, discrepancies were resolved through discussion and a final list of 7 meta-themes was produced, providing the answer to question (1).

As RPA continues to evolve, defining the field remains an important focus, as explored in 2 SLRs (ID 1; 4). RPA technologies are examined in 3 articles (ID 1; 2; 7), while the application of RPA in business practice (e.g. areas of implementation; industry domains; types of business processes suitable for RPA) attracts considerable interest and is analyzed in 5 articles (ID 1; 3; 4; 5; 8). In addition, the characteristics and key success factors of RPA projects are discussed in 5 SLRs (ID 1; 3; 4; 6; 11). Various sub-themes are explored, including RPA readiness and prerequisites, organizational maturity, critical success factors of RPA projects, and the methodology and phases of RPA implementation. The benefits and advantages of RPA implementation are the topic of 5 articles (ID 1; 4; 5; 9; 10), while 3 articles focus on the disadvantages, challenges and risks (ID 4, 5, 7). Finally, the role of RPA in other initiatives is examined in 2 articles (ID 3, 9). Of particular note are two articles (ID 2 and ID 10) that do not focus exclusively on RPA, but this term was only one of the keywords used in the search. In both articles, RPA is considered as part of intelligent automation, while other areas such as "artificial intelligence" and "business process automation" are also studied alongside RPA. These studies contribute to the "body of knowledge" in the field of RPA and are therefore included in the detailed analysis.

Analysis and discussion of research meta-themes

The next step was to identify and systematize common conclusions about the status and trends of RPA for each of the previously defined meta-themes in order to answer RQ(2).

RPA definitions

Plattfaut and Borghoff (2022) emphasize that despite the numerous definitions of RPA, a generally accepted definition within the academic community is still lacking. According to Suddaby (2010), an effective definition should encompass all essential characteristics of the term while being concise and free of tautologies or circular reasoning. After analyzing a large number of articles (47), Plattfaut and Borghoff (2022) propose the following definition: "RPA is a technology that enables the development of (multiple) computer programs (i.e. bots) that automate rule-based business processes through the use of GUIs". Although most of today's RPA vendors aim to integrate AI components into their RPA suites, Plattfaut and Borghoff (2022) emphasize a clear difference between the two concepts. RPA is primarily designed for rule-based execution of processes, while AI encompasses a broader, and in some way ambiguous conceptual framework. Although bots can be developed using AI technologies or incorporate AI applications, most RPA solutions are currently used to automate repetitive tasks that typically involve structured data (Plattfaut & Borghoff, 2022).

Syed et al. (2020) came to similar conclusions after analyzing 24 relevant studies. According to their results, RPA is located between the concepts of AI and automation. Compared to AI, cognitive methods and expert systems, RPA tends to be more structured and focused on business rules. In contrast to traditional automation, such as implementing an IS, RPA is a lightweight solution that primarily targets the front-end user interface rather than the back-end

and underlying data (Syed et al., 2020). Also, unlike BPM, which takes a top-down approach, RPA is implemented through a bottom-up method, which makes it easier to implement (Syed et al., 2020).

RPA technologies

Syed et al. (2020) emphasize that many researchers focus on RPA technologies, implementation strategies and possible improvements. Their SLR identifies three core components of RPA software: a graphical modeling tool, a robot execution orchestrator, and the bots themselves, dividing RPA into attended and unattended automation, while additional components may include schedulers, collaboration tools, and performance analytics (Syed et al., 2020). The study concludes that RPA is complementary to AI, machine learning (ML), natural language processing (NLP), cognitive methods and deep learning, with potential development in intelligent robotic process automation (IRPA) (Syed et al., 2020), supported by Ng et al. (2021), who state that AI is influencing the future development of RPA.

Ng et al. (2021) examine Intelligent Automation (IA) and investigate the connection of RPA to it. They conclude that Intelligent Process Automation (IPA) integrates RPA with AI to enable cognitive capabilities for prescriptive analytics using unstructured data, and that IPA can simulate human decision-making and employ supervised or unsupervised learning, although expert intervention is required to fine-tune performance (Ng et al., 2021). El-Gharib and Amyot (2023) explore the integration of RPA with process mining (PM) and emphasize the role of PM in identifying suitable processes for automation. However, their analysis reveals a gap in the literature in linking PM with user interface logs and monitoring post-implementation performance (El-Gharib & Amyot, 2023).

RPA in practice

When it comes to RPA in practice, the analysis of SLR articles shows that researchers are looking for answers to 2 categories of questions: (1) where RPA is implemented (in which activities and business areas); (2) and what are the characteristics of business processes/tasks that make them good candidates for the successful application of RPA. According to the results of the SLR study conducted by Afriliana and Ramadhan (2022), RPA is most commonly used in financial services and banking, tax, accounting and auditing, and the automotive industry. Pramod (2022) also points to the widespread introduction of RPA in the banking, financial services and insurance sectors. The use of RPA in healthcare and manufacturing is classified as moderate, while the use of RPA in telecommunications, agriculture and energy is increasing, with several use cases identified in these sectors (Pramod, 2022).

Syed et al. (2020) found that organizational readiness for RPA is addressed in more than half of the studies they analyzed, focusing on two main levels: organizational characteristics (e.g., business drivers, technology type, RPA maturity) and process/task-specific characteristics. Farinha et al. (2024) identify 18 criteria for selecting RPA-ready processes, while Afriliana and Ramadhan (2022) highlight 10 business process characteristics that are critical to RPA success. Plattfaut and Borghoff (2022) categorize RPA feasibility into process characteristics and supporting factors. Syed et al. (2020) also note contradictions in the RPA literature, such as different views on process standardization and data quality.

RPA initiative

Syed et al. (2020) emphasize that RPA project management relies on experience, lessons learned and best practices. Successful implementation requires aligning RPA with business strategy, redesigning processes and ensuring process standardization and maturity (Syed et al., 2020; Plattfaut & Borghoff, 2022). Strong top management support, change management and employee skill development are critical (Plattfaut & Borghoff, 2022; Afriliana & Ramadhan, 2022). Stakeholder involvement, knowledge management and communication promote the adoption of RPA (Plattfaut & Borghoff, 2022), while Schlegel et al. (2024) emphasize that non-technological factors, such as risk management, are more important than technological factors.

RPA implementation and project management are extensively discussed in the literature. Researchers recommend starting with a proof of concept, followed by a pilot phase before scaling (Syed et al., 2020). The SLR by Billion and Mauritsius (2023) highlights the benefits of using the Software Development Life Cycle (SDLC) framework. While there are different management approaches exist, there is a consensus on the use of agile methods for RPA development (Syed et al., 2020). Collaboration between IT and business units is crucial, although some argue that business units should lead RPA initiatives and involve employees early on to reduce resistance (Syed et al., 2020; Schlegel et al., 2024).

RPA benefits and advantages

The adoption of RPA has spread to key business functions in various industries, offering benefits such as shorter processing times, increased efficiency, resource optimization, scalability, flexibility, improved accuracy and cost reduction (Pramod, 2022; Plattfaut & Borghoff, 2022; Syed et al., 2020). Syed et al. (2020) highlight the advantages of RPA over traditional IS, including lower costs, faster implementation and seamless integration. In contrast to traditional automation, RPA has no impact on the core IT infrastructure and enables simple and rapid development (Plattfaut & Borghoff, 2022).

RPA improves risk mitigation and compliance by aligning automation with regulatory requirements (Syed et al., 2020). It reduces errors, improves process compliance and enhances traceability (Plattfaut & Borghoff, 2022). Furthermore, the implementation of RPA increases efficiency, performance and competitiveness, benefiting multiple business units (Moderno et al., 2024). Murphy (2024) examines the impact of RPA on employment and highlights its role in job creation, task expansion and skills enhancement. Companies leverage automation to increase productivity while focusing on skills development, effective work design, building trust and human creativity at the same time (Murphy, 2024).

RPA disadvantages, challenges and risks

Plattfaut and Borghoff (2022) emphasize that the literature on the disadvantages of RPA is relatively limited. They have categorized these disadvantages into six groups: Inferiority to back-end automation, complexity, process and data restrictions, investment requirements, IT staff requirements and IT skills requirements. Meanwhile, Pramod (2022) and El-Gharib and Amyot (2023) classify the main challenges of RPA into three broad categories: technical, human and strategic. The six disadvantage categories identified by Plattfaut and Borghoff (2022) can be aligned with these three overarching groups.

Human challenges in RPA include defining automation routines, monitoring bots, managing exceptions, overcoming resistance and ensuring employee readiness (Pramod, 2022; El-Gharib & Amyot, 2023; Plattfaut & Borghoff, 2022). Technical challenges include complexity, the inferiority of RPA to back-end automation, data access, script updates and interdependent bots (Pramod, 2022; El-Gharib & Amyot, 2023; Plattfaut & Borghoff, 2022). Strategic challenges include transparency issues in automated decision-making and the need for significant investment in identifying, prioritizing and redesigning processes for companies lacking an RPA strategy (Plattfaut & Borghoff, 2022; Pramod, 2022).

In addition to the benefits, Plattfaut and Borghoff (2022) also identify several risks in adopting RPA, namely in terms of governance challenges, especially shadow IT, as departments develop separate bots, which complicates the IT architecture. Another concern is organizational resistance, as employees may perceive bots as competition, raising fears for their job security, and workflow disruptions that may lead to resistance (Plattfaut & Borghoff, 2022). Additionally, RPA can reduce process agility, as standardized workflows embedded in bots limit adaptability to changing business requirements (Plattfaut & Borghoff, 2022).

RPA as part of other initiatives

The SLR analysis links the implementation of RPA with the introduction of AI and digital transformation. Moderno et al. (2024) highlight RPA as the least risky entry point for AI integration, serving as a foundation for automation in cloud computing, bots, visualization, cognitive computing, analytics and blockchain. The findings suggest that automation strategies are driven by business goals rather than specific technologies (Moderno et al., 2024). RPA is therefore a catalyst for the development of AI strategies. Afriliana and Ramadhan (2022) emphasize the role of RPA in digital transformation, linking it to business processes, automation, process management, digital workforce and information systems, concluding that RPA is recognized as a key technology for driving digital transformation initiatives.

Discussion of the meta-themes from the perspective of future research

The findings of this study can be valuable for business professionals, managers and IT experts involved in the practical implementation of RPA. In addition, this study makes a theoretical contribution by identifying meta-themes that have been researched so far, while highlighting the need for further research. Both theoretical and practical contributions of this study are discussed further. The analysis of SLRs based on meta-themes (Table 3) shows that the focus of researchers in the 2020-2024 period is on the issues related to the implementation of RPA in business practice, RPA initiatives and the benefits associated with RPA adoption. In contrast, less research was conducted on RPA technologies and issues related to the limitations, challenges and risks of RPA implementation. The least attention was paid to defining RPA and examining its role within other initiatives. The finding that 50% of RPA implementation projects fail (Herm et al., 2022) suggests that methodological tools and theoretical frameworks for effective RPA implementation are still insufficient. As RPA is still a new concept, there is a notable lack of clearly defined reference models and frameworks that could provide both a solid theoretical foundation and actionable guidelines for organizations. In this context, Herm et al. (2022) and Wewerka & Reichert (2023) argue for the development of a theoretical framework for the implementation of RPA. Similarly, Sobczak (2019) emphasizes the need to define the key phases of RPA implementation and to develop a reference RPA capability map. Accordingly, it is proposed to carry out new research that will make a theoretical contribution in this area.

Although scholars have not yet fully agreed on a common definition of RPA, the basic elements that constitute RPA have been recognized and studied (Plattfaut & Borghoff, 2022). In the future, the explicit inclusion of AI in the definition is likely to be discussed and further research in this direction can be expected. According to Farinha et al. (2024) and Schleger et al. (2024), subsequent research could place more emphasis on the technical factors of RPA implementation. The potential integration of RPA with other technologies and methods such as AI, ML, deep learning and NLP remains an area for further research (Farinha et al., 2024; Plattfaut & Borghoff, 2022; Pramod, 2022). Although the analysis of SLRs showed that RPA technology is "under the umbrella of AI", the authors suggest further exploring the role of RPA technologies in AI ecosystems and digital transformation (Moderno et al., 2024; Afriliana & Ramadhan, 2022; Afriliana & Ramadhan, 2022). Similarly, Schlegel et al. (2024) suggest that future research could be extended to the topic of hyperautomation, which involves the integration of RPA and AI to automate business processes. A particularly relevant aspect of this extension would be to identify the key factors necessary for the successful integration of multiple systems and to analyze how these factors differ from those in the RPA-specific context (Schleger et al. 2024). One of the suggestions for future research concerns the role of process mining in all phases of RPA implementation and utilization (Farinha et al., 2024; El-Gharib & Amyot, 2023).

The SLR conducted by Plattfaut and Borghoff (2022) indicates a lack of research on the disadvantages and risks of RPA implementation. As organizations increasingly adopt RPA, it is expected that certain risks will arise that could affect business continuity. Therefore, Farinha et al. (2024) and Plattfaut and Borghoff (2022) emphasize the need for further research in this direction. Plattfaut and Borghoff (2022), Pramod (2022) and Syed et al. (2020) highlight the need for research on the key success factors of RPA projects as well as non-technical aspects of RPA implementation, such as human resources, communication and interpersonal relationships, process organizational structure and culture, and ethical aspects of automated decision making. Measuring the benefits of RPA solutions is a challenge. Typically, the benefits of RPA are measured by the reduction of costs, time and errors in the process. But in addition to the direct benefits, it is necessary to measure the indirect and intangible results of RPA in some way. For this reason, further research should focus on developing a systematic approach to measuring the benefits of applying RPA (Syed et al., 2020). According to Pramod (2022), a future research agenda will focus on the development of RPA implementation and assessment frameworks as well as the development of RPA maturity models that can be adapted to different domains. In addition to the guidelines established in this way, which highlight potential areas for future research, it is also important to emphasize the lack of quantitative research on RPA, as noted by Moderno et al. (2024) and a lack of in-depth studies on the quantitative impact of RPA (Plattfaut & Borghoff, 2022).

Conclusion

This paper provides answers to two research questions posed in the introduction and thus fulfills the aim of the study. In relation to RQ1, seven central meta-themes were identified in this study: RPA definitions, RPA technologies, RPA in practice, RPA initiative, RPA benefits, RPA disadvantages, challenges and risks, and RPA as part of other initiatives. The results show that the research focuses mainly on the practical applications and benefits of RPA, while the technical aspects, challenges and integration with AI are less explored. Next, in relation to question 2, a synthesis of the findings of the existing SLRs identifies the key trends and

challenges. RPA is increasingly evolving towards intelligent automation, highlighting the need for deeper exploration of its integration with AI, process mining and hyperautomation. Barriers to implementation are also identified, including organizational resistance, governance of RPA solutions and limitations in the flexibility of automated processes.

This paper is not without limitations. Firstly, the analysis is based exclusively on articles from the Scopus and WoS databases, and the focus on SLRs means that original empirical studies are excluded, which may limit the representativeness of the results. Secondly, although the meta-themes were identified using a systematic methodology, their interpretation may be subjective. Despite these limitations, the results provide valuable directions for future research. They point to the need for quantitative analyzes of the impact of RPA, the development of implementation maturity models and research into the long-term organizational impact.

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KNOWLEDGE, PERCEPTION AND USAGE OF NEW TECHNOLOGIES: RESEARCH ON TOURISM DEMAND IN CROATIA

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Abstract

This study aims to explore the importance of digital technologies for tourism and the economic growth of tourist countries, how innovative technologies are transforming tourism consumption, and how consumer expectations are shifting in the digital landscape. It seeks to identify important consumption patterns in the digital age by examining major technological trends, including mobile applications, the Internet of Things, virtual reality, and artificial intelligence (AI), and their impact on tourism consumption. The research reveals that innovative technologies not only enhance the tourism experience but also drive increased tourist spending. The findings shed light on the intricate relationship between technological advancements, tourism results and tourism consumption, emphasizing the critical roles of digital technologies in shaping modern tourism experiences. Furthermore, the study discusses the implications of these insights for the tourism industry and outlines future research directions, contributing to a deeper understanding of the evolving interplay between new technology and tourism consumption in the 21st century.

Keywords: innovative technologies, tourism consumption, economic growth, tourism

JEL classification: L83, O33, Z32, O47

Introduction

Tourism and tourist activity are increasingly affected by technological changes (Buhalis et al., 2019; Tussyadiah & Miller, 2020). Multiple information and communication technologies have been adopted in the last two decades to create value, provide efficient services, and enhance tourists' experiences before, during, and after their travels. Like the global economy, tourism has changed dramatically in recent decades. With new consumer trends, technological progress, globalisation and environmental awareness, the tourism sector is undergoing major changes in the 21st century. Technological innovations are key to the way travellers research, plan and experience their trips. This topic is very timely as digitalisation and technological innovations are significantly changing the travel and tourism industry. The constant innovation in technology, including the development of hardware, software and networks, means that only

dynamic organisations that are able to assess the needs of their stakeholders and respond effectively to those needs can outperform their competitors. Continuous technological progress and the adaptation of tourism services to the changing needs of consumers are becoming key to maintaining competitiveness and relevance in the modern tourism sector.

This research focuses on analyzing various aspects of the development and application of new technologies in the tourism industry, aiming to explore their role in shaping tourist spending and behavior. Special attention is given to technologies such as mobile applications, virtual reality, artificial intelligence, and blockchain, which are increasingly influencing how tourists plan their trips, experience destinations, and manage their expenses.

The use of mobile applications for trip planning and navigation is examined in the context of their role in increasing tourist spending, while the application of virtual reality is analyzed as a factor that enhances tourist engagement and satisfaction, potentially leading to higher expenditures and repeat visits. Additionally, the study explores personalized recommendations based on artificial intelligence and their importance for tourist spending, as well as the implementation of blockchain technology in transactions.

The main goal of this research is to examine the awareness, perception, and usage of innovative technologies in the context of tourist consumption. Specifically, the research aims to: 1. Investigate the impact of various innovative technologies on tourist behavior and spending patterns; 2. Analyze tourists' perceptions of the benefits and challenges associated with the adoption of these technologies in the tourism industry; 3. Provide recommendations for further research in the field of innovative technologies to enhance the tourism experience and increase the industry's competitiveness. This research seeks to offer a comprehensive understanding of how new technologies are shaping tourism, with the ultimate goal of contributing to more effective strategies for both service providers and consumers.

A quantitative study was conducted using a questionnaire to assess consumer habits and attitudes toward specific innovative technologies in tourism. Data collection took place electronically between June 30 and July 5, 2024, from a sample of 104 respondents within the Republic of Croatia.

The research is organized into five sections. Following the introduction and literature review, the third chapter explores how are innovative technologies influencing tourism spending, and how are consumer expectations evolving in the digital environment. The fourth chapter presents methodology and outlines the research findings. The fifth chapter concludes with the final remarks.

Theoretical background

This chapter focuses on the research questions: How do innovative technologies influence tourist spending? How do innovative technologies, such as mobile applications, virtual reality, artificial intelligence, and blockchain, affect tourist behavior, spending patterns, and the overall tourism experience?

Tourist spending plays a crucial role in the dynamics of the tourism industry. It encompasses a wide range of activities, including tourists' travel to their destination, their stay during the trip, and overall expenditure on various services. With the advancement of digital technologies, the

question arises as to how these technologies can enhance tourist experiences, reduce travel costs, and increase overall satisfaction. It is assumed that technologies such as artificial intelligence, blockchain, big data, and virtual reality will have enormous potential to transform the tourism industry and other sectors, while the Internet of Things and social media will significantly shape future marketing strategies (Kostin, 2018; Rane et al., 2023). Innovative technologies greatly influence tourist spending and shape consumer expectations in the digital environment.

The emergence of artificial intelligence is leading to a paradigm shift in the travel and tourism industry by personalizing experiences, enhancing operational efficiency, improving security measures, and promoting sustainable practices. Additionally, smart tourism ecosystems are transforming the structures, processes, and practices of the industry, resulting in disruptive effects on service innovation, strategy, management, marketing, and the competitiveness of all stakeholders (Buhalis, 2019). Research shows that ChatGPT holds great promise for improving many aspects of hospitality and tourism management, including enhancing personalized customer experiences, streamlining marketing efforts, and promoting administrative efficiency (Sigala et al., 2024). There is a demonstrated need for organizational and technological integration and synergy to make artificial intelligence truly beneficial in tourism and hospitality. As a result, travelers will enjoy personalized value and co-created experiences, with services that dynamically evolve with the help of technology and/or humans, enhanced by AI (Bulchand-Gidumal et al., 2023). Tourists must make a range of decisions about their future travels, such as choosing a destination, transportation, accommodation, and activities, to name a few. These decisions have a significant impact on their overall satisfaction with the trip. However, the current offerings of destinations, transportation, lodging, and activities provide an almost endless wealth of options, for which assistance is needed. From a consumer perspective, artificial intelligence allows for faster trip planning, significantly lower transaction costs, and a fully personalized travel package tailored to their needs and interests (Bulchand-Gidumal, 2020).

Studies show that personalized recommendations based on user data can increase tourist spending. Furthermore, AI facilitates trust-based recommendations in tourism through the concept of direct and indirect trusted partners, thus increasing the convenience and reliability of personalized suggestions (Samara et al., 2020). Examples include AI-powered chatbots and virtual assistants, such as small multilingual robots that answer questions at Tokyo's airport and perform hotel check-ins (Cain et al., 2019), or multilingual virtual personal assistants on cruise ships (Chi et al., 2020). Digital marketing plays a key role in increasing tourist spending, as online advertising significantly influences tourist decisions. Understanding tourists' attitudes is crucial for designing effective strategies to increase visitor numbers to destinations (Armutcu et al., 2023). Social media, which has a strong impact on purchasing decisions, plays a critical role in tourism, particularly in the information-seeking and decision-making stages regarding destinations (Zeng & Gerritsen, 2014). In this context, the concept of "smart tourism" emphasizes the importance of technologies such as IoT and big data, which enable personalized services, enhance tourist satisfaction, and increase spending (Wang et al., 2013; Li et al., 2018). The development of new technologies, such as smartphones, artificial intelligence, virtual reality, robots, and new GIS systems, has reshaped marketing strategies in the tourism and hospitality industry, creating additional opportunities for marketing innovation (Kim & Wang, 2019). Consumers have adapted to the new marketing paradigm, and factors such as compatibility and social influence significantly shape the adoption of mobile applications. Four technological innovations, including smartphones as room keys and e-housekeeping, have been identified as key to hotel operations. Digital platforms and e-services contribute to more

sustainable tourism by improving user experiences and facilitating access to information. Several studies support the claim that technology increases consumer loyalty and encourages repeat purchases, focusing on positive digital experiences. Research shows that many respondents intend to make repeat purchases based on positive digital experiences (Buhalis & Sinarta, 2019). Rane et al. (2023) found that technologies such as artificial intelligence, blockchain, the Internet of Things, and virtual reality can enhance sustainable tourism. Their analysis shows that these technologies optimize tourism operations, reduce negative environmental impacts, and improve visitor experiences. AI, blockchain, and IoT contribute to sustainability through personalization, transparency, and smart infrastructure. These innovations can significantly enhance the sustainability of tourism, provided ethical guidelines are respected.

The tourism industry is undergoing significant transformation due to the integration of digital technologies, marking the rise of digital tourism. Sivarethinamohan (2023) also highlights the economic and environmental aspects of digital tourism, focusing on responsible tourism practices. The future of digital tourism lies in the integration of voice assistants, social media, and blockchain, as well as stakeholder collaboration to create sustainable experiences. Mobile applications have significantly changed tourist behavior and experiences, enabling real-time sharing, service ratings, and self-directed trip planning (Dias & Afonso, 2021). All these technologies foster a culture of collaboration among travelers, intensify social relationships, and facilitate experience sharing (Barbosa & Medaglia, 2019). Modern tourists are increasingly connected, informed, and demanding, while digital platforms offer greater autonomy and influence consumption patterns (Barbosa & Medaglia, 2020). Although these innovations offer opportunities to enhance tourist experiences and sustainability, they also present challenges for the industry to adapt to a rapidly evolving digital environment.

Table 1: Examples of the impact of innovative technologies on tourism consumption

Inovative technologies	Description	Impact on consumption
Online reservation platforms (e.g. AirBnB, Booking.com etc.)	They have easier access to a wide range of accommodation and services, which reduces costs (easy price comparison) and increases overall spending on more varied services (excursions, etc.)	Tourists often spend more money on experiences, e.g. local activities and restaurants, as they save on accommodation through cheaper options.
Digital payments and cryptocurrencies (Pay Pal, Apple Pay etc.)	They make it easier to spend money abroad and eliminate the need for physical money or expensive currency conversions Blockchain technology enables more transparent transactions.	Fewer barriers to spending as tourists shop faster and more securely digitally, increasing overall spend.
Personalized recommendations through artificial intelligence	Artificial intelligence through recommendation algorithms allows tourists to receive personalised suggestions for hotels, restaurants, attractions and services tailored to their preferences and previous behaviour.	Tourists are more likely to spend on additional activities and products offered to them through personalised recommendations

Inovative technologies	Description	Impact on consumption
Virtual and augmented reality	Virtual tours and experiences before the actual trip allow tourists to experience part of the destination or activity in advance, often motivating them to spend more on additional facilities when they arrive on site.	Higher spend on attractions and activities as tourists already have an impression of the experiences they want to try.
Smart cities and smart destinations	The use of sensors and smart technologies to manage crowds, reduce waiting times and improve infrastructure helps to optimise the tourist experience.	Better management of tourism resources often increases tourist satisfaction, which encourages them to spend more, especially on additional activities and services.

Source: author's compilation based on literature review

Methodology and research results

The research was conducted using a quantitative method, employing a survey to collect data on consumer habits and attitudes in the context of using innovative technologies in tourism. Data was collected between June 30 and July 5, 2024. The target group of respondents consisted of individuals aged 18 to 50, representing the traveling population, which is considered representative of the tourism industry. The survey was conducted electronically (via Facebook and other social media), and the sample included 104 respondents from the Republic of Croatia. All participants took part in the research voluntarily, and the survey was anonymous to ensure data privacy.

The questionnaire consisted of 24 questions divided into four sections. The first section included four demographic questions, while the remaining questions directly related to the research topic—namely, the respondents' attitudes and habits regarding the use of innovative technologies in tourism. Among all the questions, 11 were open-ended, while four were evaluated using a Likert scale from 1 to 5, where the responses indicated the level of agreement from "1 - strongly disagree" to "5 - strongly agree," with an additional option "0 - I don't know anything about this." The remaining questions were also rated using a Likert scale with answers ranging from 1 to 5.

The data collected through the survey was processed using descriptive statistics, analyzing patterns in respondents' attitudes and behaviors related to the use of new technologies in tourism services. The data was analyzed to identify key trends in consumer habits, levels of acceptance of innovative technologies, and differences among demographic groups regarding their attitudes toward new technologies in tourism. Based on these results, conclusions were drawn to help better understand the impact of technology on tourist behavior and improve tourism services.

The first group of data relates to socio-demographic data.

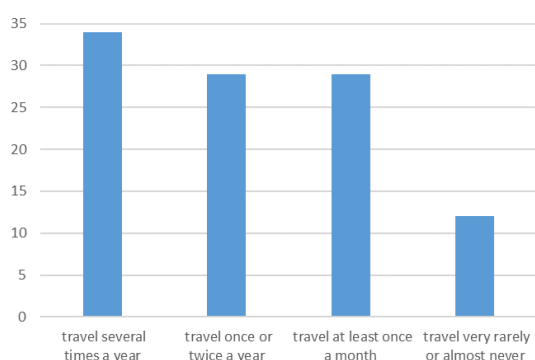
By gender, of the 104 respondents, 65.4% (68) were male and the remaining 34.6% (36) were female. By age structure, the largest share consists of respondents aged 18 to 55 years, making up a total of 89.4%, structured as follows: 18-25 years 23.1% (24), 26-35 years 36.5% (38), 36-

45 years 18.3% (19), and 46-55 years 11.5% (12) respondents. By education level, the largest group of respondents, 38.5% (40), completed secondary education. 21.2% (22) of respondents have vocational education, while 13.5% (14) have completed an undergraduate university degree. Primary school education and vocational school (diploma) were held by the same number of respondents, 10.6% (11) each. By employment status, employed persons make up 58.4% (59) of all respondents, students 21.8% (22), unemployed 15.8% (16), and pupils 4% (4) of respondents.

The second group of questions relates to the respondents' travelling habits and their views on the use of innovative technologies in tourism.

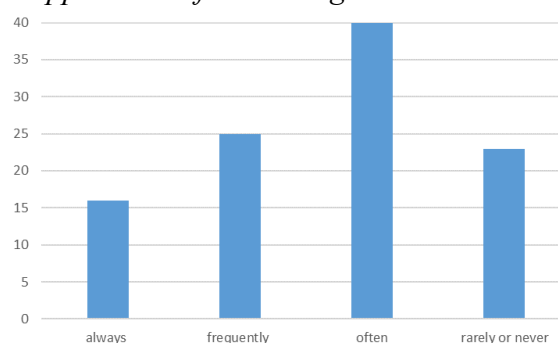
Travel habits surveys show that the largest group, 32.7% (34) of respondents, travels several times a year. 27.9% (29) travel once or twice a year, and the same percentage, 27.9% (29), travel at least once a month. Only 11.5% (12) of respondents travel very rarely or almost never. Among the respondents, there were no tourists without a permanent residence who travel constantly. The question about the frequency of using mobile applications for booking accommodation showed that 16.2% (16) of respondents always use mobile applications; 25.3% (25) use travel planning apps very frequently; 40.4% (40) use them often, and 18.2% rarely or never use them.

Figure 1: Travel habits of respondents



Source: author's research

Figure 2: Frequency of using mobile applications for booking accommodation



Source: author's research

The following are questions where respondents rated statements from 1-5, where 1 means strongly disagree and 5 means strongly agree. The respondents evaluated their familiarity with and usage of mobile applications, virtual reality, artificial intelligence, and blockchain technology before, during, and after their tourist trips. A brief analysis of their responses follows.

With the statement that using ***mobile applications makes travel planning easier***, 31.7% (33) of respondents strongly agree, which is the largest portion. 28.8% (30) agree with the statement, while 22.2% (23) neither agree nor disagree. 5.8% (6) disagree, and 11.5% (12) strongly disagree with the statement. A highly positive attitude towards using mobile applications is held by 60.5% of respondents, a neutral attitude by 22.2%, and a negative attitude by 17.3% of respondents. Of the total 104 respondents, 35.6% (37) strongly agree with the statement that mobile apps make it easier to find information about tourist activities. 29.8% (31) agree with the statement, while 20.2% (21) are undecided. Only 4.8% (5) disagree, and 9.6% (10) strongly disagree with the statement. This indicates that 65.4% of respondents have a positive attitude, 20.2% are neutral, and 14.4% have a negative attitude. Regarding the question about the help

mobile apps provide in reaching tourist attractions more quickly, 40.4% (42) strongly agree. 22.1% (23) agree, and 24% (25) are undecided. Only 3.8% (4) disagree, while 9.6% (10) strongly disagree with the statement. The group with a positive opinion comprises 62.5%.

The fact that mobile applications have a significant impact on tourist satisfaction and the overall travel experience is confirmed by several studies (Gračan et al., 2021; 2023). A positive attitude of respondents toward the use of mobile applications in the context of tourist travel—particularly emphasizing their role in facilitating trip planning and enhancing the overall destination experience—is also highlighted in the findings of Gračan et al. (2021; 2023). Well-designed and user-friendly applications can significantly contribute to greater tourist satisfaction and become a valuable tool in the development of the smart destination concept, where social network and navigation applications showed the strongest connection with satisfaction (Gračan et al., 2023). A high percentage of negative perceptions in the responses was also confirmed by these authors, who point out that a certain resistance to installing new applications is most often due to technical limitations and a preference for universal platforms.

Regarding the experience of *viewing tourist destinations using virtual reality before visiting the destination*, 44.2% (46) of respondents answered positively, while the majority, 55.8% (58), had no such experience. This data suggests insufficient familiarity or use of virtual reality opportunities. Despite the lack of virtual reality use, most respondents agree that it increases satisfaction with the solution. 17.3% (18) strongly agree that virtual reality increases tourist satisfaction, 21.2% (22) agree, which totals 38.5% of respondents expressing a highly positive attitude. Slightly fewer are undecided, with 19.2% (20), and the least, 11.5% (12), disagree with the statement. The largest group, 30.8% (32), strongly disagrees. The significant group of respondents with negative opinions likely stems from unfamiliarity with new technologies, highlighting the need for education and the implementation of digital technologies not only in business but also on a broader societal level.

The next question asked whether virtual reality makes tourist activities more interesting. A total of 20.2% (21) of respondents answered strongly agree, 16.3% (17) agree, while the largest portion, 27.2% (31), were undecided. The fewest respondents, 5.8% (6), disagreed, and 27.9% (29) strongly disagreed. Regarding the statement that virtual reality increases the likelihood of revisiting a tourist destination, 22.1% (23) strongly agree, 19.2% (20) agree, and 19.2% (20) are undecided. The least agree with the statement, with 11.5% (12) disagreeing and 27.9% (29) strongly disagreeing. In total, 41.3% hold a positive opinion, while 39.4% have a negative opinion. This question also reflects a relatively large group of negative and undecided answers, confirming the need for further education on the importance and advantages of virtual reality in tourism.

Removing barriers to the adoption of VR, such as unfamiliarity and technical limitations, is crucial for fully realizing its benefits in tourism marketing and destination promotion, which can also be linked to the results of this research. Most studies emphasize the positive impact of VR presence on attitudes toward tourist destinations, as it has been shown that VR presence positively influences enjoyment and attitudes toward destinations, which in turn affects the intention to visit. Tussyadiah et al. (2017) highlighted that VR experiences can enhance emotional engagement, leading to increased satisfaction and a higher likelihood of visiting the destination. Furthermore, research by Nam et al. (2023) emphasized that authenticity in VR content significantly influences user satisfaction, showing that authenticity related to objects and activities within VR experiences positively contributes to overall satisfaction with cultural destinations.

When asked about the **importance of artificial intelligence (AI)**, the largest group, 30.8% (32) strongly agrees with the statement that **personalized recommendations based on artificial intelligence make travel planning easier**. 23.1% (24) agree, and 17.3% (18) are neutral. The smallest group, 3.8% (4), disagrees, while 25% (26) strongly disagree with the statement. On the subject of virtual reality, 53.9% have a positive attitude, 17.3% are neutral, and 28.8% have a negative attitude. Regarding the statement that personalized recommendations are very useful for planning tourist activities, 36.5% (38) strongly agree. 28.8% (30) agree, and 14.4% (15) are undecided. 1.9% (2) disagree, while 18.3% (19) strongly disagree. Regarding the statement that personalized recommendations improve the tourist experience, the largest group, 39.4% (41), strongly agrees. 21.2% (22) agree, and 20.2% (21) are undecided. The smallest group, 2.9% (3), disagrees, and 16.3% (17) strongly disagree.

Phocuswright's research shows that generative artificial intelligence (GenAI) is proving to be highly effective in the field of travel. Travelers are adopting it rapidly and are extremely satisfied with the results. Furthermore, in 2025, autonomous AI agents will begin to redefine how we search, book, and experience travel, as well as how travel companies serve travelers (Phocuswright, 2025).

The next question concerns **the use of blockchain technology or cryptocurrencies for booking trips or paying** for tourist services. 48.1% (50) have used blockchain or cryptocurrencies for tourism purposes, while 51.9% (54) have not used either payment method. Regarding the respondents' willingness to use blockchain technology to ensure transparency and security during travel, 26.9% (28) strongly agree, 13.5% (14) agree, and 17.3% (18) are undecided. Only 7.7% (8) disagree, and the smallest group, 1% (1), strongly disagrees. The majority of respondents are unfamiliar with the technology.

Regarding the statement that blockchain technology improves the security of financial data during tourist transactions, 25% (26) strongly agree, 12.5% (13) agree, and 22.1% (23) are undecided. 4.8% (5) disagree, and only 1% (1) strongly disagrees. Again, the largest group of respondents, 34.6% (36), does not know anything about this technology. Of the total 104 respondents, 25% (26) strongly agree that blockchain technology reduces concerns about fraud in tourist transactions, while 14.4% (15) agree. 18.3% (19) are undecided, and 8.7% (9) disagree. No respondents selected "strongly disagree," but 33.7% (35) responded that they know nothing about this. Regarding the statement that using blockchain technology in tourism increases trust in tourist services and destinations, 28.8% (30) strongly agree, 14.4% (15) agree, and 16.3% (17) are undecided. 7.7% (8) disagree, and no one strongly disagreed. The largest group, 32.7% (34), does not know anything about the statement.

Several studies have explored the adoption and perceptions of blockchain technology in the tourism industry, which aligns with your findings on travelers' attitudes toward blockchain and cryptocurrencies. For instance, a study by Sarnacchiaro et al. (2024) examined the factors influencing the acceptance of blockchain technology among tourists, emphasizing the importance of security and trust in shaping behavioral intentions. Similarly, Valeri and Baggio (2021) discussed the potential of blockchain to increase transparency and security in tourism transactions, addressing concerns related to fraud and data protection. Additionally, studies have explored blockchain's ability to reduce the need for intermediaries in tourism, potentially leading to lower costs and increased trust among stakeholders (Önder & Treiblmaier, 2018).

Table 2: The respondents' opinions and average ratings - summarized and grouped by individual categories

	Respondent's opinion	Average rate (1–strongly disagree; 5-strongly agree)
1	Using mobile applications makes travel planning easier	3.63
2	Mobile apps make it easier to find information about tourist activities	3.77
3	Mobile apps provide in reaching tourist attractions more quickly	3.80
	<i>Mobile apps – Average value</i>	<i>3.73</i>
4	Virtual reality increases satisfaction with the tourist experience	2.83
5	The inclusion of virtual reality makes tourist activities more interesting	2.95
6	Virtual reality increases the likelihood of revisiting a tourist destination	2.96
	<i>Virtual reality – Average value</i>	<i>2.91</i>
7	Personalized recommendations based on artificial intelligence (AI) make travel planning easier	4.38
8	Personalized recommendations based on artificial intelligence are useful for planning tourist activities	3.63
9	Personalized recommendations based on artificial intelligence enhance the tourist experience	3.64
	<i>Personalized recommendations based on AI – Average value</i>	<i>3.88</i>
10	Respondents' willingness to use blockchain technology to ensure transparency and security during travel (e.g., authenticity of reviews, transaction security)	3.87 35 no knowledge
11	Blockchain technology improves the security of financial data during tourist transactions	3,85 35 no knowledge
12	Blockchain technology reduces concerns about fraud in tourist transactions	3.84 35 no knowledge
13	Using blockchain technology in tourism increases trust in tourist services and destinations	3.95 35 no knowledge
	<i>Blockchain technology – Average value</i>	<i>3.88</i>

Source: author's research

The average ratings indicate that the respondents involved in this research evaluated all the innovative new technologies they are familiar with with approximately the same average scores. Among the technologies examined, they were the least familiar with blockchain technology. However, blockchain and artificial intelligence received the highest ratings, followed by mobile applications, while virtual reality received the lowest rating in terms of importance for the tourism experience. Given that the average scores are significantly below the maximum values, it can be concluded that there are still many untapped opportunities in the field of new technologies in tourism, which could potentially lead to greater overall tourist spending.

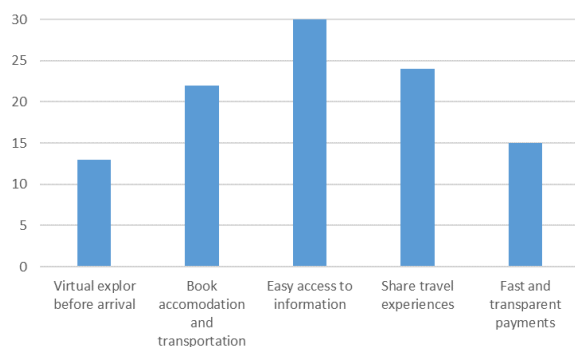
In the final part of the research, respondents were asked to assess the potential of digital technologies for tourism. Respondents were asked to evaluate the greatest advantage of using digital technologies i to: easy access to information, ability to share travel experiences with others, ability to easily book accommodation and transportation, ability to make fast, efficient and transparent payment and ability to virtually explore destinations and attractions before arrival.

The most frequently cited benefit was easy access to information, mentioned by 28.8% or 30 of respondents. The ability to share travel experiences with others was seen as a benefit by 23.1% (24), while 21.2% (22) considered the ability to easily book accommodation and

transportation as the greatest advantage. A smaller group, 14.4% (15), saw the ability to make fast, efficient, and transparent payments as the top benefit. The smallest group considered the ability to virtually explore destinations and attractions before arrival as the greatest advantage. Therefore, on this question as well, the least importance was given to virtual reality, as in the first set of questions.

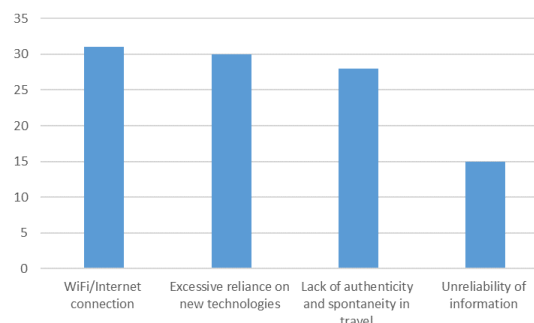
On the other hand, there are also many drawbacks that prevent users from embracing digital technologies in tourism. The largest disadvantage cited by respondents was issues with Wi-Fi or internet connections at destinations, mentioned by 29.8% (31) of respondents. The next largest issue was excessive reliance on digital technologies and information overload, mentioned by 28.8% (30). Following that, 26.9% (28) cited a lack of authenticity and spontaneity in travel as a drawback, while the smallest issue, 14.4% (15), was the unreliability of information provided by digital services.

Figure 3: Potentials for new technologies in tourism



Source: author's research

Figure 4: Drawbacks for new technologies in tourism



Source: author's research

Finally, the survey asked about respondents' views on digital technologies and whether they make their tourism experience better. Of the total 104 respondents, 87.5% (91) believe digital technologies improve the overall travel experience, while 12.5% (13) expressed a negative opinion about the tourist experience with digital technologies.

In conclusion, a large number of respondents expressed a positive attitude toward the use of digital technologies, confirming the significant contribution of innovative digital technologies to tourism, tourist spending, and the overall economic performance of the economy. For example, the study by Jelušić et al. (2022) shows that digital technologies shape destination perception and influence tourists' accommodation choices, resulting in increased tourist spending.

Final remarks

In addition to simplifying travel processes and interactions with tourism services, innovative technologies significantly increase overall spending in tourism. Digitalization, personalization, and improved infrastructure enable tourists to spend more money. Mobile applications, VR and AI have already made significant contributions to higher satisfaction and spending, while blockchain technology is promising but underutilized due to low awareness. Technological advancements are reshaping the travel and tourism, increasing engagement, and changing consumer behavior. Modern tourists, equipped with specific expectations and easy access to

information, rely on digital platforms to influence their decisions and emotions when planning trips. Rapid technological development is revolutionizing communication with consumers through social media and applications, which play a key role in shaping the tourist experience. Furthermore, the digitalization process has changed the business environment of companies and created a digital economy that thrives on new platforms and business models. In order to remain competitive in the long term, companies must quickly and efficiently approach digitalization and internationalization to keep up with this evolving industry.

Based on the survey results, it can be concluded that mobile applications significantly affect how tourists plan and book trips. Respondents most frequently use mobile apps to book accommodation, and many believe that these apps make trip organization easier, providing quicker access to information about tourist activities and attractions. VR also has its place in shaping the tourist experience, but most respondents are not fully convinced that VR significantly enhances their satisfaction or makes activities more interesting. AI-based personalized recommendations also enjoy broad support, as most respondents feel that they make trip planning easier and improve the tourism experience. On the other hand, the use of blockchain technology and cryptocurrencies in tourism is still in a growth phase, with a high level of unfamiliarity with these technologies, despite their ability to provide greater security and transparency in tourism transactions.

Although digital technologies bring many advantages, such as easy access to information and convenience in bookings, respondents also recognize several drawbacks, including issues with internet connection and dependence on technology. Despite these challenges, most respondents believe that digital technologies significantly enhance their tourism experience.

In this study, we analyzed the impact of modern technologies on the tourism, with a particular focus on mobile applications, VR, AI and blockchain technology. Based on the data collected and the analysis, we can draw the following conclusions:

The results show that tourists who use mobile applications for trip planning and navigation spend significantly more on tourism activities than those who use traditional methods. Mobile applications provide users with personalized recommendations, easy access to real-time information, and the ability to make quick reservations. These features enable tourists to discover and utilize more tourism content, leading to increased consumption. Respondents emphasized benefits such as convenience, time savings, and better insights into local attractions, confirming the hypothesis.

The results of the research indicate a significant positive impact of virtual reality on tourist engagement and satisfaction. Tourists who used VR technology reported a high level of satisfaction due to the ability to experience the destination before the actual trip. Virtual tours and enhanced experiences allowed tourists to develop a deeper understanding and connection with the destination, which encouraged higher on-site spending. Furthermore, tourists showed a greater interest in returning to destinations they had previously experienced through VR, confirming the statement that VR technology can stimulate not only immediate but also future tourism spending.

Data analysis shows that tourists highly value personalised recommendations based on AI. Personalisation makes it possible to make specific and relevant suggestions that match tourists' individual preferences and interests. Respondents expressed satisfaction with receiving customised recommendations that significantly improved their travel experience. As a result,

tourists were willing to spend more on activities and services that were recommended to them, confirming the hypothesis that AI personalisation leads to higher tourism spending.

The survey showed that the majority of respondents are not familiar enough with blockchain technology to adequately assess its impact on the tourism industry. Although blockchain offers significant benefits in terms of transparency, security and speed of transactions, the lack of awareness and understanding among tourists currently limits its effectiveness and acceptance. Modern technologies play a key role in shaping tourists' experiences and spending behaviour. However, to fully realise the potential of blockchain technology, additional steps need to be taken to educate and sensitise tourists to its benefits. The findings highlight the need for industry players to invest in digital literacy and awareness campaigns in order to fully capitalize on the benefits of blockchain technology.

This study suggests that tourism companies should prioritize the development of mobile applications and AI-driven tools to meet the growing preferences of modern travelers. By doing so, they can better position themselves in the competitive market, ultimately leading to increased customer loyalty and repeat business. This research contributes to a deeper understanding of how technological innovations can enhance tourist engagement and spending, providing valuable insights to tourism stakeholders.

The importance of technology and digitalization in all spheres of society and the economy is a strategic plan at the EU level, as confirmed by strategic documents, action plans, EU projects, and business programs implemented over the last decade. One of the significant frameworks in the EU is the Europe Digital Decade policy programme, with the following key project tasks in the areas of Skills, Government, Infrastructure, and Business: 1. a digitally skilled population and highly skilled digital professionals; 2. secure and sustainable digital infrastructures; 3. digital transformation of businesses; 4. digitalisation of public services (European Commission, 2024). The European Commission has identified list of areas for multi-country projects that pool investments from EU funds in the field of digitalisation focused on: common data infrastructure and services, Blockchain, low-power processors, Pan-European deployment of 5G corridors, high-performance computing, secure quantum infrastructure and network of cybersecurity centres, digital public administration, digital innovation hubs and high-tech partnerships for digital skills.

The implications of this research extend beyond immediate consumer behavior, suggesting that the adoption of innovative technologies is key to the sustainable growth of the tourism industry in an increasingly digital world. Digitalization and the implementation of modern technologies in the economy converge economic growth towards the direction of developed EU countries, accelerate the growth rate, and penetrate all spheres of the economy and society. Incoming tourism countries like Croatia should utilize EU instruments and incentives to speed up their technological adaptation, thereby ensuring better tourism results and greater positive economic effects from tourism.

A more developed information infrastructure in the tourism sector, along with better awareness and education of tourists as consumers, will undoubtedly change the pattern of tourism spending both domestically and abroad. The conducted research is only a small contribution to highlighting the need for monitoring this topic, especially for countries where tourism revenues are of critical importance. On one hand, it is essential to track the informatization process in the domestic market and follow technological trends in tourism, as well as the motives and consumption patterns of tourists across different age groups, particularly the younger and

middle-aged generations. In highly competitive market conditions, both on the demand and supply sides of tourism, there is an increasing focus on leveraging revenue and managing costs. While digitally literate tourists seek faster, more comprehensive, and higher-quality information about all stages of their travel, with an optimized value-for-money ratio, on the supply side, there is growing demand for increased efficiency due to rising costs, growing competition, and challenges in the labor market. Optimal business models are continuously being developed, where digital technologies play an exceptionally important role as they reshape business patterns and market behaviors in both tourism supply and demand. For this reason, continuous work on educating and presenting innovations to tourists as consumers is extremely important. Tourism professionals, in addition to implementing new technologies, must encourage ongoing research on their consumers to reduce negative perceptions and limitations in order to achieve the most positive overall effects. Such an integrated approach, which combines research on both the supply and demand sides, would provide additional input to tourism policy concerning digital technologies and their use. This research is a small contribution and an incentive for continued research to ensure a continuous income from tourist spending, which is of immense importance for our economy and the overall economy.

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DIGITAL TRANSFORMATION AND SUSTAINABILITY IN THE CROATIAN HOTEL INDUSTRY: A COMPREHENSIVE ANALYSIS OF TOP-RATED HOTEL WEBSITES

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Abstract

This paper examines the application of digital technologies in enhancing the hotel industry, focusing on the evolution of digital business practices, the current state of the hotel sector, and an empirical analysis of websites and social media accounts from top-rated hotels in Croatia. Initially, the study outlines the transformation from conventional business models to contemporary digital frameworks, examining digital tools like online reservation systems, mobile apps, and smart room technologies and their practical integration into today's hotel industry. A significant portion of the research highlights sustainability initiatives and contemporary trends within the hospitality sector. It examines sustainable practices, including energy-efficient operations, waste management strategies, and community engagement, alongside prevailing trends such as the digitalization of services and personalized guest experiences. Additionally, the paper conducts a detailed analysis of websites belonging to 105 high-ranking hotels (categorized as 4 and 5 stars) across Croatia. Only 20 of them were taken into research due to research-specific interest. This analysis evaluates various dimensions of digital presence, including online reservation availability, social media engagement, and usage of mobile apps, newsletters, site maps, and additional digital tools. Further studies were carried out to explore the hotel attributes that impact social media engagement within the hospitality industry. The findings reveal insights into the current digital maturity of the Croatian hospitality market and provide actionable recommendations for enhancing digital practices within the industry.

Keywords: digital technologies, sustainability, hotel industry, website analysis, social media

JEL classification: M15, M21

Introduction

Digital technologies have become essential to contemporary business practices, offering the hotel industry new chances to enhance service quality, reduce the complexity of operations, and enhance market competitiveness (Djevojić & Vitasović, 2023). Within the hospitality sector,

these technologies are significant in optimizing internal processes, personalizing guest experiences, and enhancing overall business performance (Astuti et al., 2024). This involves the usage of systems like reservation management systems, guest preference tracking software, digital marketing platforms, and the use of smart devices and Internet of Things (IoT) technologies in enhancing hotel functionality.

This research paper explores the application of digital technologies in the hotel industry, with a particular focus on highly rated hotels in the Republic of Croatia. Particular attention is given to the utilization of social media platforms, along with the functional aspects of specific hotel websites and social media. The primary aim is to examine how digital technologies are utilized for optimizing day-to-day operations of hotels, enhancing the user experience of guests, and affecting the competitiveness and profitability of hotels. The research question, whether the hotel attributes identified in this study impact social media engagement within the hospitality industry, is posed.

Digital marketing and social media have also enabled direct communication between hotels and their current and prospective visitors (Dimitrios et al., 2023). Hotels can advertise their offerings, showcase guest testimonials, and address inquiries promptly through platforms such as Facebook, Instagram, and Twitter. This interactivity and openness generate greater trust and strengthen guest loyalty (Xiang & Gretzel, 2010). Also, mobile applications now occupy a focal position in numerous hotels' online strategies (Parapanos & Michopoulou, 2022). The applications provide guests with instant booking and management of reservations, completion of check-in procedures, and access to a range of services and information throughout their stay. Furthermore, integration with technologies such as Radio Frequency Identification (RFID) and Near Field Communication (NFC) enhances the convenience and security of guests with wireless payment and keyless door opening (Wang et al., 2013).

The paper is structured as follows: a literature review is shown in the next chapter, followed by methodology. In the results section, research findings will be shown, following a swift discussion and recommendations. Lastly, concluding remarks are shown in the conclusion with limitations and further recommendations.

Digital business of the hotel industry

In the hotel industry, digital technologies play a vital role in modernizing operations and enhancing the guest experience (Giannoukou, 2024). These tools support functions such as real-time pricing, reservation management, and business sustainability (Zemlina et al., 2023). Platforms like OTA Insight and ProfitSage help hotels optimize rates across channels and respond to market changes effectively (Hollander, 2024). Additionally, CRM systems, chatbots, and reputation management tools enable personalized communication, targeted marketing, and improved guest satisfaction.

Digital business refers to the evolution of traditional business models through the incorporation of digital technologies, which facilitates faster, more efficient, and highly personalized communication with clients (Agustian et al., 2023). Within the hotel industry, online booking systems represent a fundamental component of digital operations. These platforms enable guests to check room availability, compare prices, and book services in real time (Gosela & Encarnacion, 2024). When integrated into hotel websites, such systems not only enhance global

visibility but also lower intermediary-related costs and provide hotels with greater control over bookings and revenue management (Buhalis & Law, 2008).

Smart technologies like IoT devices, digital keys, and mobile apps enhance guest experience and hotel efficiency. Guests can check in, access rooms, and request services via smartphones (Hollander, 2024). Mobile payments are common, especially in markets like China, and the COVID-19 pandemic accelerated contactless solutions, such as Hilton's facial recognition check-in (Nikopoulou et al., 2023).

Sustainability and energy management are increasingly vital in the hotel industry (Khatter, 2023; Ray et. al, 2023). Smart systems for lighting and climate control reduce resource use and costs while enhancing guest comfort and environmental responsibility (Hollander, 2024). Digital transformation has reshaped hotel operations, evolving from basic booking tools to advanced Integrated Property Management Systems (IPMS). These systems centralize functions like reservations and finances and integrate with other tools to support efficient, data-driven management (Commey et al., 2023; EisnerAmper, 2023). Mobile apps and IoT technologies enhance the guest experience through digital check-in, personalized services, and greater control via digital keys and room management features (Chechi, 2023).

Digital technology in the hospitality industry is rapidly advancing, driving a comprehensive transformation across operations, guest engagement, marketing, and resource management. These innovations help hotels remain competitive by offering personalized, high-quality services while reducing operational costs and promoting sustainability.

Methodology and sample description

This study involves an analysis of the websites of 105 top-rated hotels in the Republic of Croatia, as per data from the Ministry of Tourism and Sports (2024). The study focuses on 4- and 5-star hotels across various regions of Croatia, selected for their strong reputation and likely adoption of digital tools. Data was collected manually from 105 hotel websites between June 25 and July 25, 2024, using a quantitative approach. Website evaluation focused on three core dimensions, digital presence, site functionality, and guest service features, resulting in 142 categories using MS Excel. Regarding site functionality, the elements such as responsive design, sitemap availability, online booking system usability, loading speed, mobile app availability, and presence of payment gateway integrations (Salem and Čavlek, 2016; Law, 2019; Van Huy et. al., 2022; Selem et. al., 2023).

The social media presence analysis included presence (account existence), engagement (likes, shares and comments) and posting activity (in the last 30 days) on Facebook, Instagram, LinkedIn, YouTube, and X, along with how digital tools supported services like location info, guest interaction, and visual content. Furthermore, 20 hotels were selected for further validation and research analysis. Due to the purpose of this research, the hotels' social media exposure in general is not the same across all three social networks of this research interest. Therefore, only the ones that had all the specifics for LinkedIn, Facebook, and Instagram social networks, crucial to this research interest, were taken into the research analysis. Furthermore, the dependent variable, Social Media Engagement Score, was created by multiplying three important aspects: hotel presence, activity, and engagement on social media channels, following previous models (Veloso et al., 2023; Gomez-Suarez et al., 2022; Michopoulou et al., 2018; Kim et al., 2014) as seen in Table 1.

Table 1: Social Media Engagement Score (SMES) measures

Measure	Explanation
Hotel popularity (HP)	Hotels' reach and recognition on social media, including follower count & post engagement
Hotel activity (HA)	Hotel's activity level on social media, including profile completeness, posting frequency, and content variety
Hotel interaction (HI)	Hotels' social media engagement and responsiveness, including replies to comments, post sharing, and hashtag usage

Source: Authors' work

After calculating the scores for each social media network individually through weighting and normalization, the results for hotel popularity, activity, and interaction were obtained separately for LinkedIn, Facebook, and Instagram. These were then used as inputs for the creation of the overall SMES variable. Based on the previous research papers (Veloso et al., 2023; Michopoulou et al., 2018), the weights of every used social media measure are justified. The weighted formula indicates that hotel interaction has the highest proposed impact on the SMES and, therefore, has the highest weight of all (Veloso et al., 2023). The research modified SMES equation is shown below.

Equation Social Media Engagement Score (SMES)

$$SMES = 0,3 \times HP + 0,3 \times HA + 0,4 \times HI$$

Where:

HP = Hotel Popularity on social media (total followers, reach, etc.)

HA = Hotel Activity on social media (number of posts, frequency of updates, etc.)

HI = Hotel Interaction with users (likes, comments, shares, response rate, etc.)

The following Table 2 outlines the independent variables examined in this research. The variables encompass a range of potential factors influencing the SMES variable, including hotel size, location, and star level. Furthermore, additional variables such as whether hotels offer direct web booking, accept credit cards, and have a sitemap for better connectivity for search engine optimization purposes potentially play an important role in the SMES category. All variables were converted from original values to binary for simplicity purposes.

Table 2: Research independent variables

Variable	Original value	Binary Transformation
Hotel size (rooms)	Minimum 10, maximum 369	0=small (<Median); 1=large (>Median)
Hotel location	Inland, Coastal	0=inland, 1=coastal
Hotel star level	4 stars, 5 stars	0=4 stars, 1=5 stars
Direct web booking	Yes, No	0=No, 1=Yes
Online booking card acceptance	Yes, No	0=No, 1=Yes
Sitemap availability	Yes, No	0=No, 1=Yes

Source: Authors' work

To apply statistical analysis on the proposed dataset, descriptive statistics with later integration of multivariate linear regression will be implemented. Furthermore, to test the normality of the data distribution, the Shapiro-Wilk test will be implemented. To examine multicollinearity, the Variance Inflation Factor (VIF) will be implemented. Multivariate linear regression will be imposed on all the research variables simultaneously, with individual testing as well. This is due to potential differences in the significance levels of the model variables. Model fit will be shown through R^2 , AIC, and BIC values. For this purpose, JASP 0.19.3 statistical software is used.

Research results

An analysis of 105 top-rated hotels in Croatia shows a relatively even distribution across eight counties, with key concentrations in major tourist regions. Primorsko-goranska, Splitsko-dalmatinska, and Dubrovačko-neretvanska county lead with 18 hotels each, followed by Istarska with 16. Zagreb ranks next with 11, reflecting its role as a business and tourist hub. Zadarska and Šibensko-kninska counties each have 10, while Varaždinska county, with 4, highlights the smaller but notable presence of quality hotels in inland areas.

A review of hotel websites found that 94 out of 105 hotels include a marked location using an interactive map, highlighting a strong commitment to guest-oriented information. Interactive maps serve not just as visual enhancements but as valuable tools that simplify trip planning and help guests find the hotel with ease. This feature also allows users to explore nearby attractions and better understand the surrounding area, enhancing their overall experience from the outset. By offering such precise and user-friendly information, hotels demonstrate a clear commitment to guest convenience, positioning their websites as both booking platforms and practical travel resources.

An analysis of hotel websites shows that 52 out of 105 use newsletters to engage with guests. This strategy helps build loyalty, boost direct bookings, and promote special offers. Personalized newsletters keep guests informed about services, events, and local tips, while also providing exclusive deals, enhancing satisfaction, and encouraging repeat visits.

The analysis shows that 25 hotels offer a mobile app, 12 are 4-star, and 13 are 5-star, highlighting a trend among high-end hotels to enhance guest experience through digital tools. Istria County leads with 8 such hotels, mostly under the same ownership, suggesting a strategic, chain-wide approach. Most apps (22) are available on both iOS and Android, while 3 are iOS-only, likely based on target audience preferences. Mobile apps in the hotel industry often allow guests to quickly and easily perform many activities, such as online check-in, ordering room service, booking activities inside the hotel or in the surrounding area, and even communicating with hotel staff. Despite some positive examples, only 25 out of 105 hotels use mobile apps, indicating that many have yet to tap into their full potential. As digital technologies become increasingly vital in hospitality, this number should grow. Hotels need to embrace mobile solutions to enhance guest access to information and services, ultimately boosting both competitiveness and long-term guest satisfaction.

Out of 105 hotels, 91 use online reservation systems, showing strong digital adoption. They offer secure booking via online forms and central systems, support major credit cards, and primarily use internet banking for payments. However, 14 hotels, all 4-star, still rely on phone

bookings, limiting their competitiveness. While a few still use payment slips, most have shifted to internet banking, reflecting a move toward more modern, guest-friendly financial practices. A total of 25 hotels provide virtual tours on their websites, allowing guests to preview the property before booking. This feature builds trust, sets realistic expectations, and enhances satisfaction. It also gives hotels a competitive edge by meeting the needs of today's digital-savvy travellers.

A sitemap is a digital tool that acts as a blueprint for a website, helping search engines like Google efficiently find and index all its content. The most common type, XML sitemaps, is designed to enhance search engine visibility (Gibbons, 2023). Despite the benefits, only 8 of 105 top hotels use a sitemap, limiting their online visibility. Hotels should adopt sitemaps to enhance SEO and stay competitive.

The analysis of social media presence shows that most hotels understand the value of digital communication and promotion (Suligoj, M. 2024). Facebook is used by 86 hotels, followed by Instagram with 78, making them the top platforms. X (formerly Twitter) is used by 28 hotels, and LinkedIn by 21.

Facebook and Instagram are key for guest engagement through visual content, special offers, and direct interaction. Instagram is especially effective for showcasing luxury amenities, food, and events. LinkedIn serves a more professional role, helping hotels share business updates, job openings, and staff profiles, while building connections with partners and potential hires. Five-star hotels stand out in social media efforts, investing more in high-quality visuals and posting more frequently, often every three days. They use advanced design tools to create engaging content, boosting follower counts and market presence. While most hotels use social media for promotion, luxury hotels lead in content quality and consistency, strengthening their brand and appeal. Although most hotels use social media for promotion, luxury hotels set the standard with higher content quality and consistent posting, enhancing their brand image and attracting a broader audience.

Only 4 out of 105 hotels provide complete general information on their websites, including contact details, descriptions, photos, directions, and maps. This level of detail builds trust, supports booking, and shows professionalism. Most hotels lack this, risking a negative impression and missed bookings.

The research results shown in Table 3 describe the latent variables' descriptive statistics. Skewness and Kurtosis show a mix of both positive and negative values. There is a flatter curve for the majority of the variables, except for the Direct booking via web variable that shows a peak in the distribution. The majority of the variables have low to medium variation, which denotes they are more stable and clustered around the mean. Variable sitemap is the only extreme that has a value above 3 (coefficient of variation), which can suggest that it has spread values relative to the mean. Shapiro-Wilk test indicated that all variables are following a non-normal distribution, which will later be tested using Spearman's correlation.

Table 3: Descriptive statistics

Variables/ Measures	SMES	Location	Size (rooms)	Category (stars)	Direct booking via the web	Credit card acceptance	Sitemap
Valid	20	20	20	20	20	20	20

Variables/ Measures	SMES	Location	Size (rooms)	Category (stars)	Direct booking via the web	Credit card acceptance	Sitemap
Missing	0	0	0	0	0	0	0
Mean	0.541	0.850	0.500	0.500	0.950	0.850	0.100
Std. Deviation	0.342	0.366	0.513	0.513	0.224	0.366	0.308
Coefficient of variation	0.633	0.431	1.026	1.026	0.235	0.431	3.078
Skewness	0.114	-2.123	0.000	0.000	-4.472	-2.123	2.888
Std. Error of Skewness	0.512	0.512	0.512	0.512	0.512	0.512	0.512
Kurtosis	-1.368	2.776	-2.235	-2.235	20.000	2.776	7.037
Std. Error of Kurtosis	0.992	0.992	0.992	0.992	0.992	0.992	0.992
Shapiro- Wilk	0.894	0.433	0.641	0.641	0.236	0.433	0.351
P-value of Shapiro-Wilk	0.031	< .001	< .001	< .001	< .001	< .001	< .001
Minimum	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Source: Authors' work

Non-parametric Spearman's Correlation test is shown in Table 4. There are a few variables under the accepted significance level. The variables relations between Credit card acceptance and SMES, Direct booking via web and SMES, and Direct booking via web and Credit card acceptance show significance under the 10% and 5% levels. This denotes that they have a linear relation, while other variables show no significance and are thus non-linear.

Table 4: Spearman's Correlation

Variable		SMES	Location	Size (rooms)	Category (stars)	Direct booking via web	Credit card acceptance	Sitemap
1. SMES	Spearman's rho	—						
	p-value	—						
2. Location	Spearman's rho	0.158	—					
	p-value	0.505	—					
3. Size (rooms)	Spearman's rho	0.321	-0.140	—				
	p-value	0.167	0.556	—				
4. Category (stars)	Spearman's rho	0.139	0.140	0.200	—			
	p-value	0.559	0.556	0.398	—			

Variable		SMES	Location	Size (rooms)	Category (stars)	Direct booking via web	Credit card acceptance	Sitemap
5. Direct booking via web	Spearman's rho	0.379	-0.096	0.229	-0.229	—		
	p-value	0.100*	0.686	0.331	0.331	—		
6. Credit card acceptance	Spearman's rho	0.401	0.216	0.140	0.140	0.546	—	
	p-value	0.079*	0.361	0.556	0.556	0.013**	—	
7. Sitemap	Spearman's rho	0.376	0.140	0.000	0.333	0.076	0.140	—
	p-value	0.102	0.556	1.000	0.151	0.749	0.556	—

Note: Statistical significance at *10%/**5%/***/1% probability; Source: Author's work

Statistical analysis has been performed to obtain valuable results. The model summary is seen in Table 5, which shows that the independent variables describe 36.4% of the dependent variable. Furthermore, AIC and BIC values are low, indicating lower model strength. The Durbin-Watson test shows positive and significant autocorrelation, which could be the case due to the research binary values. Lastly, the model itself shows no significance, and thus, the null hypothesis has not been rejected.

Table 5: Model summary

Model	R ²	Adjusted R ²	AIC	BIC	p	Autocorrelation (Durbin-Watson)	Durbin-Watson Statistic	P
M ₁	0.364	0.071	19.807	27.773	0.348	0.341	1.229	0.033

Note: Statistical significance at *10%/**5%/***/1% probability; Source: Author's work

Nevertheless, the research authors wanted to show the whole model's multivariate linear regression results. The results are seen in Table 6 and are all non-significant, complementing the model summary results. The VIF values were below 2, indicating no severe multicollinearity issues.

Table 6: Research model multivariate linear regression results

Model variables	Unstandardized	Standard Error	Standardized	t	p	Tolerance	VIF
(Intercept)	0.541	0.077		7.066	< .001		
(Intercept)	-0.132	0.439		0.302	0.768		
Location	0.028	0.223	0.030	0.127	0.901	0.858	1.165
Size (rooms)	0.213	0.156	0.318	1.366	0.195	0.900	1.111
Category (stars)	0.104	0.174	0.156	0.598	0.560	0.722	1.384
Direct booking via web	0.336	0.455	0.219	0.738	0.473	0.555	1.802

Model variables	Unstandardized	Standard Error	Standardized	t	p	Tolerance	VIF
Credit card acceptance	0.174	0.276	0.186	0.632	0.538	0.563	1.777
Sitemap	0.239	0.267	0.215	0.897	0.386	0.849	1.178

Note: Statistical significance at *10%/**5%/***/1% probability; Source: Author's work

Since the model summary and the regression results showed non-significant values, the research authors continued with the single-variable linear regression analysis. Three variables showed significance levels, but only one of them showed both a significant model and linear regression values. The first two variables shown in Table 7, Size and Category, although significant at the 10% level (Size), have a non-significant model and, therefore, no further step could have been taken.

Table 7: Research model multivariate linear regression results – Size & Category

Model variables	Unstandardized	Standard Error	Standardized	t	p	Tolerance	VIF
Size (rooms)	0.270	0.150	0.404	1.802	0.089	1.704	0.960
Category (stars)	0.150	0.150	0.225	1.001	0.331	1.005	0.960

Note: Statistical significance at *10%/**5%/***/1% probability; Source: Author's work

Finally, the last variable, Credit card acceptance, showed a significance value under 10%, thus rejecting the null hypothesis and accepting the new model. Other parameters, such as the coefficient of determination (16.7%), AIC, and BIC, showed low values. Positive autocorrelation is evident due to the binary dataset. The values are shown in Table 8.

Table 8: Model summary – Credit card acceptance

Model	R ²	Adjusted R ²	AIC	BIC	P	Autocorrelation (Durbin-Watson)	Durbin - Watson Statistic	P
M ₁	0.167	0.121	15.194	18.181	0.073	0.471	0.952	0.012

Note: Statistical significance at *10%/**5%/***/1% probability; Source: Author's work

The single-variable linear regression visible in Table 9 showed a positive and significant influence of the Credit card acceptance on the dependent variable, SMES, under a 10% significance level. Furthermore, VIF values are low, meaning there is no multicollinearity. This suggests that, when considered alone, Credit card acceptance influences customer engagement on social media.

Table 9: Research model linear regression results – Credit card acceptance

Model variables	Unstandardized	Standard Error	Standardized	t	p	Tolerance	VIF
Credit card acceptance	0.382	0.201	0.409	1.903	0.073	1.000	1.000

Note: Statistical significance at *10%/**5%/***/1% probability; Source: Author's work

The results showed that when the variables are grouped in one single model, they did not influence the SMES variable. Therefore, single variable linear regression was implemented, which showed some significant results. Consumer choices can be influenced by many factors, of which Credit card acceptance could be a proxy for an indirect influence on hotels' social media. Digitally mature hotel companies invested in better online websites and booking systems, marketing, and customer service. Therefore, consumers understand this and are more likely to be active on their social media pages. Signals such as secure payment options enhance consumer trust and, therefore, their online behavior (Irshad et al., 2020).

Recommendations for a successful hotel website

Designing a hotel website goes beyond outlining offered services. Given that most visitors pre-plan their trips online, a high-quality website could easily be the difference between a fully booked hotel and one with vacant rooms. To achieve this, a properly designed hotel website must employ strategic features that optimize its aesthetic appeal and improve user satisfaction. An appropriate website design requires seamless navigation and an easy-to-follow layout. Shoppers should be able to acquire relevant information with no hassle. Webpages should be self-explanatory using booking systems and contact details, as well as clearly labelled pictures that showcase the rooms and services offered. Grouping information in simple systems lessens confusion, enhances understanding, and promotes increased site engagement. All of these factors combined lead to an increased likelihood of reserving a booking. With the rapid streaming of data over mobile networks, having a mobile-compatible website is no longer optional—it is essential. The site needs to cater to changing screen dimensions and offer a consistent user experience on mobile phones, tablets, and computers. In addition, fast hosting will enhance user experience by making pages load quickly, as sluggish performance will drive away users. Users' first impression is determined by what catches their eyes. The website is improved with high-resolution pictures of the rooms, the pool, the restaurant, as well as other services that are provided. Videos, as well as classic media, depict the expectation more engagingly and provide a suggestive glimpse of what it's like to be in the hotel, reinforcing the idea. To ensure users associate rooms with cleanness and elegance, every picture should be taken with professional equipment. The visibility of a website in the Google Search Engine is one of the advantages Search Engine Optimization (SEO) offers. A website's SEO should include all relevant keywords to the content, structured headings, clear, engaging descriptions, etc. The website should also have an updated blog that discusses travel tips, local attractions for a particular site, and special promotional discounts to ensure users are engaged and that site traffic is maintained. Lastly, an online booking system should be provided that is secure and simple to use, enables transparency in the reservation process, and guarantees a smooth process for guests. A guest's flexibility is greatly increased by incorporating credit cards and internet banking into online payment systems. These systems should also allow users to personalize bookings, choose additional services, and get confirmation for the reservations in real-time. Social media marketing offers a strong platform for social interaction with guests; thus, Facebook and Instagram accounts should be created. The hotel's website can be linked to these networks to enable content sharing to promote special deals and interact freely with potential guests and existing users. For example, Instagram feeds or Facebook posts can be displayed on the website, which increases engagement and additionally draws more visitors. A modern hotel's operations are composed of various components, such as ensuring the guests' data and information are secured and upholding cybersecurity principles. To safeguard guest confidentiality, measures such as the use of SSL certificates, Secure Sockets Layer payment systems, and compliance with General Data Protection Regulation (GDPR) requirements must

be put in place. Additional assurance comes from providing a clear privacy policy and straightforward instructions regarding data protection procedures. Beyond serving as an online advertisement, a hotel's website should have the capability to actively seek out users' attention, provide information, and retain their interest, functioning as an interactive hub. Thoughtful investment in advanced functionality, appealing design, optimization, and data security contributes tremendously to the hotel's business performance.

Conclusion and research limitations

This paper explores how digital technologies enhance hotel operations, improve guest experiences, and support long-term growth. By analysis of the websites of 105 high-end hotels in Croatia highlights trends in online booking, mobile apps, social media, and SEO use.

The study shows a shift toward tech-driven models, with tools like AI, IoT, and contactless services boosting efficiency and personalization. Coastal regions and Zagreb dominate the hotel scene, though inland areas also contribute. Notably, mobile apps are underused, signalling room for digital growth.

Analysis of the impact of hotel attributes on social media engagement revealed that, although a few variables were individually significant, the overall effect was not statistically meaningful. Credit card acceptance stood out, suggesting that payment flexibility builds trust, leading to higher digital engagement. This complies with the research question, whether the hotel attributes identified in this study impact social media engagement within the hospitality industry.

Limitations include the modelling technique used, which showed non-significant overall results. Future research could use methods like machine learning or logistic regression and a larger sample. Practically, offering secure payment options can act as a trust signal, boosting online guest interaction.

Recommendations include user-friendly websites, mobile optimization, and social media integration. A key limitation is the focus on only 4- and 5-star hotels; future research should expand to include lower-tier hotels and other EU countries. Ultimately, digital transformation is essential for competitiveness and long-term success in the hotel industry.

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A QUANTITATIVE BIBLIOMETRIC LITERATURE REVIEW OF BUSINESS INTELLIGENCE IN CONSUMER-ORIENTED SECTOR

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Abstract

Business intelligence is becoming the key to many industries because it provides companies with quality information and new business insights to ensure more efficient decision-making processes and timely actions in the market. Therefore, this paper conducts a quantitative bibliographic review of the literature dealing with business intelligence in user-oriented industries and uses the case study methodology. The research was conducted based on Web of Science database of scientific papers, resulting in 31 further analyzed papers. The results of the bibliographic analysis showed the dynamics of published works on a topic that combines the concept of business intelligence and consumer-oriented sectors such as retail or wholesale. Furthermore, this paper aims to show which specific industries the authors of individual papers work on in this area in the case studies and which specific companies they have chosen for their case studies.

Keywords: business intelligence, consumer-oriented sector, literature review

JEL classification: O30, O32, O33

Introduction

Nowadays, information technology is widely recognized as the foundation of an analytics-based approach, as it facilitates efficient data storage, multidimensional query processing, and algorithms to model historical data to identify trends (Berry & Linoff, 2004; Prahlad & Krishnan, 2008; Mathew, 2012). Regardless of the constant development of business and information technology in the period from the 1980s to the 1990s, the concept of business intelligence certainly plays a key role in this area of data analysis because it simultaneously represents a process, technology, tool, or end system, the adoption of which will provide every company with new knowledge for further strategic business moves (Mola et al., 2020 according to Barakat et al., 2013). Consequently, due to their capacity to offer competitive and sophisticated information inputs for the decision-making process, business intelligence systems have garnered much attention from executives and decision-makers in the current era of technological advancements and intense competition (Ain et al., 2019; Parwita Ginatra & Asana, 2021). Such tools, as business intelligence tools, aid in deciding on strategy, tactical, and operational business decisions and taking the required steps to enhance business performance (Parwita, Ginatra & Asana, 2021). It can be particularly vital for the retail industry since retaining consumers, boosting prospective sales, and fostering customer loyalty are crucial for corporate success due to increased competition from traditional and online companies (Phan & Vogel, 2010). Gathering precise, trustworthy data from various sources to gain essential insights that support retail decision-making is made possible by business

intelligence. Despite being the most diverse industry in the world, the retail sector has many challenges, including sustaining earnings, ensuring customer retention, and expanding its market and market share (Eheliyagoda et al., 2021).

Therefore, the main objective of this study is to investigate published studies aligned with business intelligence used in consumer-oriented sectors such as retail and use case studies as their research method. Accordingly, the quantitative approach of quantitative bibliometric literature review has been selected and applied as a favored and appropriate research method to accomplish the above-mentioned research goals.

After the introduction, the rest of the paper is organized as follows. The theoretical background for this study is presented in the second part of this paper. The third part of this paper describes the methods used. After that, the fourth part presents and discusses the study's results. Finally, this paper concludes with the final remarks, limitations of the paper, and recommendations for further research.

Theoretical background

According to Agiu et al. (2014), business intelligence is a collection of tools used to gather, process, and analyze data so that a company may assess the business results it has obtained and, based on how they are interpreted, guide its operations in the future. Similarly, authors Parwita, Ginatra, and Asana (2021) define business intelligence as a collection of methods for comprehending business situations through analyses of internal company data and external data from third parties. In this way, business intelligence encompasses various technologies, from data management, statistical data processing, predictive analytics, and artificial intelligence, which work together to find and use new information from multiple data sources to help companies plan their future business (Moro et al., 2015). Moreover, business intelligence combines ideas and techniques that involve gathering, transforming, and distributing data from various departments to people responsible for business decision-making and strategic processes (Fu et al., 2020).

From a technical standpoint, business intelligence is regarded as a top-priority technology that each contemporary company must use to attain profitable outcomes (Hawking & Sellitto, 2010). Typically, such success is achieved by managers' access to, evaluation, and comprehension of business data and employees' data sharing (Xia & Gong, 2014, according to Scholz et al., 2010). Access to data, its analysis, and correct interpretation by managers leads to better decision-making and timely planning of the strategic steps the company wants to take in the market. (Aruldoss et al., 2014). In this context, the efficiency of the decision-making process in the company enabled by the business intelligence concept is considered as the provision of key information to the most important people at a critical time and place (Tan, Sim & Yeoh, 2011). Such a more efficient decision-making process contributes to better strategic planning of the organization's activities, i.e., improving organizational business processes and creating new products or services (Hannula & Pirttimäki, 2003). For this reason, many companies from various industries are eager to implement and apply business intelligence technology, which means not only technology but also an understanding of the data collected about the business, corporate strategy, business goals, etc. (Sang et al., 2016).

Leveraging data is becoming increasingly crucial for businesses to thrive in the retail sector (Mirza et al., 2025). According to Reinartz et al. (2011), the retail industry is one of the most

data-intensive sectors in the industry, as it uses a variety of different systems, technologies, and tools in its business to collect an increasing amount of other data (Zamba et al., 2018). POS systems, financial systems, and e-commerce businesses are just some operational and external systems from which retailers extract a growing amount of data (Zamba et al., 2018). The ever-increasing amount of customer data produced by transactions, contacts, and new IoT devices presents retailers with many opportunities and challenges (Mirza et al., 2025). According to García-Gómez, Gutiérrez-Arranz, and Gutiérrez-Cillán (2012), retailers must quickly adopt new tactics and effectively utilize their information resources to be successful. Analytics in the retail supply chain could contribute to this (Paulino, 2022). Accordingly, retailers in developed countries were among the first industries to adopt business intelligence tools to leverage advanced analytics and gain a competitive advantage in the marketplace (Davenport & Harris, 2007; Mathew, 2012). Similarly, authors Zamba et al. (2018) emphasize in their paper how leading retailers are prioritizing analytics projects due to the retail industry's changing business intelligence standards. According to authors Eheliyagoda et al. (2021), the retail sector makes substantial use of business intelligence systems because they facilitate data collection and analysis. Likewise, Gujrati (2016) emphasizes in their research that data analysis is crucial for retail. It supports store floor management, estimates sales, creates marketing campaigns and competitive pricing models, controls inventory and satisfies consumer expectations. Namely, the US retail giant Wal-Mart has one of the world's most extensive datasets, giving them unique analytical capabilities in supply chains and customer loyalty (Mathew, 2012). Data mining and advanced analytics in retail have been the subject of several academic papers, particularly in North America, which implies that the US retail sector extensively uses business intelligence systems (Mathew, 2012). Therefore, businesses must use data analytics to inform decisions and maintain a competitive edge in the fiercely competitive retail sector (Murugan et al., 2024).

Methodology

This paper employs the quantitative method of a bibliographic literature review. This quantitative review of the literature was conducted in February 2025. Through this method, a quantitative analysis of all available literature published in the Web of Science database was conducted since this database continues to be one of the primary providers of citation data. Furthermore, its multidisciplinary coverage is one of the most significant advantages for researching and contrasting various scientific domains (Mongeon & Paul-Hus, 2016; Archambault et al., 2006). Thus, the terms "business intelligence," "retail," and "case study" were used to search the Web of Science database. The literature search procedure was not restricted. Therefore, the additional quantitative bibliometric study covered all document types published up to this point and written in a different language. Table 1 presents the research strategy.

Table 1: Literature review strategy

Criteria	Restrictions
Keywords	((TS=("business intelligence")) OR TS=("business intelligence system")) AND TS=("retail")) AND TS=("case stud*")
Document Type	No restrictions - All
Language	No restrictions - All
Time	No restrictions - All

Source: Web of Science, 2025.

Results and discussion

The literature review resulted in a total of 31 scientific papers. Of the total, 28 papers were written in English, two were written in Portuguese, and one scientific paper was written in Chinese. In the context of the type of publication in which the scientific paper was published, a total of 12 scientific papers were published as scientific articles in journals, 10 were published as doctoral dissertations, nine papers were published in proceedings of international scientific conferences or other scientific meetings, one paper was published as a result of an awarded grant, and one paper was classified as early access papers. Table 2 shows the results of the literature search according to the criteria of language and type of document in which the work was published.

Table 2: Results of the literature review according to the criteria of language and type of document

Criteria		Number of papers	Percentage of papers in total
Language	English	28	90,32%
	Portuguese	2	6,45%
	Chinese	1	3,22%
Document Type	Article	12	38,70%
	Dissertation Thesis	10	32,25%
	Meeting	9*	29,03%
	Awarded Grant	1	3,22%
	Early Access	1**	3,22%

Source: Web of Science, 2025

*paper classified as Article and Meeting

**paper classified as Article and Early Access

Furthermore, the works found were analyzed according to the year of publication. According to the results, works dealing with business intelligence in retail and those focusing their methodology on case studies were published from 2004 to 2023. The most significant number of works was published in 2017 when five works were published. The lowest number of papers was recorded in 2020 and 2021 when one paper on this topic was recorded yearly. This can be explained by a global pandemic that may have reduced research activities or changed research focus, given that many resources and attention were focused more on health crises and less on topics such as business intelligence in retail. Figure 2 shows the number of papers published from 2004 to 2023.

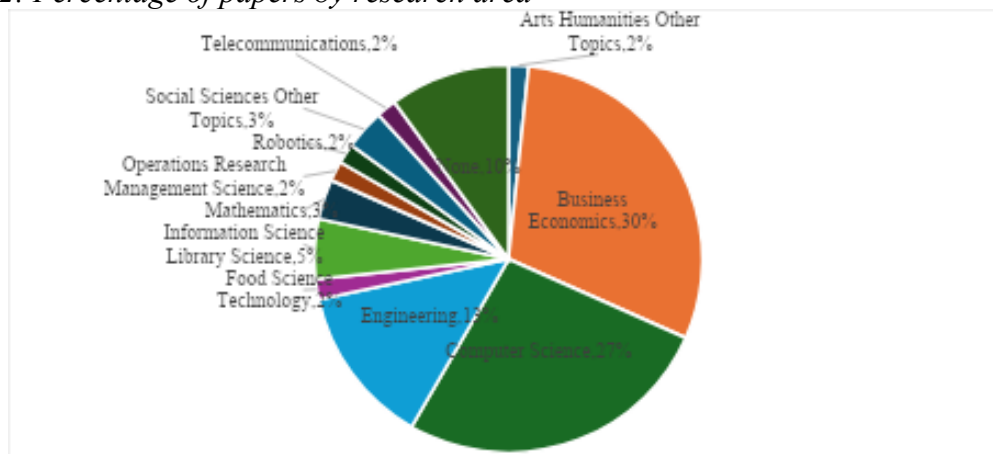
Figure 1: Number of papers by publishing year



Source: Author's work based on Web of Science data, 2025

Likewise, the literature review includes an analysis of the papers found through the research areas into which they are categorized. According to the obtained results, the most significant number of papers was classified into the research areas of Business Economics (18 papers) and Computer Science (16 papers). On the one hand, business intelligence provides the company with better quality information to help it make a more efficient decision-making process. On the other hand, it achieves this with the help of technologies and tools that, along with various methods and methodologies, make up the concept of business intelligence according to its definition. Therefore, this result is expected because business intelligence and retail, as topics often associated with data analysis, optimization of business processes, and technological solutions, belong to the aforementioned research areas such as Business Economics and Computer Science. The smallest number of papers is from telecommunications, robotics, Operations Research Management Science, Food Science Technology, and Art Humanities Other Topics. The number of papers by research category is shown in Figure 2. This result may mean that the application of business intelligence in these areas is less researched or that these areas are not so focused on retail and business intelligence.

Figure 2: Percentage of papers by research area



Source: Author's work based on Web of Science data, 2025.

The papers were also analyzed using the available data on the authors' addresses listed for each paper. According to the results obtained, it was shown that, out of a total of 42 authors across all papers, the most significant number of authors contributing to publications on business intelligence in retail who employed case study analysis methodology in their research comes from the United Kingdom (21.43%). This is followed by authors from China (16.67%), Portugal (14.29%), and the USA (11.90%). Further, 4.76% of authors are from Spain, with an equal percentage of 2.38% representing Australia, Cyprus, Greece, India, Italy, Japan, Lebanon, Malaysia, Peru, Poland, Scotland, Taiwan, and Turkey. The number of authors by country/region is shown in Figure 3.

Figure 3: Number of authors by countries/regions



Source: Author's work based on Web of Science data, 2025.

The papers were further analyzed according to the case study they were conducting. Seven works that could not be accessed were excluded from the analysis in this step. Likewise, two papers were excluded since they were not based on the set topic. In the remaining 22 papers, it was analyzed whether they used the case study analysis method and for which company. Also, the papers were classified according to whether the case study was focused on retail, wholesale, or some other industry. Table 3 shows all the analyzed works classified by author's name, publication type, publication year, name of the company that is processed in the case study (if it is mentioned and it is not anonymized), the industry that is processed in the case study (if specified) and the headquarters of the company that is processed. According to the results, it can be seen that 20 works concern the retail industry, while three are additionally concerned with wholesale. Apart from these two industries, the other three papers touch on different sectors, such as telecommunications, internet-based value-added service providers, banking, insurance, healthcare, IT operations, and pharmaceuticals. Most companies mentioned in the papers are headquartered in the United States of America (5) or the United Kingdom (4).

Table 3: Papers analyzed according to publication type, publication year, and case study method data

#	Authors	PuT	PuY	CompanyName	Industry			CoHDQ
					R	W	Other	
1	Quinde, M. & Quinde, J.	D/T	2023	ø	√	Ø	ø	ø
2	Caço, A. R. M.	J	2023	ø	√	Ø	ø	Peru
3	Trifonov, K.	D/T	2022	ø	ø	Ø	ø	ø
4	Cong, L. W., Li, B. & Zhang, Q. T.	J	2021	AirSage; Tencent Code Solution			Telecommunications; Internet-based value-added service providers	USA; China
5	Brännström, G.	D/T	2021	Nudie Jeans Co.	√	√		Sweden
6	Weinandy, T.J.	D/T	2021	ø	√	Ø	ø	USA
7	Freire, M.A.	D/T	2020	ø	√	Ø	ø	Portugal
8	Priporas, C.V.	J	2019	ø	√	Ø	ø	USA

#	Authors	PuT	PuY	CompanyName	Industry			CoHDQ
					R	W	Other	
9	Xiong, F., Chapple, L., Song, X. Y., & Hui, K. N.	J	2019	ø	√	Ø	ø	China
10	dos Santos G., Gonçalo A.	D/T	2019	AR	AR	AR	AR	AR
11	Anderson, M. & Bolton, J.	J	2018	ø	√	Ø	ø	UK
12	Carro- Rodriguez, J. M., Lorenzo- Romero, C. & Gomez-Borja, M. A.	C	2018	Zara	√	Ø	ø	Spain
13	Christoforou, K.	C	2018	BeautyLine	√	Ø	ø	Cyprus
14	He, W., Wang, F-K. & Akula, V.	J	2017	Wal-mart; Costco; Kmart; Kohl's; Home Depot	√	√	ø	USA
15	Gawin, B. & Marcinkowsk, B.	J	2017	ø	√	Ø	ø	Sweden; France; UK; Poland
16	Altuntas, S.	J	2017	ø	√	Ø	ø	Turkey
17	Krneta, S.	D/T	2017	ø	√	Ø	ø	Bosnia and Herzegovina
18	Thoumy, M. & Avedikian, G. G.	C	2017	AR	AR	AR	AR	AR
19	Audzeyeva, A. & Hudson, R.	J	2016	Clydesdale Bank; Yorkshire Bank	√	Ø	ø	UK
20	Li, J., Sato, A., Huang, R. & Chen, D.	C	2016	AR	AR	AR	AR	AR
21	Anderson, M. & Bolton, J.	C	2016	AR	AR	AR	AR	AR
22	He, W., Shen, J., Tian, X., Li, Y., Akula, V., Yan, G. & Tao, R.	J	2015	Wal- mart;Costco	√	√		USA
23	Ahmed, F. D., Majid, M. B. A., Jaber, A. N., Ahmad, M. S.	C	2015	ø	√	Ø	Telecom; Banking; Insurance; Healthcare; IT Operations	ø
24	Albors- Garrigos, J.	C	2015	AR	AR	AR	AR	AR
25	de Sousa Berberan R. & João D. P.	B	2015	AR	AR	AR	AR	AR
26	Madhuri, K. L. & Suma, V.	C	2014	ø	√	Ø	Pharmaceuticals	ø
27	Smith, A. (Principal Investigator)	AG	2014	AR	AR	AR	AR	AR

#	Authors	PuT	PuY	CompanyName	Industry			CoHDQ
					R	W	Other	
28	Giannakis, D.	D/T	2012	Eurobank EFG group; Mafin Egnatia Bank; GENIKI Bank; Millenium Bank; Proton Bank	ø	Ø	ø	Switzerland; Greece/Cyprus; Portugal
29	Golfarelli, M. & Rizzi, S.	J	2011	ø	√			Italy
30	Marketos, G. & Theodoridis, Y.	J/C	2006	ø	ø	Ø	ø	ø
31	Han, W. X.	D/T	2004	TESCO	√	Ø	ø	UK

Source: Author's work based on Web of Science data, 2025.

*PuT = PublicationType, PuY = PublicationYear, R = Retail, W = Wholesale, CoHDQ = CompanyHeadquarters, AR = AccessRestriction, D/T = Dissertation/Thesis, J = Article; C = Proceeding Paper, AG = AwardedGrant

Conclusion

This paper focuses on conducting a quantitative bibliographic analysis by investigating published scientific papers that address the topic of business intelligence in consumer-oriented sectors, such as the retail sector, and use the case study analysis method in their work. The analysis resulted in a total of 31 papers. The most significant number of papers addressing this topic was published in 2017, while the smallest number of papers were published in 2020 and 2021. Also, the quantitative bibliographic analysis showed that most papers were published as scientific papers in international scientific journals. In addition, the analysis showed that scientific papers addressing the topic of business intelligence in retail are mainly classified in business economics and computer science. Also, the analysis showed that the most significant interest in this research topic is among academics from the United Kingdom. Likewise, further analysis showed that the papers were mainly based on retail in their case studies and that they addressed companies headquartered in the USA and the United Kingdom.

However, this paper has its limitations that must be accentuated. Namely, this paper focuses exclusively on the bibliographic analysis of scientific works indexed only in the Web of Science database, which may leave out some works indexed in other scientific databases. Therefore, it would be advisable for further research to extend the bibliographic analysis to different bases of scientific works such as the Scopus database. Likewise, the recommendation for further research is to conduct an in-depth qualitative analysis of all found scientific works to get a more detailed insight into each topic that the works deal with.

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MANAGEMENT

Management is the cornerstone of organizational success and continues to be a dynamic field of academic inquiry. In today's rapidly evolving business landscape modified by the implementation of AI and constant global shifts, organizations must adopt agile strategies, foster innovation, and prioritize human-centric practices to remain competitive and resilient. Empirical and theoretical papers submitted to Management tracks highlight emerging themes such as sustainable business practices, digital transformation, workplace wellbeing, and leadership development, contributing to the defined aim and scope of the Odyssey conference. To reflect the diversity of research interests, submissions have been organized into four thematic tracks – each capturing a distinct facet of modern Management thought and practice.

TRACKS:

- TRACK 1: Business Competencies in the Age of AI**
- TRACK 2: Managing Innovation and Strategic Adaptation in the Digital Era**
- TRACK 3: Sustainability and Emerging Business Models**
- TRACK 4: Employees, Work, And Organizational Well Being**



MANAGEMENT

TRACK 1: Business Competencies in the Age of AI

PREFACE

MANAGEMENT – TRACK 1: BUSINESS COMPETENCIES IN THE AGE OF AI

The profound and accelerating impact of Artificial Intelligence (AI) and Industry 4.0 is fundamentally redefining the landscape of modern management, compelling organizations to rethink strategies, operations, and human capital. This thematic track delves into the critical challenges and transformative opportunities faced by leaders and managers as they navigate this new technological paradigm. It explores how these advanced technologies are not merely tools, but catalysts for change, influencing everything from organizational efficiency and global trade dynamics to workplace culture and corporate social responsibility. The papers within this section collectively offer cutting-edge insights and strategic guidance for effectively leading and managing enterprises in an era characterized by unprecedented technological disruption and innovation. They focus on understanding and addressing the managerial implications of AI and related digital transformations across diverse organizational and global contexts.

Bato and Kašćáková examine how emerging digital technologies, particularly AI and automation, are shaping "reglobalization" and influencing global trade strategies, supply chain resilience, and geopolitical competition, crucial aspects for international management. Čerkuć and Samardžija investigate the managerial implications of AI-driven workforce transformations on wage inequality and industry shifts, assessing the strategic benefits of reskilling programs for human resource management and organizational adaptability. Dlimi, Berakkab, Fazroun and Sibai explore the role of Corporate Social Responsibility (CSR) as a mediator in the consulting industry, examining how AI integration necessitates new management approaches to ethical conduct, transparency, and stakeholder engagement. Dlimi, Ourich, Fazroun, Berakkab, Lahnine and Loulid provide a comprehensive bibliometric review on the connections between AI, Industry 4.0, and digital transformation, identifying key research themes and future directions for management scholars and practitioners. Mišíková and Jankelová analyze the role of the digital age and artificial intelligence in shaping digital corporate culture, providing essential insights for managing employee adaptation, communication, and the evolution of corporate values in tech-driven environments.

REGLOBALIZATION: HOW EMERGING TECHNOLOGIES ARE SHAPING THE GLOBAL TRADE

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Abstract

Technological reglobalization is reshaping global trade by integrating emerging digital technologies such as artificial intelligence, blockchain, and automation into supply chains and international trade governance. This study examines how these technologies disrupt traditional trade structures, influence the resilience of supply chains, and reshape geopolitical competition over technological leadership. Utilizing a systematic literature review combined with comparative assessments, the paper identifies key technological advancements—particularly AI-driven logistics, blockchain-enabled transparency, and predictive analytics—that facilitate the evolution toward decentralized and resilient trade networks. However, it also highlights significant challenges, including regulatory fragmentation, cybersecurity threats, and widening digital inequalities. The research underscores the importance of digital trade agreements and coordinated international policies to effectively manage these challenges and balance innovation with economic security. The paper contributes uniquely by integrating an analysis of technological innovation, trade policy adaptations, and geopolitical shifts, offering strategic insights for policymakers and businesses to navigate the complexities of reglobalization.

Keywords: digital trade, reglobalization, artificial intelligence, blockchain, global supply chains

JEL classification: F10, F13, O33, L14, M21

Introduction

Technological reglobalization is reshaping global trade by integrating emerging digital technologies such as artificial intelligence, blockchain, and predictive analytics into supply chains and international trade governance. This study investigates how these technologies are transforming traditional trade structures, creating new trade hubs, and redefining geopolitical competition. In recent decades, globalization has profoundly influenced economic growth, international trade, and the structure of global supply chains. However, recent geopolitical tensions, protectionist policies, and disruptions such as the COVID-19 pandemic have significantly altered the globalization trajectory, giving rise to a new phenomenon termed "reglobalization." Unlike earlier waves of globalization, reglobalization emphasizes

restructuring global economic interactions to address contemporary technological, geopolitical, and environmental challenges.

Central to this process is the rapid adoption of advanced digital technologies, including artificial intelligence (AI), blockchain, and predictive analytics, which promise greater efficiency, transparency, and resilience in trade and supply chain operations. Despite their potential, these emerging technologies also introduce considerable challenges, notably regulatory fragmentation, cybersecurity risks, and digital inequalities, exacerbating disparities between technologically advanced economies and less developed countries. Addressing these issues requires coherent digital trade agreements and harmonized international policies.

This paper contributes to existing literature by offering an integrated analysis of technological innovations, policy implications, and geopolitical dynamics within the context of reglobalization. Its novelty lies in systematically exploring how digital transformation intersects with international business practices and policy-making processes, particularly emphasizing the role of digital trade agreements and regulatory harmonization. By combining insights from various disciplinary perspectives, this study provides practical guidance for businesses and policymakers aiming to leverage technological advancements while navigating the complexities and risks associated with reglobalization.

Literature review

Globalization has significantly reshaped global economic and political landscapes, driven primarily by liberal ideologies promoting trade liberalization, financial integration, and technological advancements (Paul, 2021). According to Bishop and Payne (2021), the recent era has witnessed a considerable shift due to increased geopolitical tensions, protectionist policies, and pandemic-induced disruptions, prompting a new phase termed "reglobalization." This phenomenon differs fundamentally from previous waves of globalization, emphasizing the restructuring of global economic interactions to address emerging geopolitical, technological, and environmental challenges (Steger, 2025; Hall, 2025).

The ongoing technological transformation, characterized by digital platforms, artificial intelligence, blockchain, and automation, is central to reglobalization. Palmié et al. (2022) assert that digital platforms play a vital role by fostering "meta-ecosystems" that bridge traditional and digital business networks. Similarly, blockchain technology significantly contributes to global trade by enhancing transparency, security, and efficiency, thereby reducing transaction costs and fraud (Li et al., 2024; Cui et al., 2024). Furr et al. (2022) identify crucial tensions within digital transformation for global firms, highlighting the strategic choices between traditional product-based business models and digital platforms, ecosystems versus individual firm strategies, and human-centric versus automated tools. These complexities suggest that digital transformation is not an objective state but a strategic choice that firms navigate to maintain competitive advantages. Moreover, entrepreneurial resiliency is a critical concept in navigating crises and managing uncertainty in the contemporary global economic landscape. According to Dana et al. (2022), entrepreneurial resilience enables businesses to adapt rapidly and effectively to disruptions, particularly through leveraging digital technologies such as artificial intelligence and data mining. Similarly, Lee (2022) emphasizes how reshoring, motivated by factors such as rising labor costs abroad and improved quality and innovation capabilities at home, significantly enhances the resilience and performance of global firms, especially in the context of technology-intensive industries.

Geopolitical shifts further complicate reglobalization dynamics. Ghauri et al. (2021) argue that contemporary international business faces new realities shaped by populism, economic nationalism, and evolving power relationships. These dynamics significantly influence global supply chains and investment decisions, prompting a reevaluation of foreign direct investment (FDI) strategies and the role of multinational enterprises (MNEs) in fostering equitable and sustainable growth (Bishop & Payne, 2021; Paul, 2021). According to Clift and Robles (2020), even international institutions like the International Monetary Fund (IMF) have adapted their strategies to address inequalities exacerbated by neoliberal globalization, although internal institutional limitations sometimes restrict the effectiveness of these efforts.

Environmental sustainability and climate change mitigation represent further critical dimensions of reglobalization. Hall (2025) emphasizes that states' legal and geographical contexts significantly impact how they engage in the global green transition. Clift and Robles (2020) support this perspective, highlighting the necessity of embedding progressive socio-economic policies within reglobalization frameworks to address inequalities exacerbated by previous neoliberal practices and to facilitate a sustainable and inclusive global economic system.

The literature underscores reglobalization as a complex and multi-dimensional process influenced by technological transformation, entrepreneurial resiliency, geopolitical reconfigurations, and environmental sustainability. The intersection of these dimensions requires scholars and practitioners to adopt nuanced, interdisciplinary approaches to understanding and navigating the evolving global economic landscape. Future research should focus on further clarifying these dynamics and developing robust, inclusive, and sustainable policy responses.

Methodology

Given the dynamic shift from traditional globalization to reglobalization, this paper aims to analyze how key technological innovations are restructuring global trade and economic systems. Specifically, it seeks to:

- Examine how digitalization, AI, blockchain, and automation are reshaping international trade flows and supply chain management.
- Assess the role of new trade policies and regional economic integration in the reglobalization process and identify challenges and risks associated with the technological transformation of global commerce.

This study employs a qualitative research methodology, utilizing a comprehensive systematic literature review (SLR) and comparative assessments to explore how emerging technologies are reshaping global trade within the context of reglobalization. The qualitative approach adopted in this research involves systematic secondary data collection and analysis. Specifically, a thematic analysis was conducted to identify, analyze, and report patterns within the reviewed literature. This methodology allows for an in-depth exploration of the complex, multi-dimensional phenomena of technological transformation and its implications for global trade.

The selection of illustrative examples for this research was purposeful, driven by their relevance in highlighting specific technological advancements and their implications for global trade.

Examples such as blockchain applications in logistics (Maersk & IBM's TradeLens platform) and AI-driven optimization in logistics (e.g., DHL, UPS) were chosen based on their significance in representing emerging trends and providing insights into broader implications of reglobalization. While these illustrative examples demonstrate critical points about the current state of technological reglobalization, they do not provide exhaustive analyses, which reflects a limitation of this methodological approach.

Furthermore, this research adopts comparative assessments to understand trade policy and regulatory developments in various geopolitical contexts. This approach is instrumental in highlighting differences and similarities in policy adaptation strategies and regulatory frameworks across regions, particularly in response to technological changes and geopolitical dynamics. This comparative method complements the thematic analysis by providing additional context to interpret how technological advancements interact with broader economic and political structures.

One limitation of this study is the limited number of articles available for the review, reflecting the nascent and evolving nature of literature on technological reglobalization. Consequently, the review might not fully encapsulate recent policy changes or newly emerging technologies and practices. Future research could benefit from an expanded range of primary and secondary data sources, including policy documents and empirical studies that capture real-time developments in reglobalization dynamics.

Results and discussion

The global economy is undergoing a fundamental transformation driven by digital technologies, which have become the cornerstone of modern trade models. Unlike traditional globalization, which was largely shaped by trade liberalization and physical infrastructure, reglobalization is increasingly defined by technological advancements such as artificial intelligence (AI), automation, blockchain, and digital platforms (Palmié et al., 2022). One of the most profound impacts of digital transformation on trade is the emergence of meta-ecosystems, where digital and physical elements merge to create seamless and highly interconnected global supply chains (Palmié et al., 2022). Digital transformation has facilitated the rise of platform-based trade models, allowing firms to engage in cross-border commerce without the need for large-scale physical infrastructure (Song et al., 2022). This transition from physical to digital ecosystems has empowered small and medium-sized enterprises (SMEs) to access global markets, effectively reducing traditional barriers to entry in international trade.

Another key driver of this shift is the growth of AI-powered predictive analytics, which allows firms to anticipate demand fluctuations, optimize inventory management, and enhance customer experiences. AI-driven insights have increased forecasting accuracy by up to 20%, leading to reduced trade volatility and more stable global supply chains (Bari, 2023). The traditional global supply chain relied on a linear model of production, where goods were manufactured in low-cost countries and transported to consumer markets through complex, multi-tier logistics networks. This structure, however, proved fragile in times of crisis—such as the COVID-19 pandemic—exposing the vulnerabilities of long-distance trade dependencies (MacCarthy & Ivanov, 2022).

In contrast, digital ecosystems are built on real-time connectivity, automation, and decentralized trade models. Technologies like blockchain and Internet of Things (IoT) enable greater

traceability and transparency, reducing inefficiencies and enhancing security in cross-border transactions (MacCarthy & Ivanov, 2022). Digitalization has also given rise to smart warehouses and automated logistics, which enhance the agility of global trade by ensuring just-in-time deliveries and reducing bottlenecks in distribution networks (Rasulov, 2022). Moreover, AI-driven automation has optimized trade finance and customs clearance, reducing paperwork and delays. The introduction of smart contracts on blockchain platforms has streamlined trade agreements and payment settlements, minimizing transaction costs and ensuring greater compliance with international trade laws (Shlapak et al., 2023). Automation and artificial intelligence (AI) are at the forefront of enhancing trade efficiency, fundamentally altering how businesses operate in the global economy. Robotic process automation (RPA) has revolutionized supply chain management by automating repetitive processes, reducing human error, and increasing efficiency in inventory management (MacCarthy & Ivanov, 2022).

AI-powered analytics provide real-time insights into market conditions, enabling businesses to adjust production schedules, mitigate supply chain risks, and enhance trade logistics. These advancements have led to cost reductions of up to 30% in global logistics operations (Merola, 2022). The rise of autonomous supply chains—where AI predicts demand, automatically reorders raw materials, and optimizes transportation routes—has significantly reduced operational inefficiencies and enhanced sustainability. Digitalization has also increased the resilience of global trade by enabling businesses to diversify their supply chains and reduce dependence on a single geographic region (Challoumis, 2024)

Digital transformation is reshaping the global trade landscape by increasing efficiency, reducing trade costs, and enhancing supply chain resilience. AI-driven automation, blockchain, and digital platforms are replacing traditional supply chains with highly integrated digital ecosystems that provide real-time insights, secure transactions, and optimized logistics. However, the transition to a digitally-driven trade order is not without challenges. Issues such as unequal access to digital infrastructure, cybersecurity risks, and workforce displacement must be addressed through inclusive trade policies, regulatory harmonization, and investment in digital education. As reglobalization continues to unfold, businesses and policymakers must embrace technological innovation while ensuring that digital trade remains equitable, resilient, and sustainable. The future of global commerce will be defined not only by who trades with whom, but how technology facilitates these exchanges.

Blockchain and trade transparency

The increasing complexity of global trade has created significant inefficiencies in supply chain management, fraud detection, and contract enforcement. Blockchain technology, as a decentralized digital ledger, offers a promising solution to these challenges by enhancing trade transparency, reducing fraud, and automating supply chain transactions (Cui et al., 2024). According to Tretiak et al. (2022) one of the primary benefits of blockchain technology in trade is its ability to create an immutable and transparent record of transactions. Traditional trade systems often suffer from fraudulent documentation, counterfeiting, and a lack of traceability, leading to disputes and inefficiencies. Blockchain eliminates these risks by ensuring that once a transaction is recorded, it cannot be altered, significantly reducing fraudulent activities.

For instance, in commodity trading and international logistics, blockchain can record each step of a product's journey—from manufacturing to final delivery—allowing all stakeholders to verify authenticity and compliance in real time. This is particularly critical for industries such as pharmaceuticals and food supply chains, where tracking provenance can prevent counterfeit

goods from entering the market. However, adopting blockchain for fraud prevention is not without challenges. Some firms are reluctant to share sensitive trade data on an open ledger, fearing loss of competitive advantage (Cui et al., 2024). To address this, companies are experimenting with permissioned blockchains, where only authorized parties can access transaction details, balancing transparency with data security.

Beyond transparency, blockchain also introduces smart contracts, which automate trade agreements, payments, and compliance checks. A smart contract is a self-executing agreement embedded in blockchain code, which automatically executes trade terms once predefined conditions are met (Rane et al., 2023)

This automation offers several advantages:

- Reduced administrative costs. Traditional contracts require intermediaries such as banks, legal firms, and auditors to ensure compliance. Smart contracts eliminate these intermediaries, cutting trade processing costs by up to 30% (Tretiak et al., 2022).
- Elimination of payment delays. Payments in cross-border trade often take days or even weeks due to regulatory checks and intermediaries. Blockchain-based smart contracts execute payments instantly once conditions are verified, improving cash flow for exporters and suppliers.
- Improved dispute resolution. Traditional trade disputes can take months to resolve due to contract ambiguities and lack of real-time verification. Blockchain's tamper-proof nature provides a shared ledger of all contractual terms and fulfillment statuses, reducing litigation risks.

However, smart contracts also present challenges. Their legally binding status remains a gray area in many jurisdictions, as traditional trade laws often do not recognize automated contracts. Additionally, any flaws in smart contract code can be exploited—leading to unintended transactions or vulnerabilities. Ensuring regulatory clarity and cybersecurity measures will be critical for widespread adoption of smart contracts in global trade.

Some industries have already embraced blockchain-based smart contracts, for example Maersk & IBM's TradeLens platform uses blockchain to streamline shipping documentation and reduce trade fraud, cutting paperwork-related costs by up to 20%. Walmart's food traceability system - blockchain enables real-time tracking of perishable goods, reducing food waste and improving safety standards. Global banks such as HSBC and JPMorgan have implemented blockchain-based trade finance solutions to speed up international transactions and reduce fraud risks.

As blockchain adoption expands across global supply chains, the next step will be ensuring interoperability between different blockchain networks and developing universal trade standards for smart contract enforcement. Additionally, governments and international trade organizations must adapt regulations to accommodate blockchain-based trade agreements, ensuring they align with existing commercial laws.

AI and big data in trade optimization

The integration of artificial intelligence and big data analytics into global trade is fundamentally altering the way trade flows are forecasted, logistics are managed, and risks are assessed. Unlike traditional trade models that rely on static historical data, AI-powered analytics leverage real-time insights, machine learning algorithms, and automation tools to create a more dynamic, adaptive, and resilient global trade system. Predicting trade patterns has always been a complex

challenge due to the involvement of multiple economic, political, and environmental variables. Traditionally, macroeconomic models and statistical regressions have been used to estimate demand for exports and imports, but these approaches often fail to account for real-time shocks, supply chain disruptions, and behavioral shifts in consumption patterns (Shah et al., 2021).

With AI-driven predictive analytics, businesses and policymakers can process vast amounts of trade-related data in real time, allowing them to:

- Identify emerging trends in global demand and adjust supply chain strategies accordingly.
- Optimize inventory levels to prevent overproduction or shortages.
- React proactively to potential trade barriers, such as tariffs, sanctions, or logistics delays.

For instance, AI-based machine learning models can analyze historical trade flows, currency fluctuations, consumer sentiment data, and geopolitical risks to anticipate shifts in international trade. This predictive capability helps firms make informed decisions on where to expand, when to scale production, and how to hedge against financial risks. A particularly effective application of AI-driven trade forecasting has been seen in the agricultural commodities sector, where weather patterns, crop yields, and global demand fluctuations must be monitored continuously (Popova & Petrova, 2024). Companies in this industry are leveraging deep learning models to forecast demand based on climate data, satellite imagery, and market conditions, allowing them to adjust exports proactively rather than reactively.

However, while AI improves the accuracy of demand forecasting, its effectiveness depends on the quality of data inputs. Trade data is often fragmented across multiple platforms, and governments and corporations may restrict access to crucial datasets due to concerns over trade secrecy and national security. This lack of data standardization remains one of the biggest challenges in AI-driven trade optimization.

Artificial intelligence is rapidly transforming global trade by revolutionizing logistics and risk assessment, two critical areas that have long suffered from inefficiencies and unpredictability. The global trade system is heavily reliant on the smooth movement of goods across borders, yet logistical challenges such as delays, unexpected costs, and geopolitical tensions often disrupt operations. AI-powered solutions offer a data-driven approach to optimizing these processes, enabling real-time monitoring, predictive analytics, and automated decision-making to create more agile and cost-effective supply chains. AI's ability to analyze vast amounts of data in real-time allows companies to optimize shipping routes, anticipate disruptions, and improve overall trade efficiency. By integrating machine learning algorithms, logistics firms can dynamically adjust to traffic patterns, weather conditions, and port congestion, ensuring that shipments are rerouted efficiently to minimize delays and reduce fuel consumption. This is particularly evident in companies such as DHL and UPS, which leverage AI-driven logistics systems to predict disruptions before they occur and proactively reroute deliveries. The rise of autonomous cargo vehicles further enhances efficiency, reducing both transit times and operational costs by minimizing human intervention and streamlining supply chain movements.

In addition to transportation optimization, AI is revolutionizing warehouse management and distribution centers. Advanced robotics equipped with AI capabilities can autonomously sort, label, and package goods, significantly reducing manual labor and improving processing speeds. Companies like Amazon have demonstrated the effectiveness of AI-powered robotic systems in fulfillment centers, achieving up to a 40% reduction in order processing times.

However, despite these benefits, the widespread adoption of AI in logistics is hindered by several barriers. Many smaller firms lack the necessary infrastructure and capital to integrate AI-driven logistics platforms, leading to a digital divide between multinational corporations and smaller trade participants. Furthermore, regulatory inconsistencies across different countries create additional challenges, as AI adoption in customs and trade compliance is subject to varying levels of governmental oversight and approval. Without a harmonized regulatory framework, AI-powered logistics may struggle to achieve its full potential in facilitating seamless cross-border trade.

Beyond logistics, AI is also reshaping risk assessment in international trade by providing businesses with advanced tools to anticipate and mitigate potential disruptions. The volatility of global markets makes risk assessment a crucial component of trade management, and AI-driven models are now being used to evaluate financial risks, currency fluctuations, and geopolitical instability. By analyzing macroeconomic indicators, AI can predict potential financial crises, allowing companies to hedge against currency depreciation or supply chain disruptions before they escalate. One of the most promising applications of AI in risk assessment is its role in customs compliance and fraud detection. AI-powered compliance systems can analyze trade documentation, identify anomalies in import/export declarations, and flag potential fraudulent activities. This level of automation significantly reduces human error and enhances regulatory adherence, minimizing the risk of financial penalties or legal disputes. Similarly, AI is being used to assess supplier risks by evaluating creditworthiness, labor conditions, and ESG (environmental, social, and governance) compliance. With increased global scrutiny on ethical supply chains, businesses are leveraging AI to ensure that their sourcing strategies align with sustainable and socially responsible trade practices.

Another breakthrough in AI-based risk assessment is the application of natural language processing (NLP) for automated contract analysis. AI algorithms can scan trade agreements and identify hidden risks, ambiguous clauses, and potential legal disputes, enabling businesses to avoid costly litigation. This not only streamlines contract negotiations but also ensures greater transparency and accountability in international trade transactions. However, despite its growing capabilities, AI is not without its limitations in risk management. Many AI models rely on historical data, which may not account for black swan events such as pandemics, wars, or sudden economic downturns. While AI excels in pattern recognition and predictive analytics, it remains vulnerable to unprecedented shocks that do not fit existing datasets. To mitigate this limitation, companies are increasingly integrating AI-driven risk assessment models with scenario planning techniques, allowing them to develop contingency strategies for unexpected global trade disruptions.

Despite its transformative potential, AI-driven trade optimization raises several ethical and regulatory concerns. One of the most pressing challenges is data bias and reliability, as AI models are only as effective as the quality of data they process. If trade data is incomplete, biased, or manipulated, AI-driven decisions may inadvertently reinforce existing market inequalities rather than mitigate them. Additionally, regulatory compliance remains a significant hurdle, as different nations impose varying restrictions on AI adoption in trade finance, logistics, and customs. The absence of a unified regulatory framework slows down AI-driven innovation in global trade, making it difficult for businesses to scale AI solutions across multiple markets. Another major concern is job displacement, as AI-driven automation increasingly replaces traditional roles in customs processing, logistics coordination, and risk assessment. While AI can enhance efficiency, its widespread adoption raises social and economic challenges, particularly for workers in trade-related industries who may struggle to

transition into new roles. To address this, governments and businesses must invest in reskilling programs to ensure that workers can adapt to an AI-driven trade environment.

Overall, AI and big data analytics are redefining the landscape of global trade by improving logistics efficiency, enhancing risk assessment, and creating more resilient supply chains. By harnessing AI-driven insights, businesses can optimize trade flows, reduce operational risks, and ensure greater transparency in international transactions. However, realizing the full potential of AI in trade requires addressing key challenges, including regulatory harmonization, data standardization, and workforce adaptation. Moving forward, a collaborative effort between governments, businesses, and international trade organizations will be essential in developing standardized AI frameworks that balance innovation with fair trade practices. If implemented effectively, AI has the potential to make global trade more inclusive, sustainable, and adaptive to the complexities of the modern economic landscape.

Economic and geopolitical implications of technological reglobalization

Technological reglobalization brings significant economic and geopolitical implications, reshaping global trade patterns, shifting economic power centers, and influencing the dynamics of international relations. As digital technologies, automation, and artificial intelligence (AI) integrate more deeply into global commerce, traditional supply chains are being disrupted, new trade hubs are emerging, and geopolitical competition over technological dominance is intensifying. At the same time, digital trade agreements and evolving regulatory frameworks are redefining the rules of engagement in international trade.

One of the most profound changes brought about by technological reglobalization is the disruption of traditional supply chains. For decades, global trade was dominated by extensive, linear supply chains that stretched across multiple regions, primarily benefiting established manufacturing hubs such as China, Germany, and the United States. However, as emerging technologies enable greater efficiency, flexibility, and localization, businesses are increasingly shifting towards regionalized production networks and digital supply chains. AI-driven logistics, blockchain-enabled transparency, and predictive analytics allow companies to reduce their reliance on single sourcing and instead distribute production across multiple locations, mitigating risks associated with geopolitical instability, trade restrictions, and supply chain shocks. This transition has led to the rise of new trade hubs that are better positioned to take advantage of digital infrastructure and advanced manufacturing capabilities. Countries in Southeast Asia, such as Vietnam and Indonesia, have become attractive alternatives to China for manufacturing due to lower labor costs and government incentives for high-tech investment. Similarly, nearshoring and reshoring strategies are driving investment in North America and Europe, as companies seek to bring production closer to consumer markets to enhance supply chain resilience. These shifts challenge the traditional structure of global trade, leading to a more fragmented but technologically interconnected global economy.

At the same time, geopolitical competition over technological dominance is escalating as nations recognize that leadership in emerging technologies—such as AI, quantum computing, and semiconductor manufacturing—translates into strategic economic and security advantages. The United States and China are at the forefront of this competition, with both nations investing heavily in technological innovation while simultaneously imposing restrictions on technology exports and foreign direct investment. The semiconductor industry has become a focal point of this rivalry, as access to cutting-edge chip technology is critical for advancements in AI, telecommunications, and defense. The European Union, seeking to assert its technological

sovereignty, has also introduced policies to reduce dependency on foreign technology providers and support domestic innovation. This geopolitical struggle extends beyond economic competition and has tangible consequences for global trade policies and digital trade agreements. Nations are increasingly leveraging trade policies as tools of economic statecraft, using tariffs, sanctions, and export controls to exert influence over strategic industries. At the same time, digital trade agreements are emerging as a critical mechanism for regulating cross-border data flows, intellectual property rights, and digital services. Agreements such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the Digital Economy Partnership Agreement (DEPA) reflect a growing effort by governments to establish common standards for digital trade, ensuring that technology-driven globalization remains inclusive and rules-based.

However, these developments also raise concerns regarding data sovereignty, cybersecurity, and economic inequality. While technological reglobalization presents opportunities for efficiency and economic growth, it also exacerbates disparities between nations with advanced digital capabilities and those struggling to keep pace. Countries that fail to invest in digital infrastructure and workforce development risk being left behind, deepening global economic divides. Moreover, as governments tighten regulations on cross-border data transfers, businesses face increasing challenges in navigating complex compliance requirements, potentially hindering the seamless flow of digital trade.

In conclusion, technological reglobalization is reshaping the global economic landscape by disrupting traditional supply chains, intensifying geopolitical competition, and transforming trade policies. While this shift presents opportunities for innovation and economic expansion, it also introduces new complexities that require careful navigation. As the world moves towards a more digitalized and interconnected trade environment, governments and businesses must work collaboratively to balance innovation with regulatory coherence, economic security with open markets, and technological advancement with global inclusivity. The success of this transition will ultimately depend on the ability of policymakers to develop forward-looking trade frameworks that accommodate both technological progress and geopolitical realities.

Challenges and risks of technological reglobalization

While technological reglobalization offers significant benefits for global trade, it also introduces critical challenges and risks that must be addressed to ensure inclusive and secure economic integration. One of the primary concerns is the digital divide and unequal access to technology. Advanced economies with well-developed digital infrastructure can quickly adapt to AI-driven logistics, blockchain transparency, and automated trade systems, while developing nations struggle with outdated infrastructure, limited internet connectivity, and insufficient digital education. This growing gap risks creating a two-tier global trade system, where technologically advanced nations dominate digital commerce while others remain marginalized. Addressing this issue requires international cooperation to invest in digital capacity building, support technology transfer, and ensure fair participation in digital trade agreements.

Another significant challenge is regulatory fragmentation and cybersecurity threats in global trade. Different countries impose varying levels of data protection laws, digital taxation, and AI governance, leading to inconsistencies that complicate cross-border trade operations. The lack of harmonized digital trade regulations makes it difficult for businesses to comply with multiple jurisdictions, increasing costs and legal uncertainties. Moreover, as trade becomes

increasingly digitized and reliant on AI-driven decision-making, the risk of cyberattacks, data breaches, and digital espionage grows. Trade-related cyber incidents—such as supply chain disruptions caused by ransomware attacks—pose serious threats to global commerce. Governments and international trade organizations must work toward creating standardized regulations, enhancing cybersecurity measures, and promoting transparency to ensure that technological advancements do not become sources of economic vulnerability.

If these risks are not adequately addressed, technological reglobalization could lead to greater economic inequalities, geopolitical tensions, and systemic vulnerabilities in global trade networks. The challenge ahead lies in striking a balance between innovation, security, and inclusivity to create a stable and equitable global digital economy.

Conclusion

Technological reglobalization is fundamentally reshaping global trade by integrating advanced digital technologies, artificial intelligence, blockchain, and automation into supply chains and trade governance. This transformative shift marks a departure from traditional globalization models by prioritizing decentralization, resilience, and technological integration. One of the most profound outcomes is the emergence of digitally interconnected trade networks, moving away from centralized, linear supply chains toward more adaptive and resilient structures. This shift enables firms to respond quickly to disruptions, enhance operational efficiency, and leverage real-time data analytics for strategic decision-making.

Geopolitical implications of reglobalization are significant, intensifying competition among major global economies—particularly the United States, China, and the European Union—for technological supremacy. This rivalry extends beyond mere economic competition into strategic dominance, influencing international trade agreements, digital governance standards, and technology-related policies. Consequently, trade policies have increasingly become instruments of economic and technological statecraft, as evidenced by strategic actions in sectors like semiconductors, AI, and digital infrastructure. The rise of digital trade agreements such as the CPTPP and DEPA further highlights the critical role of regulatory harmonization in managing cross-border data flows, intellectual property rights, and cybersecurity.

However, this transformation presents substantial challenges, including significant disparities between nations in digital infrastructure and technological capabilities. The digital divide, characterized by uneven access to high-speed internet, advanced computing resources, and digital literacy, risks deepening existing economic inequalities. Countries with well-developed digital ecosystems, typically high-income and technologically advanced nations, stand to gain disproportionately from technological reglobalization. Conversely, developing nations, which often lack essential digital infrastructure, robust educational systems, and adequate investment capacity, may find themselves increasingly marginalized from global economic activities, thus exacerbating socio-economic divides. Moreover, regulatory fragmentation across different jurisdictions complicates the seamless adoption and integration of digital technologies on a global scale. Differences in national regulations pertaining to data privacy, cybersecurity standards, digital taxation, and intellectual property rights create complex and sometimes conflicting requirements that firms must navigate. This patchwork of regulatory frameworks not only increases compliance costs for businesses but also generates uncertainty, potentially deterring smaller enterprises from participating fully in the global digital economy. Such fragmentation can inadvertently limit innovation and stifle economic growth, undermining the

potential benefits of digital technologies.

Additionally, the accelerated adoption of AI and automation presents profound ethical challenges, such as algorithmic biases that could reinforce existing social and economic inequalities. The increasing collection and use of personal data for commercial purposes raise significant data privacy and surveillance concerns, highlighting the need for robust data protection regulations. The transition toward automated systems also risks considerable workforce displacement, affecting both low-skilled and white-collar workers and potentially leading to significant social disruptions if not managed appropriately. To effectively address these multifaceted challenges, a comprehensive and coordinated response involving governments, international institutions, and the private sector is critical. Substantial investments must be made in digital infrastructure, especially in underserved regions, to bridge the digital divide and facilitate inclusive participation in technological advancements. Inclusive trade policies and international digital trade agreements should aim at harmonizing regulatory standards, protecting intellectual property rights, ensuring equitable market access, and establishing unified cybersecurity frameworks.

Furthermore, proactive strategies must be implemented to address workforce displacement through targeted reskilling programs and education reforms, preparing workers to transition successfully into digitally enabled roles. Ethical considerations must be integrated systematically into AI development, emphasizing transparency, accountability, and fairness to mitigate algorithmic biases and protect data privacy. International collaboration is paramount in establishing universally accepted ethical guidelines and robust cybersecurity frameworks to safeguard digital ecosystems against threats and vulnerabilities.

In conclusion, technological reglobalization represents a pivotal transformation in global trade dynamics, defined not by a retreat from globalization but by a reconfiguration of its mechanisms through technology. The success of this transformation depends on the ability of global stakeholders to navigate complex economic and geopolitical landscapes, embracing innovation while addressing the associated risks and inequalities. Future research and policy development should continue focusing on balancing technological advancement with regulatory stability, economic inclusivity, and global resilience, ensuring the benefits of reglobalization are widely and sustainably shared.

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AI AND THE FUTURE OF WORK: WAGE INEQUALITY, INDUSTRY TRANSFORMATION, AND RESKILLING BENEFITS

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Abstract

AI-driven workforce transformations can reshape labor markets by improving productivity and innovation while disrupting wage structures. Although existing research examines AI's role in automation and productivity, limited studies explore its direct impact on wage polarization and the effectiveness of AI-driven reskilling programs in boosting productivity. This study addresses these gaps by investigating how AI-driven changes affect wage disparities while assessing the role of AI reskilling programs in reducing negative impacts. The study tests two hypotheses: (H1) AI adoption increases wage gaps, benefiting high-skilled workers while limiting opportunities for low-skilled workers, and (H2) industries that invest in AI reskilling experience higher productivity and innovation, while those that do not face economic stagnation. This study synthesizes empirical research and industry trends to identify patterns in AI-driven labor market shifts using a systematic review of secondary data sources, using a systematic review of peer-reviewed literature, labor market reports, and policy documents, the research draws from trusted databases such as Web of Science, JSTOR, and ScienceDirect. The findings indicate that AI-driven changes tend to benefit high-skilled employees, contributing to wage inequality, while reskilling programs are associated with improved productivity and job retention. The findings of this research suggest that AI-driven transformations could reinforce wage inequality, benefiting high-skilled workers while limiting wage growth and job security for low-skilled employees contributing to wage inequality. This aligns with Skill-Biased Technological Change, highlighting AI's role in widening income gaps. However, industries that implement AI reskilling programs, tend to experience increased productivity and job retention supporting Endogenous Growth theory. Reliance on secondary data limits the long-term insights of this study. Future research should incorporate real-time workforce tracking to assess AI's sustained labor market impact using empirical data.

Keywords: Artificial Intelligence, Wage Polarization, Labor Market Adaptability, AI Reskilling, Economic Inequality

JEL classification: J21, J24, J31, O33, P46

Introduction

Introduced in 1955, artificial intelligence (AI) is defined as machines' ability to think and simulate human behavior. (Gama & Magistretti, 2025). Key concepts of modern AI include

machine learning which allows computers to learn from and make predictions based on data; neural networks that form the basis of deep learning; natural language processing, allowing machines to understand, interpret, and generate human language, and image understanding allowing computers to process visual information (du Boulay, 2001).

AI demonstrates a growing impact on innovation across different industries. Companies such as IBM, Netflix, and Mastercard implemented AI to analyze data to produce content, recognize diseases, or prevent fraud (Gama & Magistretti, 2025). With its rapid development, the implementation of AI across different industries is not only expected but also evident. Sultan and Sultan (2024) believe AI will create new jobs and boost productivity by allowing the workforce to focus on creative tasks rather than repetitive ones. They further state that AI will bring major changes in the healthcare, manufacturing, and financial sectors (Sultan & Sultan, 2024). However, there is fear AI will lead to job displacements, wage gaps, and economic divergence.

Given these extensive advantages and disadvantages of AI development, continuous research regarding its implications for the labor market is essential. Such research can help create seamless cooperation between human capital and technology, potentially leading to GDP growth, leveling global competition between underdeveloped and developed nations, and increasing productivity.

Wage polarization refers to the increasing disparity in wage distribution, where wages grow at the highest and lowest ends of the spectrum while stagnating or declining in the middle. Angelini et al. (2009) claim this phenomenon is often driven by technological advancements, changes in labor market structures, and differences in skill demand across industries.

While research on AI's role in automation and productivity exists, there is limited focus on wage polarization and the importance of AI-driven reskilling programs. This study aims to investigate how the level of AI adoption affects wage inequality. Additionally, it assesses how investment in AI reskilling programs impacts industry competitiveness. By examining these relationships, the study evaluates the role of AI-driven changes in wage disparities and labor market equity, while exploring how AI reskilling programs contribute to boosting productivity. The paper seeks to raise awareness of the potential effects of AI implementation and encourage companies and policymakers to develop informed strategies regarding the implementation.

Literature review

The skill premium, in the context of globalization, refers to the wage differential between skilled and unskilled workers, shaped by trade liberalization and entrepreneurial selection. Increased competition from trade can lead less capable educated workers to exit entrepreneurship, raising the supply of skilled labor and lowering returns on higher education, which in turn influences income distribution and contributes to household income polarization (Xu, 2020). A rise in wage inequality and the skills premium in the U.S. has been observed since the 1970s, correlating with the increase in automation since the 1990s (Grant, 2024). This trend is driven by rising wages for high-skilled workers and declining wages for low-skilled workers (Grant, 2016, 2024). Furthermore, Grant (2024) highlights an inverse relationship between the wages of AI-educated high-skilled workers and their supply, suggesting that as more high-skilled workers receive AI education, wage gaps between skill levels should narrow.

Grant's findings align with Acemoglu (1998), who argues that technological advancements drive increased demand for high-skilled labor, raising the skill premium. However, as the supply of high-skilled labor rises, the skill premium initially declines before increasing again due to further technological progress. Most industries in the US faced an increase in demand for AI skills over the 2010-2019 period, especially the information, professional services, administrative services, and finance sectors (Alekseeva et al., 2021). Alekseeva et al. (2021) also conclude that within the same company, jobs requiring AI skills tend to offer an 11% higher salary compared to jobs that do not require AI skills. Additionally, within the same job title, positions involving AI skills come with a 5% higher salary compared to those that do not involve AI skills. When it comes to differences within the industries, across different firms, the requirement of AI skills leads to higher wages (Alekseeva et al., 2021).

Acemoglu & Restrepo (2018) conclude that AI automation leads to both positive and negative outcomes, as automation can lead to a displacement effect and a decline in labor share in the national income. However, they observe how AI reduces production costs leading to higher productivity and the creation of new tasks. These positive effects might be sufficient to counterbalance the displacement and the reduced labor share in income. Nonetheless, they believe the automation process will be slow and unpleasant for the workforce due to primary job displacements and potential skills mismatch. The skills mismatch might slow the process of rehiring the displaced labor and obstruct the productivity gains of automation (Acemoglu & Restrepo, 2018).

Webb (2020) comes to a similar conclusion stating that AI automation can both increase and decrease the demand for labor depending on the complexity of the job's tasks and consumer response to price changes. He emphasizes how in past cases automation led to lower wages and fewer jobs which might continue. Although technological advancements may create new jobs, Webb states that this does not alter the conclusion that automation replaces jobs. Which is why he underlines the importance of developing the ability to switch jobs easily. While there is an increase in the demand for labor, labor share in income has been dropping since 1975 across the four largest economies (Lou & Zhou, 2021). Studies state that there is an increase in the demand for labor, supported by the overall decline of labor share income. Meaning that, if this trend continues, AI, which might significantly boost productivity and economic growth, might not provide adequate wage benefits for labor. AI-automatization could further damage the labor market, especially due to the increase in demand and value of AI-educated labor.

Domini et al. (2022) report that AI automation has not widened wage gaps in France. Instead, workforce composition has historically influenced wage disparities—long-term employees typically earn more than newly hired workers, even when performing the same role. Additionally, Georgieff (2024) examined AI automation between 2014 and 2018, concluding that while AI had no significant impact on wage gaps across occupations, it did reduce wage disparities within occupations. However, he notes that this study covered a period with relatively little AI-driven automation, highlighting the need for further research.

All in all, Frank et al. (2019) conclude that AI has the potential to increase wage disparities by favoring certain skill sets and automating up to 47% of jobs in the US and 54% of jobs in the EU. There is not enough quantitative data to accurately assess the automation impact on labor market trends, urging researchers and policymakers to disclose and dive into the raw data regarding job postings and requirements to further assess the differences before and after automation.

Table 1: Key findings discussing wage gaps from the literature review

Source	Key findings
Grant (2024)	There is a gap between AI-educated high-skilled workers and non-AI-educated high-skilled workers.
Acemoglu (1998)	Technological advancements drive skills premium.
Alekseva et al. (2021)	AI skills drive salaries up to 11%
Acemoglu & Restrepo (2018)	AI can displace jobs and reduce labor share in income while also boosting productivity and creating new tasks.
Webb (2020)	The effects of automation on labor demand is dependent on the complexity of tasks and the consumers' response to price changes. In the past automation brought negative effects.
Lou & Zhou (2021)	Labor share in income has been continuously dropping.
Domini et al. (2022)	Wage gaps in Europe are driven by a rise in employment
OECD (2024) [Georgieff (2024)]	AI automation has had no impact on wage gaps across occupations, and it has decreased the wage gaps within occupations.
Frank et al. (2019)	There is potential to automate up to 50% of jobs, but the quantitative data to assess the exact impact of AI automation on labor demand is insufficient.

Source: Authors, based on the most relevant articles used

Role of AI education and reskilling programs

According to Bodea et al. (2024), proficiency in digital skills is crucial for AI adoption within a company, and these skills should be held by all employees, not just those specialized in programming or data analysis. Both specialized and non-specialized employees must continuously improve their skills to effectively utilize AI. AI adoption will vary across the European Union due to economic disparities.

Acemoglu & Restrepo (2020) argue that the current wave of automation has led to stagnating labor demand, declining labor share in national income, rising inequality, and lower productivity growth. Building on these findings, the European Commission (2022) emphasizes that AI skills development should focus on upskilling and reskilling programs to enhance both hard and soft skills. Additionally, it is crucial to increase the number of graduates specializing in AI-related educational fields to meet the demands of the new industrial revolution.

In their recent 2025 study, Shokran et al. explore how AI implementations in the workforce lead to improved decision-making, enhanced productivity as well as innovation. Underlining that organizations that invest in AI training experience market dominance, while workers with AI skills experience better salary opportunities and market adaptation skills. Meaning that, AI training brings benefits for both organizations and the workforce.

Adding to that, World Economic Forum research (2025) found that companies that adopt AI early see better operational visibility, optimized resource allocation, as well as increased productivity by almost 2.5 times along with costs reduction of almost 15%

Yi & Ayangbah (2024) conducted a quantitative analysis of AI implementation in the workforce. They concluded that there is a positive correlation between AI adoption and Productivity as well as GDP and productivity. However, they found a negative correlation between the employment rate and productivity.

Additionally, Jolly et al. (2023) emphasize the need for academia-industry partnerships as they can be crucial for driving innovation and addressing workforce needs. Such partnerships could have a meaningful impact on research and workforce adaptation.

However, according to Bervenmark & Kihlen (2024) to maximize the benefits of AI implementation, such as increased productivity and skills development, it is necessary to form a strategic approach addressing both technical and behavioral aspects, as the implementation of AI for skills development varies among organizations and is primarily unplanned.

Limited investment in research, innovation, and brain drain may widen technological gaps (Istudor et al., 2024). To address this, accessible AI reskilling and upskilling programs are essential. Technological inaccessibility has historically driven social inequality, and AI-driven workforce training can promote labor market equity and reduce unemployment. In the U.S., AI adoption initially disrupts labor markets, causing job displacement. However, strategic policies, including reskilling programs, can minimize these effects and enhance employment conditions (Adhikari et al., 2024). Comprehensive AI strategies and regulations are crucial for workforce stability and economic inclusion. Without intervention, AI risks deepening inequalities, but targeted policies can foster a more balanced labor market.

Table 2: Key findings discussing AI education and reskilling programs from the literature review

Source	Key findings
Acemoglu & Restrepo (2020)	Automatization has brought stagnating labor demand, declining labor share in national income, rising inequality, and lowering productivity growth
European Commission	There is a growing need for AI education, upskilling, and reskilling programs.
Bodea et al. (2024)	Digital skills among all laborers are of huge importance for a company.
Istudor et al. (2024)	Unequal opportunities for investments in technology will drive technological gaps across Europe.
Shokran et al. (2025)	Organizations that invest in AI training experience market dominance.
World Economic Forum (2025)	Companies that adopted AI early experience 2.5 times higher productivity and almost 15% lower costs.
Yi & Ayangbah (2024)	While there is a positive correlation between AI adoption and productivity, there is a negative correlation between productivity and employment rate.
Jolly et al. (2023)	There is a growing need for academia-industry partnerships for reaping the benefits of AI implementation.
Bervenmark & Kihlen (2024)	The implementation of AI for skill development is primarily unplanned and requires a strategic approach.

Source: Authors, based on the most relevant articles used

Theoretical framework

Artificial Intelligence (AI) adoption and wage inequality

The integration of AI into the workforce could have profound implications for wage inequality, reshaping labor market dynamics and altering the demand for different skill levels. AI-driven automation can potentially amplify wage disparities, particularly between high- and low-skilled workers. Skill-Biased Technological Change (SBTC) Theory helps explain this phenomenon.

SBTC Theory (Wu, 2025) argues that AI adoption increases demand for skilled workers who develop, manage, and operate AI technologies, thereby driving up their wages. In contrast, low-skilled workers, whose tasks are more easily automated, experience wage stagnation or job displacement, widening income inequality. Drydakis (2025) confirms the theory by concluding that AI adoption caused higher employment and wages for high-skilled workers while causing job displacements for low-skilled workers. This means that the wage gaps have been amplified due to AI adoption and that both increased employment and unemployment have occurred depending on the skillfulness of the workforce.

The Role of AI reskilling programs

AI-driven reskilling and upskilling programs are crucial for moderating the negative effects of automation and reducing wage disparities. Several economic and organizational theories provide insight into how reskilling can support workforce adaptation and economic growth. Endogenous Growth Theory (Hayes, 2022) suggests that investing in human capital through reskilling programs fosters innovation, productivity, and long-term economic growth. This theory highlights the importance of reskilling programs in ensuring an adaptable, skilled workforce and minimizing labor market inequalities.

Table 3: Theoretical Framework and Hypothesis Alignment

Hypothesis	Theories Aligned	Key Conclusions
H1: AI adoption increases wage gaps, benefiting high-skilled workers while limiting opportunities for low-skilled workers.	Skill-Biased Technological Change (SBTC) Theory (Wu, 2025)	AI adoption increases demand for high-skilled workers, leading to wage growth while displacing low-skilled workers, deepening wage inequality. It also replaces routine manual tasks, eliminating middle-skilled jobs while expanding opportunities for high-skilled workers, contributing to labor market polarization.
H2: Industries that invest in AI reskilling experience higher productivity and innovation, while those that do not face economic stagnation.	Endogenous Growth Theory (Hayes, 2022)	Industries that invest in AI reskilling foster innovation and increase productivity, benefiting economic growth. Technological advancements create new roles while eliminating outdated jobs, requiring effective reskilling strategies to reduce unemployment.

Source: Authors, based on the most relevant articles used

Methodology

This study employs a systematic review methodology to synthesize existing research and industry reports on the impact of Artificial Intelligence (AI) on wage inequality, labor market transformation, and the effectiveness of AI-driven reskilling programs. The objective is to examine how AI adoption influences wage disparities, labor market equity, and the role of reskilling initiatives in moderating the negative consequences of AI implementation.

Systematic search strategy

A systematic search was conducted using Google Scholar, JSTOR, ScienceDirect, SpringerLink, and Web of Science. Key terms included “AI wage inequality,” “AI reskilling programs,” “AI labor market impact,” “Automation and wage polarization,” “AI and social inequality,” “AI-driven productivity,” “AI workforce adaptation,” and “AI and job displacements.” Filters included peer-reviewed articles and reports from reputable institutions like OECD, World Bank, and ILO to ensure high academic and professional standards.

A Web of Science search on “Artificial intelligence, automation, and work” found 5,569 publications, showing growing academic interest. Of these, 2,068 are open access, enhancing global accessibility, while 313 are reviews, reflecting comprehensive analyses of AI. Notably, 71 papers are highly cited, indicating substantial academic influence. In annual output, 881 papers were published in 2022, 713 in 2023, and 702 in 2024, showing sustained activity. These publications have garnered 101,740 citations, emphasizing relevance across disciplines like computer science, labor economics, and public policy.

Table 4: The most popular AI and labor market research papers according to the WoS

Title	Author(s) and Year	Journal	WoS Citation Count
Why do new technologies complement skills? Directed technical change and wage inequality	Acemoglu, D. (1998)	The Quarterly Journal of Economics, 113(4)	2,800+
Artificial intelligence, automation, and work	Acemoglu, D. & Restrepo, P. (2018)	Econometrica, 88(6), pp. 2097–2149	1,200+
Toward understanding the impact of artificial intelligence on labor	Frank, M. R. et al. (2019)	PNAS, 116(14), pp. 6531–6539	500+
The impact of artificial intelligence on the labor market	Webb, M. (2020)	The Quarterly Journal of Economics, 135(2)	300+
The demand for AI skills in the labor market	Alekseeva, L. et al. (2021)	Labour Economics, 71, 102002	60+

Source: Web of Science, accessed March 25, 2025

Research questions and hypotheses

This study is guided by two primary research questions that align with the theoretical framework. The first research question examines how AI adoption affects wage gaps between high-skilled and low-skilled workers. The second research question explores the impact of AI reskilling programs on workforce adaptability, industry productivity, and job displacement.

To address these questions, the following hypotheses were created:

- H1: AI adoption increases wage gaps, benefiting high-skilled workers while limiting wage growth for low-skilled workers.
- H2: Industries that invest in AI reskilling experience higher productivity and innovation, while industries that do not implement reskilling programs face job losses and economic stagnation.

Variables

H1; AI adoption increases wage gaps by favoring high-skilled workers while limiting opportunities for low-skilled workers. Independent Variable: Level of AI adoption in industries, measured by AI-related investments or automation rate, and Dependent Variable: Wage inequality, measured by the wage gaps between high and low-skilled labor. The choice of AI adoption as the independent variable and wage inequality as the dependent variable was supported by existing research highlighting their relationship in labor market dynamics. AI drives wage inequality by increasing demand for high-skilled workers and reducing opportunities for low-skilled labor. The relationship was assessed by analyzing wage trends in industries with high AI adoption compared to low AI adoption.

H2; Industries that invest in AI reskilling experience higher productivity and innovation, while those that do not face economic stagnation. Independent Variable: Investment in AI reskilling programs, measured by industry expenditure on AI training or percentage of the workforce receiving AI-related reskilling. Dependent Variable: Industry competitiveness, measured by productivity growth, revenue growth or market share expansion. The decision to use AI adoption as the independent variable and wage inequality as the dependent variable was based on previous research that emphasizes their notable relationship in labor market dynamics. This approach aligns with our goal to assess the influence of AI adoption on wage disparities.

Theoretical framework and hypothesis alignment

The theoretical foundation of this study is based on key economic and labor market theories that explain how AI adoption influences wage inequality, reskilling initiatives, and labor market polarization. These theories provide the conceptual basis for the study's hypotheses and help interpret AI's role in reshaping labor market dynamics.

The first hypothesis (H1) suggests that AI adoption increases wage gaps, benefiting high-skilled workers while limiting wage growth for low-skilled workers. This is supported by Skill-Biased Technological Change (SBTC) Theory, which argues that technological advancements favor high-skilled labor by increasing demand for specialized AI-related expertise while simultaneously reducing opportunities for low-skilled workers. Similarly, Capital-Labor Substitution Theory highlights how AI automation replaces routine manual tasks, leading to job displacement and wage stagnation among low-skilled employees, while high-skilled professionals see wage gains. Labor Market Polarization Theory further reinforces this trend by illustrating how AI eliminates middle-wage jobs, increasing demand at both extremes of the

labor market. Automation and Job Displacement Theory and the Polarized Economy and Wage Inequality Theory similarly argue that AI-driven technological advancements disproportionately benefit high-skilled workers while exacerbating economic inequalities for those in lower-skilled roles.

The second hypothesis (H2) posits that industries that invest in AI reskilling experience higher productivity and innovation, while those that fail to implement reskilling programs face job losses and economic stagnation. Endogenous Growth Theory explains how investment in human capital, particularly through AI-driven reskilling, enhances workforce productivity and long-term economic growth. Creative Destruction Theory underscores how technological innovations disrupt traditional job roles, requiring businesses to adapt through reskilling to remain competitive. Job Creation and Destruction Theory further elaborates that while AI eliminates certain job categories, it also creates new employment opportunities, making reskilling essential for workforce sustainability and economic resilience.

Inclusion and exclusion criteria

The selection of studies for this systematic review was guided by specific inclusion and exclusion criteria to ensure relevance and methodological rigor. Studies included in this review comprised peer-reviewed journal articles, industry reports, and policy documents published within the last 10 to 15 years, focusing on AI's impact on wage inequality, labor market transformations, and reskilling programs. Both quantitative and qualitative empirical studies were considered to provide a comprehensive analysis. Exclusion criteria eliminated articles that did not directly address AI or automation's role in labor market shifts, those that focused solely on technical AI advancements without exploring socioeconomic implications, and research lacking empirical data or real-world applications.

Article screening and selection

The screening and selection process was conducted in two stages. In the first stage, titles and abstracts were reviewed to identify studies that aligned with the research questions. The second stage involved a full-text review of the selected studies to confirm their relevance and methodological rigor. Studies that met the inclusion criteria were analyzed in detail to extract key findings related to AI adoption, wage inequality, and reskilling programs.

Data synthesis

The findings from the selected studies were synthesized using a narrative synthesis approach, which allowed for integrating results across different study designs and methodologies. The synthesis process focused on two key themes corresponding to the study's hypotheses. The first theme examined how AI adoption influences wage inequality, emphasizing the growing gap between high-skilled and low-skilled workers. The second theme explored the relationship between AI reskilling programs and industry productivity, comparing industries that have successfully integrated reskilling initiatives with those that have not.

Discussion and results

Hypothesis 1 (H1): AI adoption increases wage gaps, benefiting high-skilled workers while limiting wage growth for low-skilled workers

The findings of this study support the argument that AI-driven transformations may increase wage inequality, primarily favoring high-skilled workers while restricting wage growth for low-skilled employees. This observation aligns with the Skill-Biased Technological Change (SBTC) Theory, which states that technological advancements can disproportionately elevate the demand for high-skilled labor, resulting in increased wages while simultaneously reducing opportunities for lower-skilled workers (Wu, 2025). Grant (2024) and Acemoglu (1998) establish a strong correlation between AI-driven automation and the rising skills premium, which amplifies wage disparities. However, Grant (2024) also suggests that as more high-skilled workers receive AI education, wage gaps between skill levels should narrow, highlighting the potential for reskilling to moderate these drawbacks.

Hypothesis 2 (H2): Industries that invest in AI reskilling experience higher productivity and innovation, while those that do not face job losses and economic stagnation

Industries that proactively implement AI reskilling programs exhibit better productivity and innovation, aligning with the Endogenous Growth Theory, which states that investment in human capital can serve as a fundamental driver of economic expansion (Hayes, 2022). Empirical findings prove these claims. For instance, Alekseeva et al. (2021) note that AI skills command higher salaries, underscoring the importance of reskilling to enhance workforce adaptability and competitiveness. The global decline in labor share of income further emphasizes the necessity of workforce adaptability (Lou & Zhou, 2021).

Moreover, while AI can lead to job displacement and reduced labor share in income (Acemoglu & Restrepo, 2018), it also creates new tasks and enhances productivity (Webb, 2020). To minimize the negative effects, strategic AI reskilling programs are essential. These programs can not only enhance productivity but also promote labor market equity by ensuring that workers across all skill levels can adapt to technological changes (Bodea et al., 2024). By investing in AI education and reskilling, policymakers and corporate leaders can maximize the benefits of AI while minimizing its drawbacks. The literature emphasizes the complexity of AI's impact on labor markets. For instance, Alekseeva et al. (2021) and Frank et al. (2019) note that AI skills tend to bring higher salaries, driving wage gaps within companies. This trend appears to be consistent across industries. However, studies like those by Acemoglu and Restrepo (2018) and Webb (2020) warn that while AI can boost productivity and create new tasks, it also leads to job displacement and skills mismatches. These challenges highlight the need for strategic reskilling programs to moderate negative impacts. Interestingly, Domini et al. (2022) and Georgieff (2024) suggest that AI may not always widen wage gaps, as workforce composition and internal wage disparities can be more influential.

Recent studies, such as Shokran et al. (2025) and World Economic Forum research (2025), highlight the benefits of AI adoption for both organizations and workers, including improved decision-making, productivity, and market adaptation. However, Yi & Ayangbah (2024) note a negative correlation between employment rates and productivity, suggesting that AI's benefits may come at the cost of job losses.

To address these challenges, academia-industry partnerships have been suggested to play a crucial role in driving innovation and workforce adaptation. Moreover, Bervenmark & Kihlen (2024) stress the need for a strategic approach to AI implementation that addresses both technical and behavioral aspects to maximize benefits. In conclusion, addressing these

challenges through targeted policies and practices might be crucial for ensuring that AI adoption benefits both organizations and workers, possibly leading to sustainable economic growth.

Limitations and future research

This research finds several limitations that impact conclusions drawn from the findings. While some quantitative data exists, there is insufficient data regarding the extent of impact of AI implementation in the workforce. Ideally, a few year-long longitudinal study comparing companies that have implemented AI and reskilling programs, those that have only implemented AI without reskilling, and those that have not adopted AI at all would provide the clearest data regarding the effects of AI. Such research would allow for stronger and more direct conclusions. The existing literature on the impact of AI implementation is highly divided with some stating a strong positive effect of AI implementation while others warn about displacements and wage gaps. This divide complicates drawing a concise conclusion regarding expected effects of AI. It is widely acknowledged that AI will affect job displacements. However, the rate of job creation following the implementation of AI is unknown and requires long-term data.

Methodological constraints

Since the study's design does not allow for an accurate comparison of companies with different AI and reskilling strategies, future research should prioritize experimental designs to allow for the isolated effects of AI on reskilling and productivity. Due to the limitations of the current study, its findings may not be generalizable to all industries or economies. A broader, more diverse dataset would be necessary to ensure that conclusions apply across the workforce. By acknowledging these limitations, the study highlights the need for further research to provide more definitive insights into the complex relationships between AI adoption, reskilling, productivity, and wage inequality.

Conclusion

The findings of this study indicate that AI adoption can contribute to wage disparities and labor market polarization, disproportionately benefiting high-skilled workers while presenting challenges for low and middle-skilled employees. This aligns with the Skill-Biased Technological Change theory, which highlights the role of technological advancements in widening income gaps. However, industries that invest in AI-driven reskilling programs usually demonstrate resilience, enhanced productivity, and reduced social inequality, supporting the Endogenous Growth theory. AI adoption is reshaping the labor market by increasing wage disparities between high- and low-skilled workers. Technological advancements tend to favor high-skilled employees, resulting in higher wages and more job opportunities for those with specialized expertise. In contrast, low-skilled workers often face job displacement and limited wage growth, contributing to broader economic inequality. However, industries that invest in AI-focused reskilling programs show improved productivity, innovation, and adaptability. These programs help workers transition into new roles and reduce the negative effects of automation. Strategic investment in human capital is essential to balance the disruptive impact of AI while encouraging long-term economic growth ensuring a more sustainable labor market outcome.

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During the preparation of this work, the authors used ChatGPT to check the grammar errors and improve the style of writing to achieve a more cohesive text. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the paper.

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ARTIFICIAL INTELLIGENCE AND ORGANIZATIONAL EFFICIENCY: EXPLORING CORPORATE SOCIAL RESPONSIBILITY AS A MEDIATOR IN THE CONSULTING INDUSTRY

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Abstract

The advent of Artificial Intelligence (AI) is profoundly transforming business practices, redefining almost all aspects of socially responsible behavior through its unique characteristics of autonomy, learning capability, and inscrutability. At the same time, Corporate Social Responsibility (CSR) has become a fundamental pillar of corporate strategy, focusing on ethical conduct, sustainability, and stakeholder engagement. Traditionally, CSR has been defined as context-specific organizational actions and policies that account for stakeholders' expectations and address the triple bottom line of economic, social, and environmental performance. The literature has primarily examined the factors influencing corporate decision-makers to act responsibly toward stakeholders, including customers, employees, suppliers, communities, and the environment. The intersection of AI and CSR presents unprecedented opportunities for leveraging advanced technologies to address social, environmental, and economic challenges. Integrating AI into CSR frameworks has been shown to improve CSR performance, particularly through enhancing transparency, optimizing resource utilization, and achieving better social and environmental outcomes. Empirical findings confirm that AI adoption significantly strengthens CSR initiatives by improving accountability and resource efficiency. However, ensuring responsible AI use requires embedding ethical principles within CSR strategies, a necessity emphasized by recent studies. Transparency plays a pivotal role, especially in AI-driven decision-making, to foster trust in CSR initiatives. This is particularly crucial when AI decisions have direct social or environmental impacts. Consequently, future research should continue to investigate how ethical governance mechanisms can guide the responsible integration of AI into CSR frameworks, ensuring sustainable and trustworthy organizational outcomes.

Keywords: Artificial Intelligence (AI), Corporate Social Responsibility (CSR), organizational efficiency (OE), Consulting Sector (CS).

JEL classification: M14, O35, O32

Introduction

In the era of digital the analysis emphasizes that multiple approaches can effectively reinforce an organization's culture, depending on the management style adopted and the level of employee commitment. Flexibility remains essential, as it enables organizations to adapt management strategies to their specific contexts and challenges. By recognizing the unique needs of their workforce and organizational framework, managers can cultivate a culture that supports the company's strategic objectives and strengthens overall cohesion. transformation, AI is profoundly reshaping organizational practices, offering unprecedented opportunities to automate processes, analyze massive volumes of data, and improve strategic decision-making. These technological advancements go beyond operational efficiency by also influencing how companies respond to the growing expectations of stakeholders regarding ethics, sustainability, and accountability. In this context, CSR – once seen as merely an image or compliance tool – is evolving into a crucial strategic lever, integrating economic, social, and environmental dimensions into the core of organizational strategy (Hull & Rothenberg, 2008; McWilliams & Siegel, 2010).

According to Koh et al. (2014), CSR not only enhances companies' reputations but also acts as a factor of sustainability by creating long-term value for stakeholders and shareholders. At the same time, AI, as a key technology, is transforming CSR practices by automating complex tasks, analyzing environmental, social, and economic impacts, and optimizing strategic initiatives (Russell & Norvig, 2016; Dogru & Keskin, 2020). However, this transformation raises significant ethical challenges. Data protection, algorithmic biases, and social inequalities exacerbated by certain AI applications (Zuboff, 2019; Zou & Schiebinger, 2018) compel companies to rethink their approaches to ensure a responsible and inclusive adoption of technologies.

In this context, a central question arises: to what extent can the integration of AI into CSR practices enhance Organizational Efficiency, and how can this synergy be optimized in the face of ethical and technological challenges? This issue raises complex concerns related to the interaction between technological innovation, social responsibility, and organizational competitiveness.

The consulting sector, known for its rapid adoption of emerging technologies, provides a fertile ground for examining these dynamics. Companies in this sector leverage AI not only to improve operational efficiency but also to meet the growing demands for sustainability and transparency. However, the real impact of this convergence between AI and CSR remains underexplored, particularly regarding its influence on Organizational Efficiency.

This article provides an in-depth empirical analysis of these issues. Drawing on resource-based theory, which positions stakeholder image and support as key strategic assets (Godfrey, 2005; McWilliams & Siegel, 2010), and relying on a rigorous quantitative methodology, our study examines the direct and indirect effects of AI on Organizational Efficiency, as well as the mediating role of CSR in this relationship. By clarifying the levers for optimizing this synergy

and exploring strategies to overcome ethical challenges, this work aims to guide companies seeking to reconcile technological innovation and CSR in an ever-changing environment.

Existing studies highlight the positive role of AI in improving CSR performance through transparency and value for money, but few have addressed the challenges of aligning AI autonomous decision-making processes with the CSR core principles of accountability, sustainability and inclusivity (Floridi & Cowls, 2022; Zicari, 2020). Further empirical research is therefore needed to conceptualize the responsible integration of AI into CSR frameworks, exploring in particular how ethical governance mechanisms can mitigate the risks posed by AI while maximizing its benefits for social, environmental and organizational outcomes.

Theoretical framework and research model

The Relationship Between Corporate Social Responsibility (CSR) and organizational efficiency: CSR was traditionally seen as a way for businesses to enhance their market positions (Hull & Rothenberg, 2008; Klein & Dawar, 2004). It posits that CSR not only boosts a company's reputation and sustainability (Koh et al., 2014) but also establishes solid relationships with stakeholders, resulting in support from major clients, increased employee engagement, and social legitimacy (Lev et al., 2010; Sen & Bhattacharya, 2001; Greening & Turban, 2000). During economic crises, the ethical capital from CSR practices can protect shareholder value (Godfrey, 2005; Koh et al., 2014). The resource-based theory supports the notion that a strong image and stakeholder support, derived from effective CSR, are valuable assets that enhance a company's competitive edge (McWilliams & Siegel, 2010). Several studies confirm a positive link between CSR and organizational efficiency (Kuldip, 2021; Al-Galbi, 2005; Jane, 2007; Orlitzky, 2003).

In Morocco's consulting sector, this relationship remains less examined despite the sector's role in facilitating strategic industry transformations. With the growing importance of aligning with international ESG standards, testing this CSR-organizational efficiency relationship is crucial for Moroccan consulting firms, as it could significantly affect their ability to attract clients and talent (Zayer & Benabdelhadi, 2023).

H1: CSR has a positive effect on organizational efficiency.

The Impact of Artificial Intelligence on Corporate Social Responsibility: The integration of AI into CSR practices is revolutionizing how companies address their ESG responsibilities. By utilizing AI technologies like machine learning and data analysis, businesses can enhance their CSR strategies and more effectively tackle global challenges (Russell & Norvig, 2016; Dogru & Keskin, 2020; Gore et al., 2023; Atanasov et al., 2023). However, this shift introduces ethical issues, such as increased cybersecurity risks and potential exacerbation of social inequalities due to algorithmic biases (Martin et al., 2017; Zuboff, 2019; Zou & Schiebinger, 2018). Despite these challenges, AI also enables innovative CSR approaches that promote sustainable growth and ethical business practices (Lakhan, 2022). Overall, integrating AI into CSR not only optimizes initiatives but also helps redefine corporate responsibility, emphasizing ethics, sustainability, and inclusivity (Gore et al., 2023; Dogru & Keskin, 2020).

H2: AI positively impacts CSR within organizations.

The Impact of Artificial Intelligence on organizational efficiency: AI is increasingly vital for enhancing organizational efficiency, offering substantial benefits and challenges. Brynjolfsson et al. (2023) observed a 14% productivity boost in customer support through an AI conversational assistant, especially aiding novice employees by spreading experienced workers' tacit knowledge. This underscores AI's role beyond mere automation, enhancing skills and reducing onboarding times (Brynjolfsson et al., 2023). Li et al. (2024) found that teams aided by generative AI tools outperformed those without, particularly in solving complex problems and speeding up decisions. Yet, adding more AIs didn't increase benefits, suggesting a saturation point where AI effectiveness plateaus (Li et al., 2024).

Hainsworth (2023) noted no significant link between AI adoption and productivity in UK firms from 2015 to 2019, hinting at implementation delays or sector-specific adoption issues, emphasizing that AI's success depends on the organizational context and integration strategy (Hainsworth, 2023). In CSR, AI is used to optimize sustainability and risk management. Kotzian (2021) noted that AI enhances CSR compliance through automated data handling, while Shkalkenko & Nazarenko (2024) discussed AI and IoT's role in improving financial risk management and sustainable development, stressing the need for institutions to adapt to tech innovations (Risks, 12(6), 87). Schwaewe et al. (2025) see AI as a driver for sustainable organizational change, advocating for responsible AI practices that uphold fairness and transparency (Review of Managerial Science).

Overall, AI not only augments efficiency and competitiveness but also plays a crucial role in CSR, enhancing environmental, social performance, and stakeholder interaction. Its full potential hinges on strategic implementation and effective human-machine collaboration.

H3: The Use of AI Improves organizational efficiency

Artificial Intelligence Driving Organizational Efficiency: The Mediating Role of CSR

The integration of AI within organizations indirectly contributes to enhancing organizational efficiency, with this relationship being mediated by CSR practices. The implementation of AI positively influences CSR initiatives, which in turn bolster organizational efficiency.

Li & Jin (2024) demonstrated that the intensity of AI adoption improves companies' sustainability performance, with organizational change playing a crucial mediating role in this dynamic. This suggests that AI facilitates internal transformations that strengthen CSR practices, ultimately leading to increased organizational efficiency.

Additionally, Gazi and colleagues (2024) highlighted that an organization's AI capability positively impacts its organizational creativity and green innovation, both of which mediate the relationship between AI and sustainable performance. These factors, closely linked to CSR initiatives, illustrate how AI can foster responsible practices that enhance organizational efficiency.

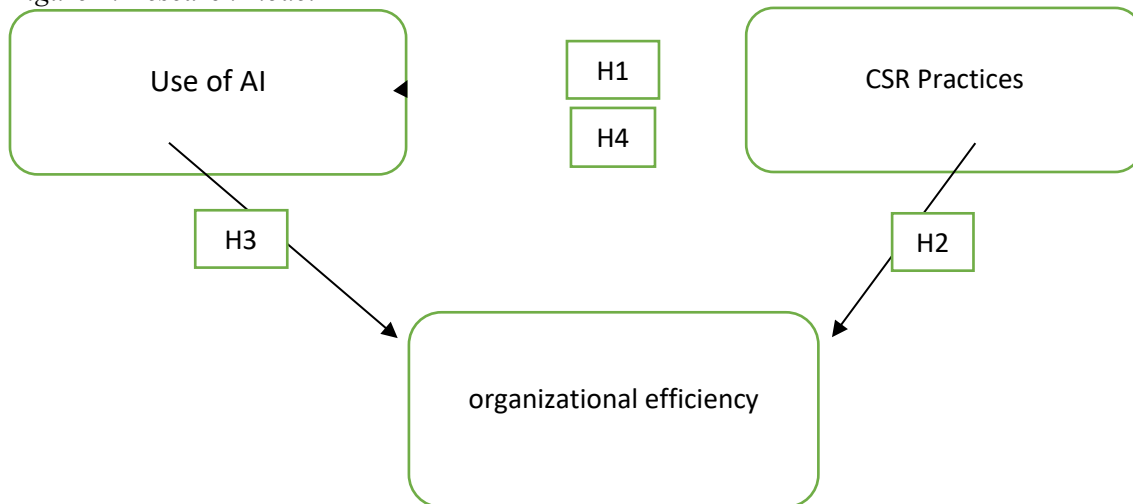
Furthermore, a study conducted by Zhang et al. (2023) revealed that high-intensity AI adoption drives organizational changes that, in turn, improve sustainable performance. These changes, including optimized processes and increased flexibility, enable companies to better meet societal and environmental demands, thereby strengthening their overall performance.

In summary, CSR practices play a fundamental mediating role between AI adoption and Organizational Efficiency. By developing their CSR initiatives alongside AI integration, companies can not only meet societal expectations but also enhance their overall performance.

H4: AI have an indirect effect on organizational efficiency, mediated by the CSR Practices.

Figure 1 illustrates the key concepts of this study, along with the associated hypotheses, integrated into the proposed research model.

Figure 1: Research model



Source: authors

Methodology and research results

Method

We employed Structural Equation Modeling (SEM) using the Partial Least Squares (PLS) method, a flexible approach ideal for small samples and non-normally distributed data. PLS is designed to maximize the explained variance of dependent variables and allows for the modeling of complex causal relationships between theoretical (latent) constructs and their observed indicators, providing a thorough analysis of both the measurement and structural models.

The PLS methodology includes several key steps:

1. **Model Specification:** We define the latent variables, their indicators, and the relationships between these variables.
2. **Parameter Estimation:** Using the PLS algorithm, we iteratively calculate path weights, coefficients, and factor loadings. This non-parametric estimation enhances the robustness of the PLS method against traditional statistical assumptions, such as data normality.
3. **Model Evaluation:** This involves assessing the measurement model to ensure the validity and reliability of the constructs, and analyzing the structural model to evaluate the significance and explanatory power of the identified causal relationships.

In our analysis, CSR is conceptualized as a second-order construct, represented by three first-order dimensions: social, economic, and environmental. These steps allow for a structured approach to understanding and modeling the multifaceted nature of CSR within the specified framework.

Sample and data collection

The nature of our study required data collection from employees working in companies, whether or not they adopt AI. We specifically targeted employees from the consulting sector due to its dynamic nature and extensive exposure to emerging technologies such as AI, as well as the diversity of organizational practices it encompasses.

A pilot study was first conducted with 40 participants to test the validity of the questionnaire items and verify the unidimensionality of the measurement scales, which helped refine the items before conducting a confirmatory study with 135 respondents. Participants, contacted electronically, were invited to complete the questionnaire focusing on their professional experience and the perceived impact of AI within their company.

The sample is characterized by a balanced gender representation (53% male and 47% female) and a predominance of young adults, with 46% aged between 25 and 34 years, followed by 28% aged between 35 and 44 years. Participants under 25 years and those aged between 45 and 54 represent 10% and 13%, respectively, while 4% are 55 years or older. Moreover, the majority of participants have high education levels, with 63% holding a Master's degree and 16% holding a Doctorate. Only 16% have a Bachelor's degree, while 5% possess a technical or vocational diploma or a high school diploma.

This diversity, coupled with a rigorous methodology including scale validation and confirmatory analysis using SEM, provides our study with statistical reliability and particular relevance for analyzing the interactions between AI, CSR, and organizational efficiency.

Measurement of variables

Table 1: Operationalization of the Variables Used

Variable	Measurement Indicators	Source
AI Utilization	Frequency of use, Task diversity, Process complexity, Trust, Efficiency	Dubey et al. (2020)
Organizational Efficiency	Productivity, Execution speed, Cost reduction, Decision quality, Overall efficiency	Guenole & Feinzig (2019)
CSR	Social Dimension: Employee care, Workplace inclusion; Economic Dimension of CSR: Quality of products/services, Business relations, Energy savings; Environmental Dimension of CSR: Environmental impact reduction	Gallardo-Vázquez, D., Herrador-Alcaide, TC et Sánchez-Domínguez, J. de la C. (2023)

Source: authors

Statistical Analysis and Empirical Results

To verify the validity and unidimensionality of the measurement scales, we applied Principal Component Analysis (PCA), a statistical method that converts a group of initially correlated variables into a new set of uncorrelated variables known as principal components. This method focuses on maximizing the variance explained by each component and is instrumental in

purifying the measurement scale to enhance the validity and reliability of the constructs used (Churchill, 1979).

To assess the correlation among variables, we utilized the Kaiser-Meyer-Olkin (KMO) measure for sampling adequacy and Bartlett's test of sphericity. The KMO index is deemed acceptable when it exceeds 0.50 and high if it is above 0.70 (Evrard et al., 2009; Fall, 2015). Bartlett's test of sphericity, significant at a p-value lower than 0.05, allows us to reject the null hypothesis that assumes the independence of the variables, indicating that not all correlations among variables are zero (Fall, 2015).

Additionally, we employed the Kaiser criterion for selecting the most significant principal components, which suggests retaining only those components with eigenvalues greater than 1. These components are significant as they explain a substantial portion of the total variance, thus facilitating the study of construct dimensionality.

This PCA was conducted for the purpose of item purification and determining dimensionality within a sample of 48 companies, using SPSS 27 software.

Table 2: Results of Scale Purification – KMO Indices, Bartlett's Test, and Total Variance Explained

Scale	KMO Index and Bartlett's Test				Total Variance Explained	
	Kaiser-Meyer-Olkin (KMO) Index for Sampling Adequacy	Chi-square	df	p-value	Total	% Of the variance
Use of AI	0.790	214.739	10	<.001	3.951	79.015
Organizational Efficiency	.872	257.444	10	<.001	4.265	85.302
CSR Practices	.683	2189.105	406	<.001	17.525	60.430

Source: authors

The analysis confirms the effectiveness of our approach across different dimensions. For artificial intelligence, PCA indicates a strong unidimensionality with a KMO of 0.790 and 79.015% of the variance explained by the first component, supported by high factor loadings which validate the hypothesis of a singular dimensional measurement. In the case of Organizational Efficiency, the fit is excellent with a KMO of 0.872 and 85.302% of the variance explained by the first component. The high factor loadings confirm the construct's unidimensional validity and conceptual coherence.

For CSR practices, PCA shows a coherent three-dimensional structure, supported by a KMO of 0.683 and significant results in Bartlett's test. The analysis divides CSR into three distinct dimensions: social, economic, and environmental, with each component logically aligned with specific CSR aspects—social practices, economic initiatives, and environmental management, respectively.

Significant correlations between these dimensions, with Pearson coefficients up to 0.518, indicate strong interconnectivity, underscoring CSR as a multidimensional construct where each dimension not only contributes uniquely but is also interlinked with others. This robust analysis provides a solid foundation for further understanding and modeling CSR practices.

Table 3: CSR Dimensions

CSR Dimension	Associated Component	Examples of Variables	Correlation with Other Dimensions
Social	Component 1	Social engagement, employee well-being	Moderate correlation with Economic (0.452) and Environmental (0.518)
Economic	Component 2	Performance, economic efficiency	Weak correlation with Environmental (0.372)
Environmental	Component 3	Sustainable management, carbon footprint reduction	Significant correlation with Social (0.518)

Source: authors

The principal component analysis (PCA) effectively purified the measurement scales and confirmed the dimensionality of each construct, evidenced by high KMO indices, significant p-values, and substantial eigenvalues, ensuring the statistical validity of our methodology. These results create a robust foundation for further analyses, particularly in structural equation modeling (SEM), where scale robustness is essential for interpreting the complex relationships between constructs.

To verify the internal reliability of these scales, we conducted an analysis checking the consistency of the items associated with each construct. High Cronbach's alpha values, all exceeding 0.90, indicate excellent internal reliability for the scales measuring organizational efficiency, the various CSR dimensions (economic, environmental, social), and technology use. These findings affirm that the measurement scales are both well-defined and consistent, making them reliable for further statistical exploration.

Table 4: Cronbach's Alpha Values

Variable	Cronbach's Alpha
Organizational Efficiency	0.96
CSR-Economic	0.94
CSR-Environmental	0.96
CSR-Social	0.96
Use of Artificial Intelligence	0.94

Source: authors

In our study, we employ structural equation modeling (SEM) with a Partial Least Squares (PLS) approach to analyze complex relationships between observed and latent variables. PLS is particularly suitable for our needs due to its flexibility with small samples and non-normal data distributions.

The PLS methodology involves:

1. **Model Specification:** Identifying latent variables and their observed indicators, and establishing the structural relationships among them.
2. **Parameter Estimation:** Applying the PLS algorithm to iteratively compute path weights, coefficients, and factor loadings. This step benefits from being non-parametric, thus mitigating issues related to standard statistical assumptions like normality.
3. **Model Evaluation:** Focusing on validating the measurement model for construct validity and reliability, and assessing the structural model for the significance and explanatory power of the causal relationships.

Our analysis treats CSR practices as a second-order construct represented by three first-order dimensions: social, economic, and environmental. We begin the analysis by examining the reliability and validity of the measurement scales used.

Table 4.a: Reliability and convergent validity of the first-order measurement model

	AVE	Cronbach's Alpha	Composite reliability (Rho_c)
organizational efficiency	0.85	0.96	0.97
CSR-Economic	0.73	0.94	0.95
CSR-Environmental	0.77	0.96	0.96
CSR-Social	0.69	0.96	0.97
Use of AI	0.79	0.94	0.95

Source: authors

The "organizational efficiency" dimension shows high reliability and convergent validity with item factor loadings between 0.90 and 0.95, exceeding the 0.70 standard, and an AVE of 0.85, surpassing the required 0.50 (Hair et al., 2019; Fornell & Larcker, 1981). Its reliability indices, Cronbach's alpha (0.96) and composite reliability rho_c (0.97), also exceed the 0.70 threshold, indicating strong internal consistency (Nunnally & Bernstein, 1994). The "CSR-Economy" dimension demonstrates excellent reliability and validity with factor loadings from 0.81 to 0.89 and an AVE of 0.73. The reliability indices, Cronbach's alpha (0.94) and rho_c (0.95), confirm high internal consistency. In the "CSR-Environment" dimension, factor loadings range from 0.83 to 0.93, with an AVE of 0.77. Reliability is robust with Cronbach's alpha (0.96) and rho_c (0.96) both exceeding the 0.70 standard. The "CSR-Social" dimension shows strong internal consistency with factor loadings between 0.76 and 0.91 and an AVE of 0.69. Cronbach's alpha and rho_c are both high at 0.96 and 0.97 respectively.

Finally, the "Use of Artificial Intelligence" dimension exhibits strong loadings from 0.85 to 0.92 and an AVE of 0.79, with reliability indices, Cronbach's alpha (0.94) and rho_c (0.95), exceeding the 0.70 threshold, indicating high internal consistency.

Table 4.b: Discriminant validity of the first-order measurement model according to the Fornell-Larcker criterion

	organizational efficiency	CSR-Economic	CSR-Environmental	CSR-Social	Use of AI (UAI)
organizational efficiency	0.92				
CSR-Economic	0.60	0.85			
CSR-Environmental	0.46	0.61	0.88		
CSR-Social	0.60	0.64	0.64	0.83	
Use of AI (UAI)	0.84	0.53	0.44	0.59	0.89

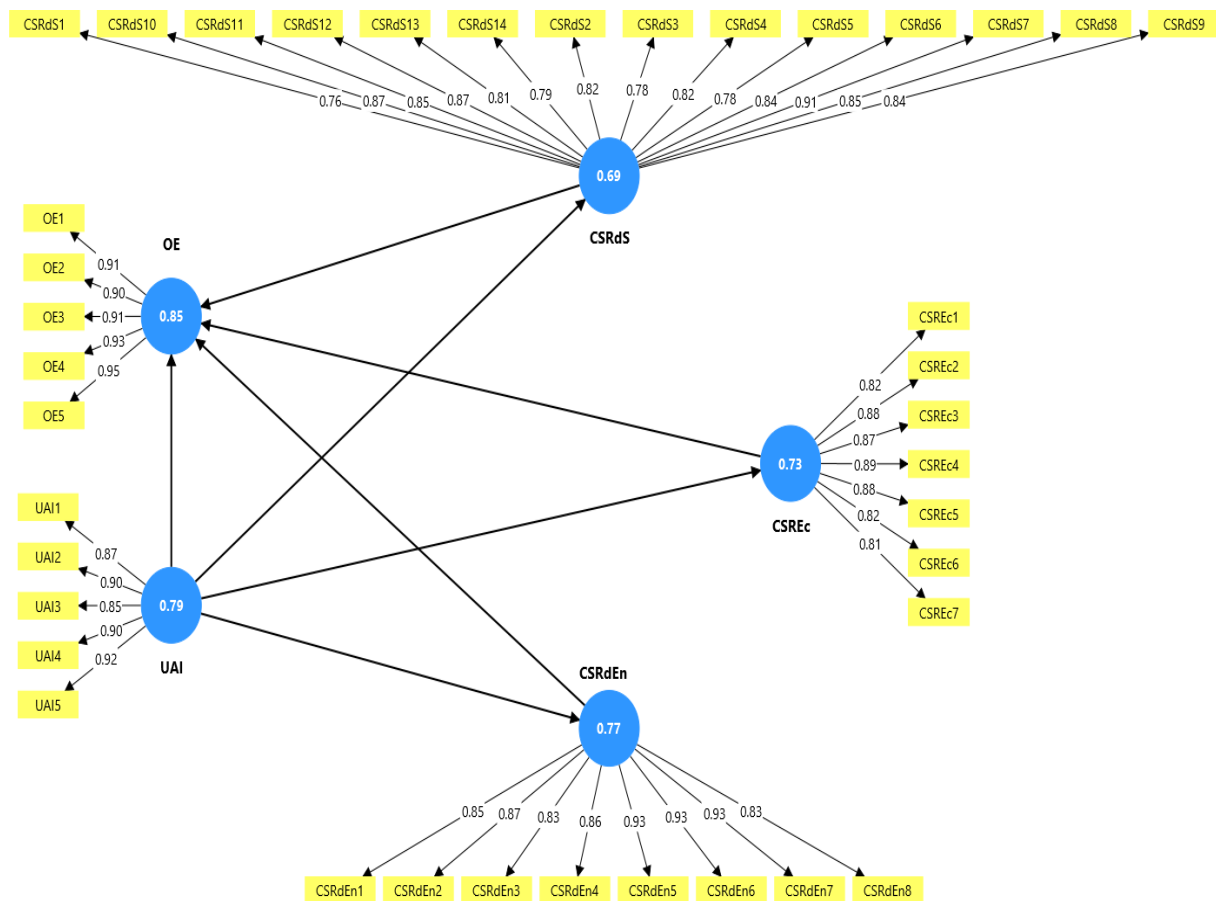
Source: authors

The Fornell-Larcker criterion assesses discriminant validity by comparing the square root of the Average Variance Extracted (AVE) of each construct with its correlations with other constructs. For a construct to meet discriminant validity, the square root of the AVE (diagonal values) must be greater than its correlations (off-diagonal values) with other constructs (Fornell & Larcker, 1981).

In conclusion, all the studied dimensions show reliability and convergent validity indices that are consistent with methodological standards. The high values of AVE, factor loadings, and reliability indices (Cronbach's alpha and composite reliability rho_c) indicate that the items effectively measure their respective constructs. These results attest to the excellent quality of the scales used for these dimensions.

The diagram below presents our first-order measurement model

Figure 1: first-order measurement model



Source: authors

Next, we will present and analyze the second-order constructs corresponding to the three dimensions of CSR.

We begin by assessing the reliability and convergent validity of the CSR construct.

Table 5: Reliability and Convergent Validity of the Second-Order Construct

Variable	Indicator	Loading	Cronbach's Alpha	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
CSR	LV Score - CSRdEc	0.87	0.84	0.90	0.75
	LV Score - CSRdEn	0.84			
	LV Score - CSRdS	0.89			

Source: authors

The external loadings of the latent scores for the CSR dimensions (CSRdEc, CSRdEn, CSRdS) are all high and exceed the recommended threshold of 0.70, indicating that each dimension significantly contributes to the overall CSR construct.

Cronbach's alpha is 0.84, which exceeds the acceptable threshold of 0.70. This indicates good internal consistency among the CSR dimensions. The composite reliability (rho_c) of 0.90 is also above the recommended threshold of 0.70, confirming that these latent scores accurately measure the overall latent CSR construct.

Regarding the Average Variance Extracted (AVE), the value is 0.75, surpassing the minimum threshold of 0.50. This indicates that the majority of the variance in the latent scores is explained by the CSR construct, rather than measurement errors.

The comparison of the square roots of the AVE with the cross-correlations shows that the square root of the AVE for the CSR construct is 0.87, which is higher than its correlations with OE (0.64) and UAI (0.60). These results confirm discriminant validity according to the Fornell-Larcker criterion, indicating that the CSR construct is distinct from the other constructs in the model.

In summary, the CSR construct demonstrates strong reliability, convergent validity, and discriminant validity, confirming its robustness as a second-order construct in the model.

Table 6: Discriminant Validity According to the Fornell-Larcker Criterion

	OE	CSR	UAI
OE	0.92		
CSR	0.64	0.87	
UAI	0.84	0.60	0.89

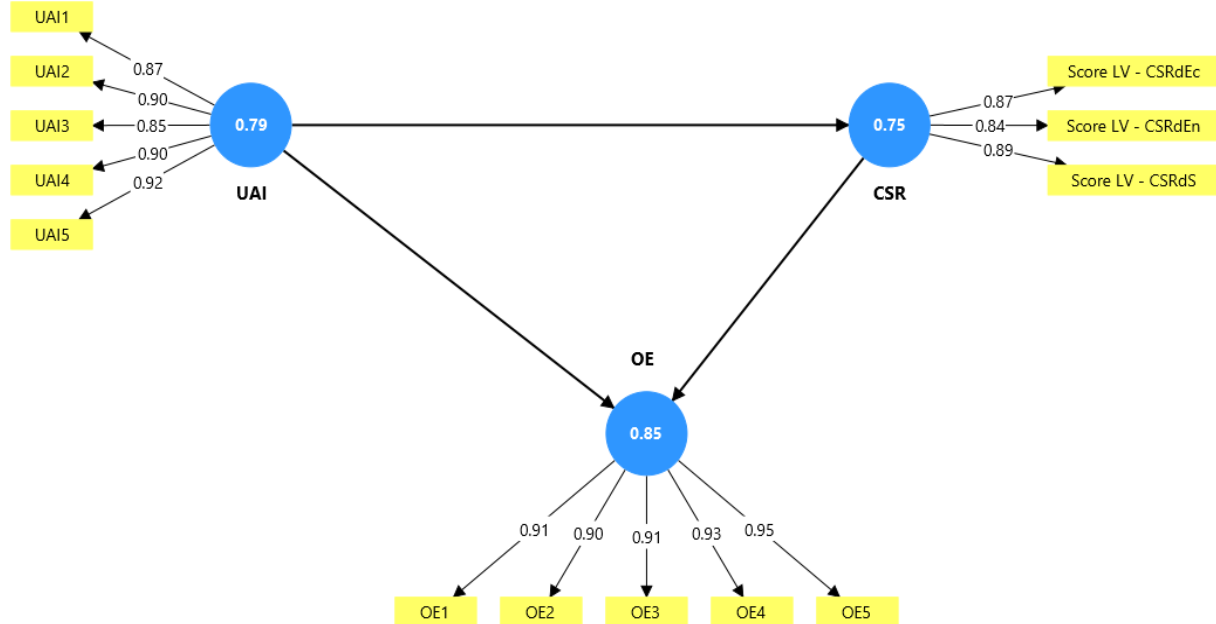
Source: authors

- **OE**: organizational efficiency
- **CSR**: Corporate Social Responsibility
- **UAI**: Use of AI

In summary, the results confirm the reliability and validity of the second-order CSR construct. The underlying dimensions (CSRdEc, CSRdEn, CSRdS) effectively measure the overall CSR construct, and discriminant validity is demonstrated by the Fornell-Larcker criterion. Therefore, this construct can be confidently used in the evaluation of the structural model.

Our second-order structural model is based on a hierarchical approach, where CSR is conceptualized as a global construct reflected by three interconnected dimensions: social, economic, and environmental.

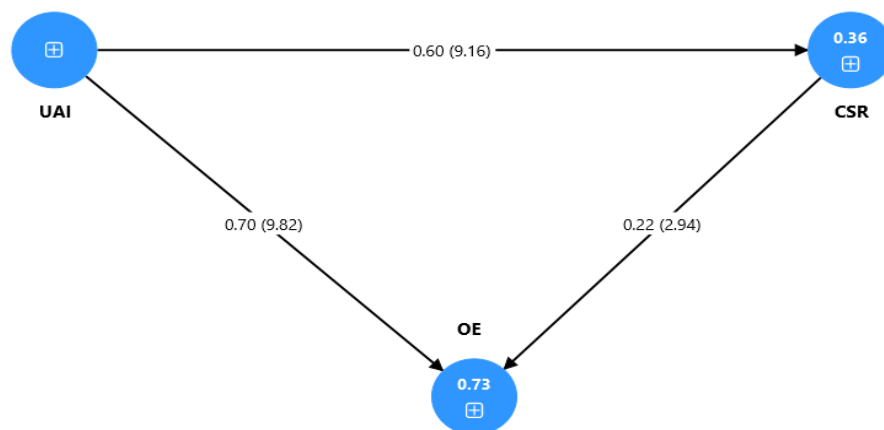
Figure 2: Second-Order Measurement Model



Source: authors

To assess the quality of the structural model, several criteria were used: the overall fit to the data through the R^2 coefficient of determination, and the multicollinearity test.

Figure 3: Structural Model



Source: authors

The coefficient of determination (R^2) for organizational efficiency (OE) is 0.73. This means that 73% of the variance in OE is explained by the independent variables, namely CSR and the

Use of AI. This high value demonstrates the strong explanatory power of the model in predicting organizational efficiency.

For the CSR variable, $R^2 = 0.36$, indicating that 36% of the variance in CSR is explained by the use of AI (UAI). This value is considered moderate, suggesting that the use of AI significantly contributes to explaining CSR practices. A coefficient of determination (R^2) up to 0.10 is considered significant (Croutsche et al., 2002). R^2 values of 0.25, 0.50, and 0.75 for target constructs are regarded as weak, moderate, and substantial, respectively (Hair et al., 2021).

Table 7: Coefficient of Determination

	R^2
OE	0.73
CSR	0.36

Source: authors

In our model, where the dependent variable is organizational efficiency (OE) and the predictors are CSR and the Use of AI (UAI), the variance inflation factor (VIF) values for these two predictors are both equal to 1.57. Therefore, in our case, with VIF values of 1.57, our predictors show low multicollinearity, meaning that the correlations between CSR and UAI do not pose a major issue for the stability of the model.

Table 8: Multicollinearity Test

	VIF
CSR -> OE	1.57
UAI -> OE	1.57

Source: authors

To test our hypotheses, we examine the significance of the path coefficients by calculating the Student's t-statistic values obtained through Bootstrapping resampling (Chin, 1998). The positive or negative effect of an independent variable on a dependent variable is considered significant if the Student's t-value is greater than 1.64 or if the p-value is less than 0.05, considering a 5% significance threshold. In order to test the direction of the effect (positive or negative), we perform a one-tailed test.

Table 9: Hypothesis Testing Results

Hypothesis Testing	Path Coefficient (β)	Student's t Statistic	p-value
CSR -> OE	0.22	2.94	<0.01
UAI -> OE	0.70	9.82	<0.01
UAI -> CSR	0.60	9.16	<0.01
UAI -> CSR -> OE (indirect effet)	0.13	2.85	<0.01

Discussion

The aim of this study is to explore the interactions between AI, CSR and organizational effectiveness within companies. The results confirm several of our initial hypotheses, highlighting the significant impact of AI and CSR on Organizational Efficiency.

Our results indicate a moderate positive effect of CSR on organizational effectiveness ($\beta = 0.22$, $p < 0.01$), corroborating theories suggesting that responsible practices improve overall corporate performance, notably through improved reputation and employee satisfaction.

AI shows a strong positive impact on CSR ($\beta = 0.60$, $p < 0.01$) and organizational effectiveness ($\beta = 0.70$, $p < 0.01$). These results suggest that the integration of advanced technologies not only facilitates the management of CSR practices, but also optimizes organizational processes. The indirect effect of AI via CSR on organizational effectiveness is also significant ($\beta = 0.13$, $p < 0.01$), indicating that AI can improve organizational effectiveness by strengthening CSR practices.

These findings enrich our understanding of the impact of AI on the management of CSR practices and, by extension, on organizational effectiveness. They offer valuable insights for business leaders aiming to integrate AI into their CSR strategies to boost their overall performance. The limitations of this study include sample size and specificity, which could influence the generalizability of the results. Future research could examine these relationships in different sectoral or geographical contexts and incorporate other moderating or mediating variables.

Results and conclusion

Our study shows the mediating impact of CSR and the use of AI as a lever for efficiency in the Moroccan consulting sector. It identifies a significant gap in the existing literature regarding the adoption of the latest technological trends by this sector, despite an environment that is generally quick to integrate innovations. It highlights a significant relationship between the use of AI, CSR practices, and organizational efficiency, revealing both direct and indirect effects that are rich in insights. AI stands out for its ability to transform organizational processes by automating complex tasks and leveraging massive volumes of data to improve decision-making and overall efficiency.

By integrating predictive analytics algorithms and machine learning systems, companies can not only increase their productivity but also anticipate risks and optimize their resources. The results of our study show that AI positively influences CSR initiatives, enhancing companies' reputations, their credibility with stakeholders, and their ability to meet growing regulatory and social demands.

Moreover, CSR practices significantly contribute to organizational efficiency by incorporating ethical, social, and environmental commitments that improve internal cohesion and employee sense of belonging. By creating a work environment that respects sustainability and inclusion principles, CSR helps reduce turnover and enhances employer brand image, which are crucial elements in a competitive landscape to attract talent. This holistic approach also fosters social and technological innovation by encouraging teams to collaborate on high-value projects for both the organization and society.

The mediating role of CSR between AI and organizational efficiency is also highlighted in this study. By enriching the technological approach with an ethical and sustainable dimension, companies can leverage the benefits of AI while avoiding pitfalls related to algorithmic biases or the risk of trust loss due to data protection issues. CSR thus provides a structuring framework to ensure the responsible use of AI and promote greater transparency in governance practices.

However, the effectiveness of this synergy relies on the implementation of strategies adapted to the organizational context and the adoption of solid technological governance. It is imperative to develop monitoring mechanisms to continuously assess the impact of AI tools on decision-making processes and stakeholder relationships. This involves setting up ethics committees and conducting regular audits to ensure compliance with regulations and alignment of practices with organizational values.

The retraining of human resources emerges as an essential lever to support this technological transformation. Continuous training programs and skills development are crucial to reduce internal resistance and strengthen employees' ability to make optimal use of AI tools. At the same time, support systems must be established to facilitate adaptation to change and maintain a high level of engagement.

Our work also opens up interesting avenues for further research. A deeper exploration of the sectoral impact could help better understand how the dynamics between AI, CSR, and organizational efficiency vary across industries. Additionally, studying stakeholder perceptions of AI-related transparency and social inclusion could enrich the debate on ethical and social issues. Finally, a longitudinal analysis of AI's effects on organizational efficiency would provide a clearer understanding of long-term transformations and identify best practices.

However, certain limitations must be taken into account. The sample, while relevant, is restricted to certain consulting sector companies, which may limit the generalization of the results. Furthermore, reliance on declarative data could introduce a bias related to respondents' subjective perceptions. Triangulating the data with objective quantitative indicators and complementary studies could strengthen the robustness of the conclusions.

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ARTIFICIAL INTELLIGENCE AND INDUSTRY 4.0 AN OVERVIEW OF THE CURRENT STATE OF RESEARCH AND FUTURE PERSPECTIVES IN BUSINESS AND MANAGEMENT: BIBLIOMETRIC LITERATURE REVIEW

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Abstract

Academic interest in the connections between artificial intelligence (AI), Industry 4.0, and digital transformation has significantly increased in recent years. However, a comprehensive bibliometric analysis of this domain remains rare. This study seeks to fill this gap by using VOSviewer to explore the relevant scientific literature. We analyzed a set of 261 peer-reviewed articles indexed in Scopus to identify the main themes, the most influential authors, and key publications in this field. The preliminary analysis focused on the evolution of publications, highlighting the most influential journals and the geographical distribution of contributions, which show a strong predominance of research in developed countries, with growing contributions from emerging economies. The keyword analysis conducted with VOSviewer identified several key themes structuring the intellectual foundation of this study. Among the main themes are: (1) AI and Industry 4.0, (2) the enhancement of industrial processes through AI, (3) the impact of digital transformation on supply chains, (4) sustainability in the context of Industry 4.0, and (5) the interconnections between AI, Industry 4.0, and digital transformation. The article delves into these themes, highlighting the dynamics and interconnections that underpin them, and concludes by identifying existing research gaps and opportunities for future studies.

Keywords: artificial intelligence, Industry 4.0, digital transformation, sustainability, optimization of industrial processes.

JEL classification: M14, O35, O32

Introduction

Artificial Intelligence (AI) and Industry 4.0 are central to the digital transformation of modern enterprises. Though often examined separately, these domains are intricately linked and jointly impact organizational efficiency, competitiveness, and sustainability in an increasingly globalized world. As businesses adopt emerging technologies to stay competitive, understanding the interplay between AI, Industry 4.0, and digital transformation is essential for crafting effective innovation strategies.

In today's fast-evolving technological landscape, companies navigate complex challenges where AI and cyber-physical systems (CPS) integration play a key role in enhancing performance. Industry 4.0 now goes beyond automation, encompassing transformations in supply chains, production processes, and sustainable practices.

AI, recognized as one of the most disruptive technologies, not only boosts efficiency through automation but reshapes how organizations engage with their environments. Despite its growing significance, the mechanisms linking AI and Industry 4.0 to business model transformation, sustainability, and competitiveness remain insufficiently explored.

Although progress has been made in adopting these technologies, researchers stress the need for deeper insights into how they drive innovation and long-term advantage. Studies (e.g., Bag et al., 2022; Tortorella et al., 2023) reveal that strategic integration of AI into sustainable business models remains fragmented and that sector-specific, longitudinal studies are scarce. Bibliometric reviews (e.g., Kamble et al., 2023) echo these findings, highlighting persistent gaps in cross-sectoral analysis and integrated frameworks.

Moreover, barriers such as system integration, data governance, and workforce adaptation continue to limit widespread AI deployment, especially in manufacturing (Windmann et al., 2024; Jagatheesaperumal et al., 2021).

This study aims to bridge these gaps by offering a conceptual framework clarifying how AI and Industry 4.0 jointly drive business model innovation, sustainability, and competitiveness. To achieve this, a bibliometric analysis of publications indexed in Scopus was conducted, identifying key theoretical frameworks, knowledge gaps, and future research directions.

The study addresses the following research questions:

- What is the current state of knowledge on the interconnections between AI, Industry 4.0, and digital transformation?
- How does the evolution of publications by time, geography, and themes inform this understanding?
- What are the dominant topics, conceptual themes, and interdisciplinary collaborations in the literature?

The analysis, based on 261 peer-reviewed articles published between 2018 and 2024 (data retrieved July 1, 2024, using keywords in Table 2), spans engineering, management, and computer science fields.

This research enhances understanding of AI, Industry 4.0, and digital transformation, identifying emerging trends and future research needs. The methodology, following PRISMA guidelines (Donthu et al., 2021), ensures rigor and offers a solid foundation for both theoretical and empirical inquiry into these key interconnections.

Defining industry 4.0 key concepts and technologies in business and management

Table 1: Defining the key technologies associated with Industry 4.0, including their description and corresponding references. of this research.

Concept	Definition	Authors/References
Industry 4.0	<i>“Introduced in Germany in 2011, Industry 4.0 includes technologies such as nanotechnology, cyber-physical systems, artificial intelligence (AI), robotics, and the Internet of Things (IoT). It drives organizations to transform themselves into intelligent entities in order to remain competitive”.</i>	Bag et al. (2021); Demlehner et al. (2021); Grover et al. (2020); Hu et al. (2021); Hughes et al. (2020); Muller et al. (2018); Pillai et al. (2020); Wang (2016)
Additive manufacturing (3D printing)	<i>“A technology that produces physical objects from 3D digital representations by depositing successive layers of material. It enables faster, less costly development of prototypes and customized products.”</i>	Berman (2012); Sodhi et Tang (2017); Dong et al. (2018)
Advanced Robots	<i>“Robots improved through advances in communication, sensors, and AI, able to work side by side with humans in complete safety, automating complex tasks.”</i>	(Strauss et al., 2022)
Drones	<i>“These unmanned aerial vehicles are used for tasks such as surveillance, delivery and inspection, improving logistics and operational processes.”</i>	(Strauss et al., 2022)
Internet of Things (IoT)	<i>“A network of devices connected via the Internet, enabling remote communication and control, thus improving operational efficiency. IoT adoption has increased significantly due to falling sensor costs and technological advances.”</i>	(Strauss et al., 2022)
Blockchain	<i>“Distributed, secure registry enabling data to be stored and accessed in a decentralized way. Despite its limitations, blockchain holds great promise for transforming supply chain operations.”</i>	Olsen et Tomlin (2019); Babich et Hilary (2019); Wang et al. (2019)
Artificial Intelligence (AI)	<i>“AI mimics human intelligence through the use of algorithms to interpret data, learn, and perform complex tasks such as predictive analysis. Examples: IBM Watson, GE Predix Cloud.”</i>	(Strauss et al., 2022)

Source: By the authors.

Data sources and analysis methods

Data analysis

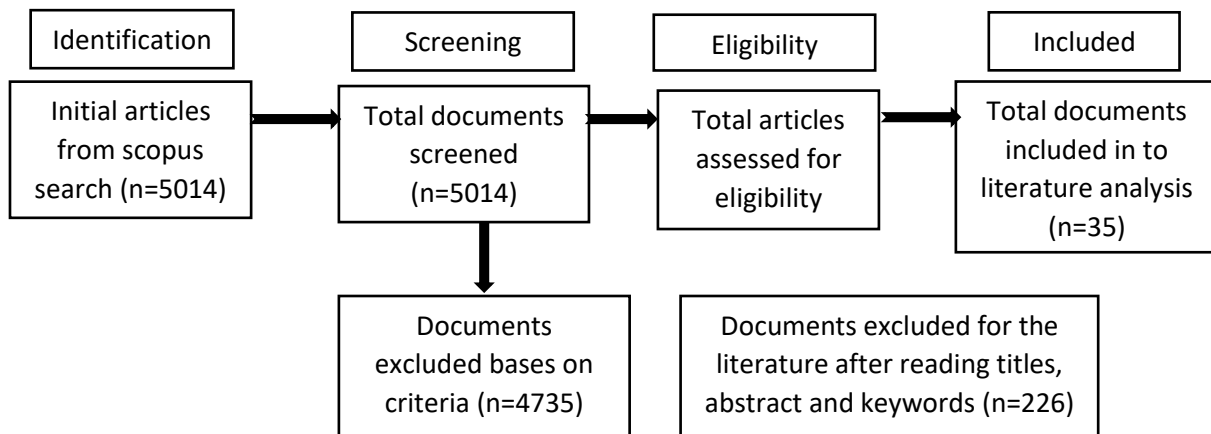
This study conducted a systematic and rigorous bibliometric analysis based on publications from the Scopus database, recognized for its wide academic coverage and peer-reviewed quality. The focus was on Artificial Intelligence and Industry 4.0, two key drivers of transformation in industrial practices and supply chain management.

Following the PRISMA methodology, a comprehensive search was carried out on July 1, 2024, using relevant keywords in titles, abstracts, and keywords, yielding 12,384 documents from 2018 to July 2024. The selection was narrowed to 261 peer-reviewed journal articles, limited to disciplines such as engineering, management sciences, and computer science.

To support the literature review, the study selected the 35 most cited articles (ranging from 421 to 70 citations), published in leading journals such as *Technological Forecasting and Social Change*, *International Journal of Information Management*, *Journal of Business Research*, *Journal of Cleaner Production*, and *Production and Operations Management*, among others. The selection emphasized publications in business, management, engineering, and computer science, ensuring relevance and impact.

This robust methodological approach ensures the reliability and validity of findings related to research trends, disciplinary distribution, and international collaborations in the field of AI and Industry 4.0.

Figure 1: Prisma diagram.



Source: by the authors

Data sources

To perform the bibliometric analysis, metadata from 261 Scopus-indexed articles were extracted and cleaned to remove duplicates and correct inconsistencies in author names and affiliations. Descriptive statistics were used to address the first research question, focusing on the evolution of scientific output related to Artificial Intelligence and Industry 4.0. This included an analysis of publication growth and topic diversity using Scopus tools.

The second and third research questions were explored through author co-citation and document citation analyses using VOSviewer (version 1.6.19). Citation analysis helped identify the most

influential articles, while co-citation analysis revealed the key conceptual frameworks in the field. By measuring how often authors were cited or co-cited together, the study highlighted intellectual connections and central figures in the literature.

Keyword analysis was another critical step, aiming to identify the main themes and emerging trends. Relevant keywords were selected and used to retrieve the documents from Scopus. Their frequency and co-occurrence were then analyzed in VOSviewer to detect dominant concepts and research clusters in the AI and Industry 4.0 domains.

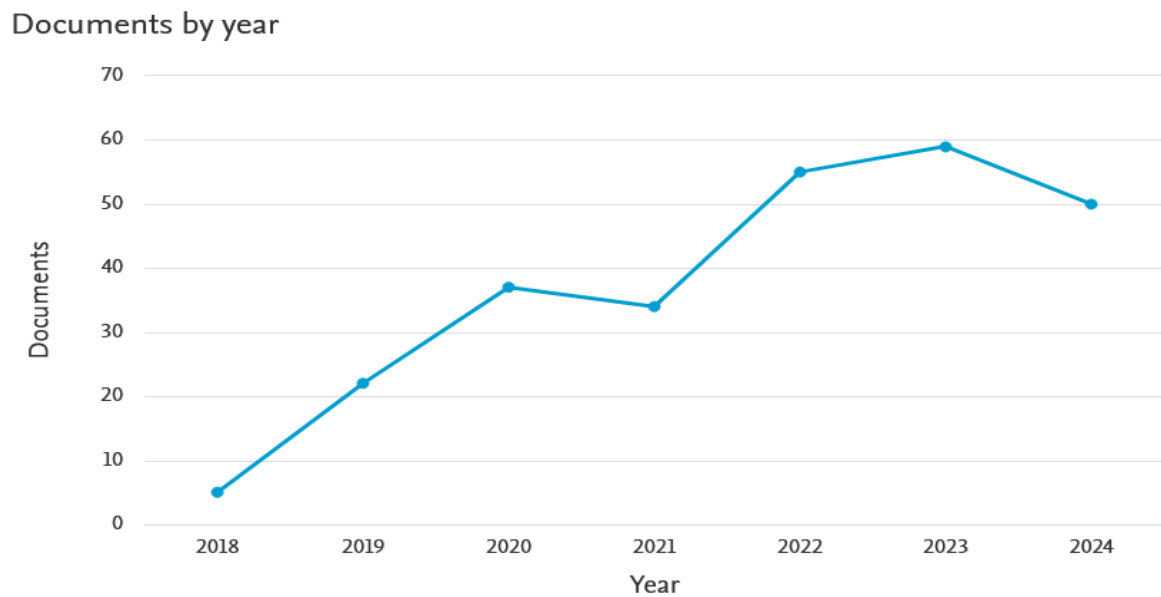
This structured approach enabled the identification of impactful publications, influential authors, and thematic trends, offering a comprehensive overview of the intellectual landscape within the field.

Bibliometric analysis results

Analysis of the evolution of scientific publications on AI and Industry 4.0

The evolution of the number of publications on AI and Industry 4.0 between 2018 and 2024 reveals some notable and significant trends in the research field. First, there is notable growth in the number of publications between 2018 and 2020, illustrating the emergence and rapid adoption of these concepts. In 2018, only 5 publications were listed, indicating a still emerging academic interest. However, by 2019, the number of publications quadrupled, reaching 22 papers, and continued to grow in 2020 with 37 publications. This period of initial growth shows that researchers were beginning to actively explore these new fields, integrating AI and Industry 4.0 into their work. A phase of stabilization then occurs between 2020 and 2021, when the number of publications reaches 37 and 34 respectively. This slight decrease could signal a phase of research consolidation, with studies becoming more in-depth and critical. The following period, between 2022 and 2023, marks a peak in publications, with 55 documents in 2022 and 59 in 2023, reflecting the growing maturity of technologies and their massive integration into academic and industrial discussions. This peak also underlines the growing importance of these themes in contemporary research, with an emphasis on empirical studies and concrete applications. Finally, a modest decline to 50 publications in 2024 could indicate a readjustment of research priorities or partial saturation of the field, suggesting a possible reorientation towards new research questions or other emerging topics. This overall trend testifies to the sustained interest and fluctuating dynamics of AI and Industry 4.0 research, with a potential turning point observed from 2024 onwards.

Figure 2: Evolution of Publication Activity on AI and Industry 4.0: Trend Analysis from 2018 to 2024



Source: Scopus database.

Several authors have distinguished themselves as major contributors to the field of artificial intelligence (AI) and Industry 4.0. Researchers such as Yogesh K. Dwivedi, Shivam Gupta, Surya Prakash Singh, and Mohd Javaid occupy a prominent place in this research. Their influence is particularly marked, as their work is frequently cited and co-cited, reflecting the importance of their contributions to the development of these subjects.

These researchers are associated with renowned academic and research institutions such as Swansea University, Jamia Millia Islamia University, and the Indian Institute of Technology Delhi. These institutions stand out for their significant academic output in the fields of AI and Industry 4.0, underlining the importance of international collaborations to advance research in these expanding fields.

To ensure accurate identification of authors in the database, the authors Scopus identifiers were used. In addition, the h-index of each author was taken into account to measure the productivity and citation impact of published articles. Table 2 presents this information to provide a clear overview of the contributions of the most influential authors in this field.

The main research topics identified in the 35 publications analyzed include Industry 4.0:

- Industry 4.0: Development and integration of smart manufacturing technologies, optimization of industrial processes, and adoption of cyber-physical systems.
- Artificial Intelligence: Machine learning, deep learning algorithms, and automation of decision-making processes.
- Digital Transformation: Impact of new technologies on business models, innovation in supply chain management, and adapting companies to the digital age.

Emerging topics such as the Internet of Things (IoT), Blockchain, and sustainability in relation to Industry 4.0, illustrate the growing impact of advanced technologies and environmental concerns on industrial and business practices.

The journals Technological Forecasting and Social Change and International Journal of Production Research stand out, having published around 14% of the articles identified. This is not surprising, given that these journals are frequently chosen by interdisciplinary researchers to disseminate their work on AI, Industry 4.0, and digital transformation. Figure 2 shows the 10 most influential journals publishing articles on these themes, according to our search criteria.

Table 2: The top 10 journals.

Rank	Review	Percentage of articles
1	Technological Forecasting and Social Change	8 %
2	International Journal of Production Research	6 %
3	Journal of Cleaner Production	5 %
4	Journal of Business Research	4 %
5	IEEE Engineering Management Review	4 %
6	Journal of Industrial Integration and Management	3 %
7	Journal of Business Ethics	3 %
8	Production Planning and Control	2 %
9	Sustainability	2 %
10	Journal of Manufacturing Technology Management	2 %

Source: by the authors.

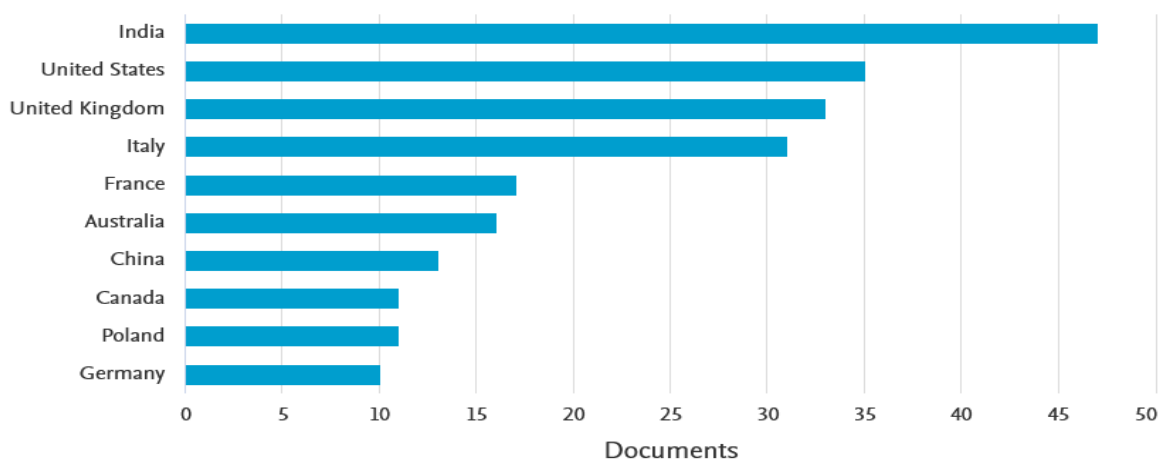
Analysis of publication activity shows a notable increase in research on AI and Industry 4.0, with a peak in 2023. The key authors and institutions identified play a crucial role in advancing research, while emerging themes and new technologies continue to reshape the field, offering numerous prospects for future research and practical applications. This analysis provides a comprehensive overview of publication activity, highlighting trends, main topics, and significant contributions in the field of AI and Industry 4.0.

Distribution of the literature

Figure 3: Geographic distribution

Documents by country or territory

Compare the document counts for up to 15 countries/territories.



Source: Scopus database.

The chart shows a global spread of research on AI and Industry 4.0, led by India (47 publications), followed by the U.S. (44) and the U.K. (36). Italy (32), France and Australia (24–

25) also show strong engagement. China contributes 18 papers, possibly reflecting a greater focus on applied research. Canada, Poland, and Germany (10–15 each) demonstrate moderate involvement. These results highlight the strategic importance of AI and Industry 4.0 across diverse national contexts. Countries with strong academic and technological infrastructures lead in publications, reflecting growing international interest in digital industrial transformation and innovation.

High-impact literature on the interconnections between artificial intelligence, industry 4.0 and digital transformation

Bibliometric analysis of papers, authors, and journals highlights major contributions in the fields of artificial intelligence (AI), industry 4.0, and digital transformation. Significant works, such as those by Dwivedi (2020), Gupta (2021), Javaid (2019), and Singh (2022), stand out for their influence on the understanding and application of AI technologies in industrial processes and supply chains. These studies are frequently cited, underlining their central role in the evolution of these fields.

Researchers such as Yogesh K. Dwivedi, Shivam Gupta, Surya Prakash Singh, and Mohd Javaid stand out for the number of citations and publications, reflecting their vital contribution to AI and Industry 4.0 research. These authors are mainly affiliated with recognized academic institutions, including Swansea University, Jamia Millia Islamia University, and the Indian Institute of Technology Delhi. These institutions play a crucial role in academic production, highlighting the importance of international collaborations for progress in these rapidly expanding fields.

Table 2 shows the most cited authors, their number of publications, and the total strength of their links in the citation network, providing an overview of the most influential contributors in this field.

Table 3: Top 10 authors.

Authors	Documents	Citations	Total Link Strength
Dwivedi, Yogesh K.	3	761	6
Gupta, Shivam	4	627	0
Singh, Surya Prakash	3	532	2
Haleem, Abid	4	460	21
Javaid, Mohd	4	460	21
Chiarini, Andrea	5	287	5
Bag, Surajit	2	473	0
Rana, Nripendra P.	2	340	6
Chatterjee, Sheshadri	3	253	0
Suman, Rajiv	2	219	11

Source: by the authors.

The analysis of co-citations highlights the most influential sources in the field of AI and Industry 4.0, with several clusters of key themes standing out. Among these, sustainable production and operations management come out on top, dominated by journals such as Journal of Cleaner Production and International Journal of Production Economics, which highlight the integration of sustainable practices into modern industrial processes. Another notable theme concerns renewable energies and scientometric evaluation, explored by publications like Energies and Scientometrics, which examine the intersections between technological

innovations for energy efficiency and their societal implications. Furthermore, the impact of technology on business strategies is highlighted by sources such as the Journal of Business Research and the Journal of International Business Studies, which focus on the influence of new technologies on corporate competitiveness in a globalized context.

Table 3 illustrates these influential sources according to their number of citations and total link strength, demonstrating their importance in the evolution of knowledge about AI and Industry 4.0.

Table 4: Top 10 publications identified by Scopus between 2018 and July 2024

Source	Citations	Total Link Strength
International Journal of Production Research	371	23,044
Production Planning & Control	104	6,518
Annals of Operations Research	36	2,611
Sustainability	211	10,792
Technovation	38	2,443
The International Journal of Logistics Management	29	2,085
The Sage Handbook of Organizational Research Methods	41	2,111
Tourism Management	22	1,203
Transforming Government: People, Process and Policy	14	1,278
Waste Management	8	584

Source: by the authors.

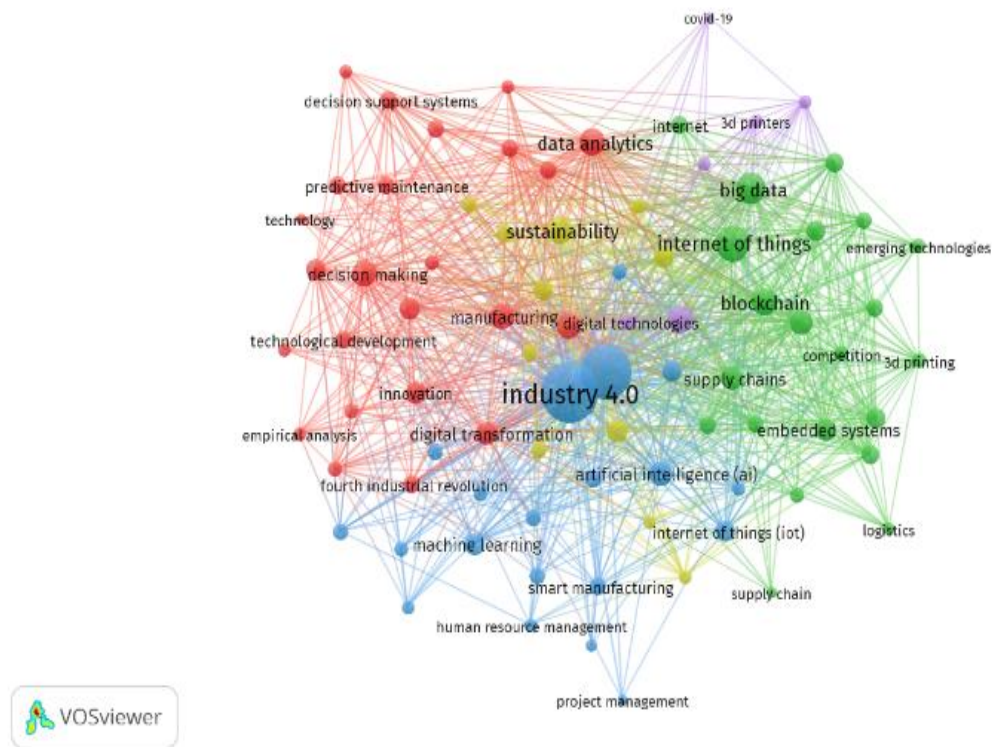
These sources represent the most influential contributions in the field, based on their number of citations and total link strength, highlighting their central role in advancing AI and Industry 4.0 research.

By recognizing the importance of these contributions and the research clusters identified, researchers can better direct their future work towards emerging themes and fill existing gaps, contributing to the ongoing evolution of knowledge and practice in this rapidly expanding field.

Keyword analysis

An analysis of the keywords associated with publications on artificial intelligence (AI) and industry 4.0 reveals a complex, interconnected network, with “Industry 4.0” playing a central role. This keyword is the pivotal node of the network, underlining its importance as an integrating concept in academic research. The network is divided into several distinct but interconnected clusters, each representing specific themes. The red cluster highlights the importance of data analysis, decision-making, and technology development, illustrating how Industry 4.0 leverages these elements to drive innovation. The green cluster focuses on emerging technologies such as the Internet of Things (IoT), Big Data, and Blockchain, highlighting their crucial role in supply chain management. The blue cluster focuses on artificial intelligence, machine learning, and digital transformation, showing how these technologies are redefining industrial processes and human resource management. The yellow cluster highlights the growing importance of sustainability in Industry 4.0, linked to environmentally-aware industrial practices. The interconnections between these clusters demonstrate that these thematic areas are closely linked, creating a research ecosystem where technological innovations, environmental challenges, and digital transformation meet to shape the future of industry. This bibliometric network illustrates the multidisciplinary and integrated nature of Industry 4.0 research, with artificial intelligence as a catalyst for change across different sectors.

Figure 4: Bibliometric map of Artificial intelligence and Industry 4.0



Source: VOSViewer.

Table 5: the different clusters found

Clusters	Cluster keywords
Red Cluster: Industry 4.0 & AI	Data Analysis, Decision Making, Innovation, Technology Development
Green Cluster: Internet of Things & Blockchain	Internet of Things, Blockchain, Big Data, Supply chains
Blue Cluster: Artificial Intelligence & Machine Learning	Artificial Intelligence, Machine Learning, Digital Transformation, Human Resources Management
Yellow cluster: Sustainability & digital transformation	Artificial Intelligence (AI), Machine Learning, Smart Manufacturing, Human Resource Management

Source: By the authors.

Discussion

Industry 4.0 and AI: towards sustainable and proactive optimization of industrial processes

The integration of the Internet of Things (IoT) and Blockchain into supply chain systems under Industry 4.0 has revolutionized the management of material, financial, and information flows. These technologies enhance transparency, traceability, and resource efficiency, aligning supply chains with increasing demands for sustainability and operational performance.

IoT enables real-time data exchange between interconnected physical devices, allowing firms to monitor processes, enhance predictive maintenance, and reduce downtime (Gilchrist, 2016;

Weyer et al., 2015). Smart sensors embedded in production systems automate routine tasks and optimize resource use, significantly cutting operational costs (Shrouf et al., 2014; Lin et al., 2016).

Blockchain, as a decentralized and secure ledger, strengthens data integrity and trust among supply chain partners (Wang et al., 2019; Olsen & Tomlin, 2019). It facilitates end-to-end product traceability, helping companies meet regulatory and sustainability standards.

The adoption of these technologies can be framed through multiple theoretical lenses. Institutional Theory (Meyer & Rowan, 1977) highlights how external pressures drive organizations to adopt innovations like IoT and Blockchain. Organizational Resilience Theory (Ambulkar et al., 2015) shows how these tools help firms adapt to disruptions and maintain continuity. Elkington's Triple Bottom Line (1997) supports the environmental, social, and economic benefits of these innovations. Finally, Rogers' Diffusion of Innovation Theory (1983) explains how these technologies spread from early adopters to mainstream usage.

In conclusion, the contributions of Chiarini (2021), Zeba et al. (2021), Gupta et al. (2021), and Xu et al. (2018) show that the integration of AI and Industry 4.0 technologies into decision support systems, data analytics, and predictive maintenance is key to transforming industrial practices. These innovations enable informed, proactive and sustainable decision-making, essential for remaining competitive in today's industrial environment.

Internet of things and block chain: what impact for optimized supply chain management?

The integration of the Internet of Things (IoT) and Blockchain technologies under Industry 4.0 has reshaped how companies manage material, information, and financial flows. These innovations enhance transparency, traceability, and resource efficiency, supporting both sustainability and operational effectiveness.

IoT allows real-time data exchange between interconnected devices, enabling continuous process monitoring, predictive maintenance, and reduced downtime (Gilchrist, 2016; Weyer et al., 2015). Smart sensors in production systems, as shown by Shrouf et al. (2014) and Lin et al. (2016), contribute to cost reduction by automating tasks and optimizing resource use.

Blockchain technology, as highlighted by Wang et al. (2019) and Olsen & Tomlin (2019), ensures secure and tamper-proof data sharing across supply chains. It fosters trust among stakeholders and enables full traceability from raw materials to end products, aiding compliance with sustainability regulations.

The adoption of these technologies is explained by several theoretical frameworks:

- Institutional Theory (Meyer & Rowan, 1977): Companies respond to external pressures by adopting IoT and Blockchain to meet regulatory and consumer expectations.
- Organizational Resilience Theory (Ambulkar et al., 2015): These tools help firms detect and respond to disruptions in supply chains.
- Triple Bottom Line Model (Elkington, 1997): IoT and Blockchain support environmental, social, and economic performance through waste reduction, energy efficiency, and product traceability.
- Diffusion of Innovation Theory (Rogers, 1983): Adoption typically starts with leading firms and spreads gradually across industries.

In conclusion, the combination of IoT and Blockchain in supply chains, supported by institutional, organizational resilience, Triple Bottom Line, and diffusion of innovation theories, provides an integrated framework for more agile, responsive and sustainable operations management. These technologies are essential for driving innovation and sustainability within global supply chains, responding to fluctuating customer demands and growing pressures for responsible and ethical management.

Artificial Intelligence and machine learning: catalysts for industrial transformation in Industry 4.0

In the context of Industry 4.0, the integration of Artificial Intelligence (AI) and Machine Learning has become a cornerstone of industrial transformation. These technologies enhance productivity, enable real-time decision-making, and bring unprecedented flexibility to manufacturing systems.

Machine Learning, a core component of AI, supports Smart Manufacturing by processing vast volumes of real-time data from connected systems. It optimizes operations and reduces human error, offering adaptive and responsive production processes (Zhong et al., 2017). Deep learning further improves equipment failure prediction, minimizing downtime and boosting efficiency (Swathi et al., 2019).

AI-driven automation enhances decision-making by adjusting production parameters in real time, improving product quality while lowering costs (Zheng et al., 2018). It also plays a key role in supply chain optimization by forecasting demand fluctuations and improving resource allocation.

However, the rise of AI also challenges human resource management. Increased automation requires workforce reskilling to align with evolving job roles. Companies must invest in digital skills training to leverage AI effectively and mitigate risks of job displacement (Bughin et al., 2019). HR strategies must integrate continuous learning and change management to support this transition.

AI also enables mass customization without compromising efficiency, helping firms meet diverse customer demands. Its flexibility allows rapid adaptation to market changes while maintaining performance standards (Mao et al., 2019).

In conclusion, artificial intelligence and machine learning are essential catalysts for industrial transformation within the framework of Industry 4.0. They optimize production processes, strengthen human resource management, and improve productivity as well as the flexibility of industrial systems. Contributions from researchers such as Zhong et al. (2017), Zheng et al. (2018), and Bughin et al. (2019) highlight the importance of these technologies in maintaining business competitiveness in an increasingly automated and data-driven industrial environment.

Sustainability and digital transformation

In the Industry 4.0 era, sustainability has become a central objective, supported by digital transformation and advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and additive manufacturing. These tools not only enhance operational performance but also drive more eco-responsible industrial practices (Tiwari & Khan, 2020).

Industry 4.0 supports the circular economy by promoting efficient resource use and minimizing waste and emissions (Laskurain-Iturbe et al., 2021). Core principles like reuse, recycling, and material reduction (Vermeulen et al., 2014; Rli, 2015) are actively enabled by technologies such as AI and additive manufacturing, which reduce material consumption and increase energy efficiency (Mellor et al., 2014; Peukert et al., 2015).

Smarter and greener practices emerge through digital transformation (Ghobakhloo, 2018). The ReSOLVE framework (Ellen MacArthur Foundation, 2015) emphasizes optimization, regeneration, and virtualization for sustainability. Cyber-physical systems (CPS) and AI support real-time tracking and lifecycle management, reducing emissions and environmental impact (Xu et al., 2018).

Additional technologies such as Big Data, IoT, and robotics contribute to sustainability via predictive maintenance, environmental monitoring, and production optimization (Rüßmann et al., 2015; Shrouf et al., 2014; Caggiano, 2018).

Concluding remarks

The integration of Artificial Intelligence (AI) and Industry 4.0 technologies into industrial decision-making, data analytics, and predictive maintenance marks a major shift in process optimization. These innovations enable real-time decisions, enhance efficiency, and promote sustainable practices, reshaping industrial competitiveness.

This bibliometric study, based on Scopus-indexed publications, reveals a consistent rise in research on AI and Industry 4.0, peaking in 2023. Key contributors such as Yogesh K. Dwivedi, Shivam Gupta, Surya Prakash Singh, and Mohd Javaid have had significant influence, with highly cited work advancing the field. Their roles underscore the importance of international and interdisciplinary research collaborations.

The analysis identified dominant themes including smart manufacturing, AI-driven process optimization, and the deployment of cyber-physical systems. Emerging areas like IoT, Blockchain, and sustainability highlight a shift toward more responsible and future-oriented industrial models.

Co-citation and keyword analyses illustrated the interconnection of technological innovation, digital transformation, and environmental concerns, revealing how these factors collectively shape industrial evolution. Influential journals such as *Technological Forecasting and Social Change* and the *International Journal of Production Research* play a leading role in disseminating impactful research.

This study emphasizes the growing relevance of AI and Industry 4.0 in academic and industrial contexts. To meet future economic and environmental challenges, further research should focus on the evolving themes identified, bridging current gaps and supporting sustainable, tech-driven industrial transformation.

Limitations

Firstly, this bibliometric review focuses primarily on analyzing the general characteristics and trends of academic literature concerning artificial intelligence (AI) and Industry 4.0, rather than

detailed findings from specific studies. Although our study has identified theoretical patterns and interconnections in these fields, it relies primarily on inferences drawn from co-citation analyses and bibliographic data from the Scopus database. These results may thus provide a starting point for future research employing more detailed review methods to explore specific study findings in depth.

Secondly, relying only on Scopus as a data source may be perceived as a limitation, as other relevant articles on AI and Industry 4.0 could be listed in other databases such as Web of Science, Google Scholar, or other academic platforms. Consequently, the findings of this analysis may not cover all the available literature, which could reduce the scope and representativeness of the results. To obtain a more comprehensive view, it would be beneficial to include data from multiple databases in future research.

Research opportunities

This bibliometric study uncovers several promising research avenues to further explore the complex relationship between Artificial Intelligence (AI), Industry 4.0, and digital transformation.

1. **Advanced AI Applications:** While AI's role in Industry 4.0 is widely acknowledged, the specific ways it enhances efficiency and optimizes processes warrant deeper investigation. Future research could focus on empirical studies related to AI's influence on real-time decision-making, predictive maintenance, and product customization.
2. **Sectoral and Regional Comparisons:** Although geographic diversity in publications is evident, the sectoral and regional variations in AI and Industry 4.0 adoption remain underexplored. Comparative studies across industries and emerging economies could offer insights into context-specific technological models.
3. **Sustainability and Digital Technologies:** The integration of IoT, Blockchain, and other advanced technologies presents opportunities to study their role in fostering sustainable practices—such as waste reduction, emissions control, and enhanced supply chain traceability.
4. **Crisis Resilience in Industrial Systems:** The COVID-19 pandemic exposed the importance of resilient operations. Future studies could investigate how digital technologies support organizational agility and resilience in times of disruption, as well as the lessons learned for future crisis preparedness.
5. **Ethics and Governance:** Aligning Industry 4.0 innovations with ethical standards and responsible governance is a growing concern. Research is needed to explore how organizations can integrate ethical considerations without compromising performance and innovation.
6. **Long-Term Impact of Technologies:** Longitudinal studies are essential to assess the sustained effects of AI and digital transformation on industrial performance. Such research would help identify effective, long-term strategies in a continuously evolving technological landscape.

These research opportunities offer promising avenues for deepening understanding of the complex relationships between AI, Industry 4.0, and digital transformation, while improving industrial and organizational practices in a constantly changing environment.

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THE ROLE OF THE DIGITAL AGE AND ARTIFICIAL INTELLIGENCE IN SHAPING DIGITAL CORPORATE CULTURE

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Abstract

The era of digital technologies and artificial intelligence (AI) is fundamentally impacting the business environment and shaping the ways in which companies build and maintain their corporate culture. The rapid development of digital technologies and their implementation in business processes pose new challenges to the way we manage, adapt employees and maintain corporate values. Despite the ever-growing awareness of the issues under study, there is a lack of comprehensive analyses examining the impact of AI on the business environment. The aim of this paper is to explore, through a systematic literature search, what role does the digital age play in building corporate culture and to answer the research question, "What role does the digital age play in building corporate culture?" The study focuses on two research areas (1) the role of artificial intelligence in modern corporate culture, where we analyze the impact on decision-making processes and employee adaptation, and (2) the transformation of corporate culture under the influence of digital technologies, where we investigate the impact of online tools, hybrid working and digital collaboration on corporate culture change. Our findings show that the digital age brings advantages in efficiency and flexibility at work, but also creates new challenges in the areas of corporate identity, communication and employee adaptation. The contribution of the study is the identification of the main directions for the development of corporate culture in the digital age and recommendations for companies that want to create a cohesive corporate culture in an environment of constant technological development.

Keywords: corporate culture, digital age, digital technologies, artificial intelligence, work environment

JEL Classification: M14, O31, O33

Introduction

Digital technologies and artificial intelligence are moving the world. They are becoming part of business processes and fundamentally impacting the way businesses around the world operate. Several studies such as Isensee et al. 2022 or Leal-Rodríguez et al. 2023 have already addressed the impact that digitalization has on the enterprise, but a specific examination of the link between artificial intelligence and corporate culture is absent. The present study therefore seeks to bridge this research gap and provide a systematic review of current knowledge in the

area under investigation. We analyze available data and draw on scholarly sources indexed in databases such as Scopus and WoS. The main objective of our study is therefore to answer the research question posed: *"What is the role of the digital age in building corporate culture?"* How quickly companies can adapt to the everyday use of digital technologies and AI becomes a key factor in building their competitiveness. Therefore, the importance of this study lies mainly in bringing the issue not only to the academic environment but also to the practical environment from a management perspective. The results may provide interesting insights for managers and practitioners in the field of corporate culture and digital transformation.

A significant proportion of the human population spends most of their lives working in companies. Cr  mer (1993, p.354) defined corporate culture as "the part of the stock of knowledge that is shared by a substantial proportion of the firm's employees but not by the general population". Corporate culture is an essential element of building successful companies, with many studies suggesting that there are differences in cultural values between leading and less successful companies (Gorton et al., 2022). Flamholtz & Randle (2011) highlight that corporate culture has an admittedly tacit but profound effect on employees. Corporate culture is based on values and norms, thus guiding employee behaviour in different work and life situations. A well-adjusted corporate culture promotes just the kind of individual behaviour that is necessary for the achievement of corporate goals (Graham et al., 2022). A firmly grasped corporate culture can be a more important element than formal management mechanisms in certain situations. As Whitesell said, "You can have all the right strategies in the world, but if you don't have the right culture, you're dead" (Zaman, 2024). Corporate culture reduces the need for constant managerial scrutiny, eliminates short-term approaches, and promotes effective internal communication and performance in companies (Zaman, 2024).

Corporate culture in the age of digital technologies and artificial intelligence

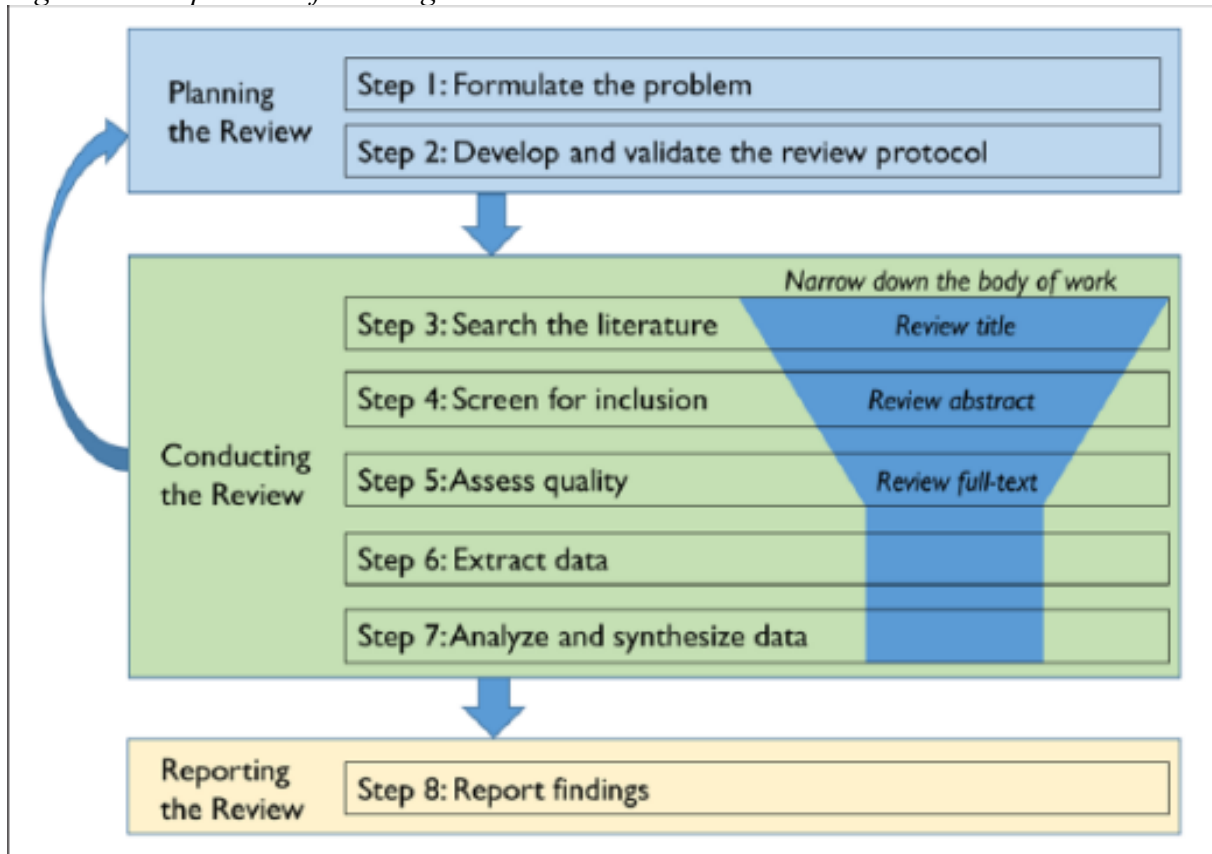
The contemporary world is a dynamic place to live. Information and communication technologies are fundamentally changing the way we function. Digital technologies have become an integral part of everyday life, creating a global virtual cyberspace (Levin & Mamlok, 2021). Digital transformation is changing the times. It is changing traditional business models and processes, as well as affecting all other spheres of society (Plekhanov et al., 2023). The COVID-19 pandemic and Industry 4.0 have only accelerated this coming revolution, yet many companies are currently underperforming due to a mismatch between their corporate culture and working with digital technologies and AI (Leal-Rodr  guez et al., 2023). Digitalisation is promoting sustainability and transparency in companies, supply chains and is a key element for responsible sourcing (Dreichuk & Sytnyk, 2024). Similarly, artificial intelligence has become part of the digital everyday and digital systems, supporting the change of business models (Isensee et al., 2022). However, for its successful adoption and integration into corporate values and culture, a positive employee attitude towards technology is required. Organizations with a positive attitude towards today's technological innovations are able to implement them much faster and more effectively (Akyazi, 2023).

Methodology

This study follows the systematic literature review process adopted by Xiao & Watson, (2017). The systematic literature review process is illustrated in the following figure. In the content analysis, we systematically extracted and categorized key insights from the selected literature. We then categorized the data according to two identified key research areas (1) *the role of AI*

in modern corporate culture, and (2) the transformation of corporate culture under the influence of digital technologies. The keywords used to search for relevant sources were “corporate culture“, „digital technology“, „artificial intelligence“ and „digital transformation“. Through the literature sources analysed and their arrangement through the tables created, the "conclusion" section sought to answer the stated research question „What role does the digital age play in building corporate culture“?

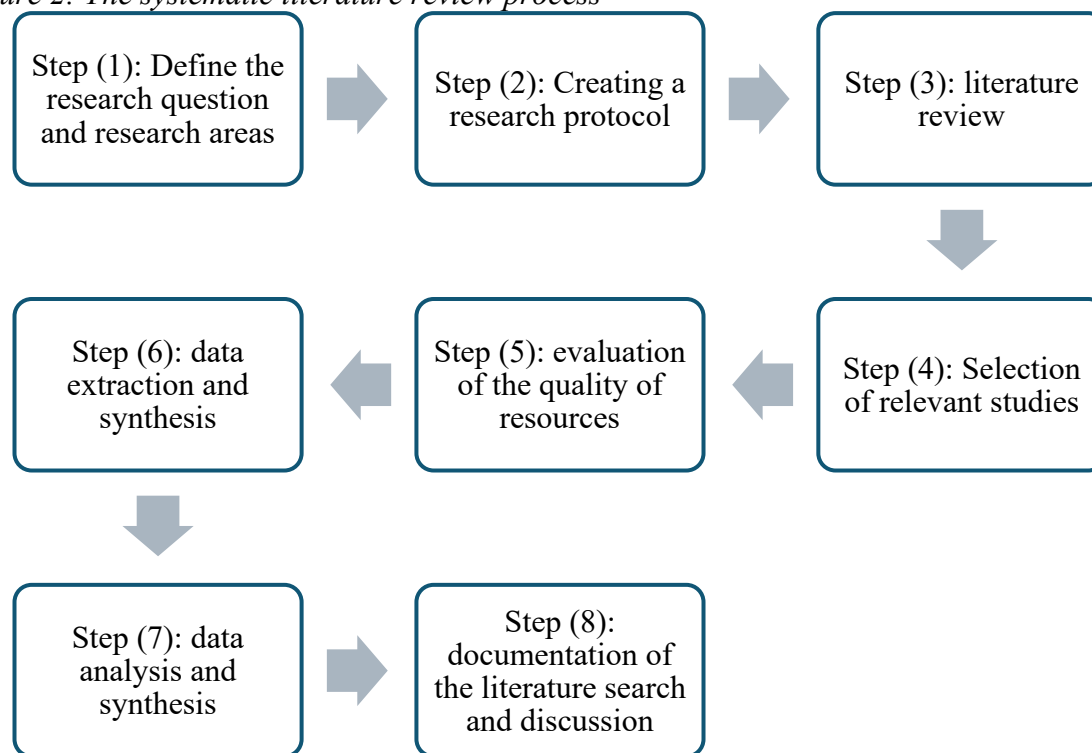
Figure 1: The process of creating a literature search



Source: Xiao & Watson (2017)

To visualize the methodological procedure, we have summarized the steps into key concepts and presented them in the diagram below.

Figure 2: The systematic literature review process

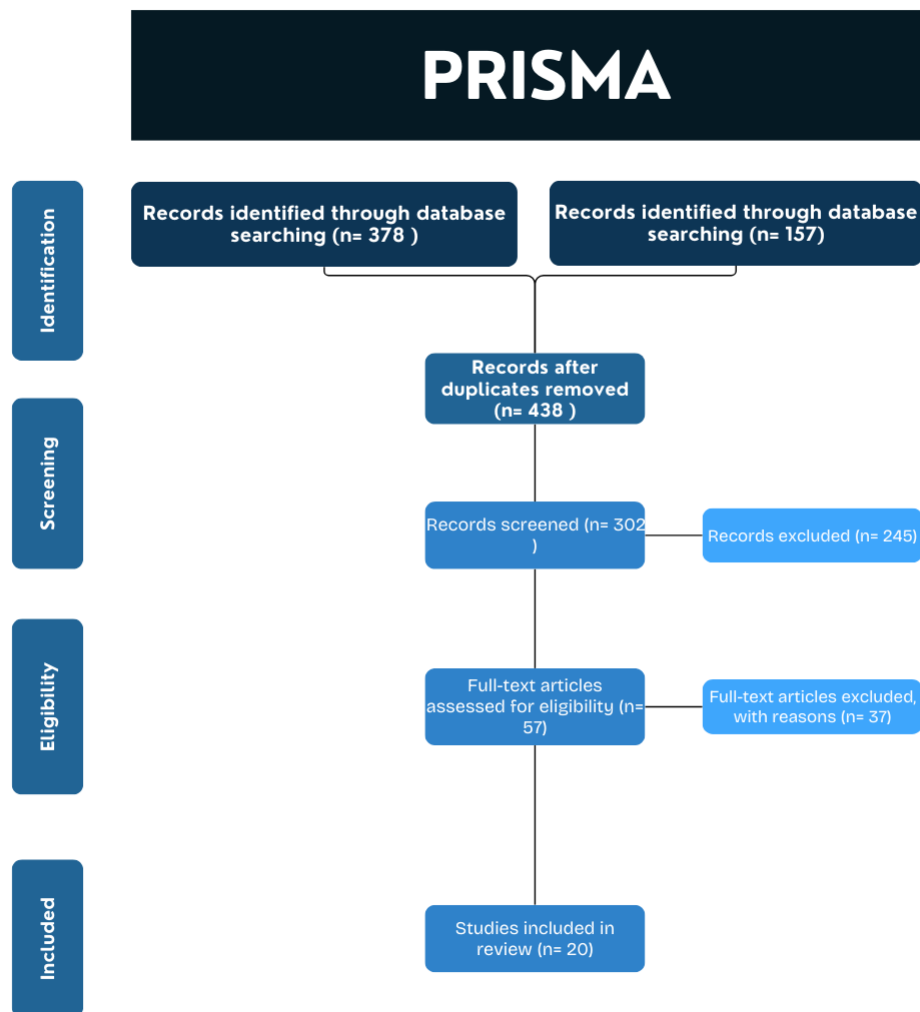


Source: own elaboration

The first stage of the research process was to develop the research question and then map the areas of investigation so that the direction of the research could be determined. This step allowed us to gain a critical perspective on hundreds of potential scholarly sources, and we also established boundaries for the inclusion or exclusion of particular publications. The creation of a research protocol provided us with empirical direction to minimize bias in the selection and analysis of sources. The systematic literature review was based on searches of the electronic databases WoS, SCOPUS, Google scholar, as well as backward and forward referencing. The relevance of the articles was assessed on predetermined inclusion criteria such as keyword use, language and date of publication. Once a preliminary list of articles was generated, a two-stage selection process followed with a review of the abstracts of each source followed by a review of the full content of the literature sources to eliminate publications that were not sufficiently relevant to our research. The final sample of the systematic literature review for publication needed to ensure that gaps in the existing research process were noted and presented as opportunities for future research direction. The formal outline presents the findings through tables within each section of the research. The review of the quality of the sources ensured, on the one hand, a diverse but, on the other hand, sufficiently homogeneous selection of the research from which the data were drawn. The repeatability of the data ensured that any subsequent external researcher who could potentially repeat the study in the future would be familiar with similar findings and conclusion of the study. After analysis, the findings were compiled into a formal outline to ensure cohesion and were exclusively shared with the study research team based on in-text analysis.

The procedure according to the modified PRISMA methodology for the exclusion and inclusion of relevant literature is illustrated in the figure below.

Figure 3: Exclusion and inclusion of resources



Source: own elaboration, according to: López-Sánchez et al. (2023)

Research results

The following tables provide an overview of the sources and relevant literature related to two chosen areas of investigation (1) *the role of artificial intelligence in modern corporate culture*, and (2) *transformation of corporate culture under the influence of digital technologies*. The tables are divided separately and respond separately to the issues under investigation. From the key information for each area, we have created a discussion and output of our paper.

Table 1: Review of the research results first study area

Author, author's collective	The role of artificial intelligence in modern corporate culture
Al Samman, 2024	Data-driven approach, analytical and objective decision making, chatbots and analytical tools, team dynamics, innovation
Jumani et al., 2021	Automation, predictive analytics, customer interaction, improving performance, replacing jobs, changing work dynamics, relationships and decision making, maintaining competitive advantage

Author, author's collective	The role of artificial intelligence in modern corporate culture
Rane et al., 2024	Analysis of large data sets, trend forecasting, process automation, environmental thinking, change in decision-making processes, sustainable practices
Isensee et al., 2021	Sustainable corporate culture
Randive & Nalkar, 2024	Process automation, optimisation and innovation in communication (content, form, applications), personalisation of communication, intelligent response systems, efficiency
Maddula, 2018	Data-driven decision-making, adaptability, decentralised and agile leadership, trend prediction and process optimisation, open communication, transparency, long-term sustainability
Srikanth et al., 2024	Changing traditional hierarchical leadership, data-driven decision making, collaboration, inclusion, automation, adaptation to new technological challenges
Chourasia et al., 2024	Changing values, norms, behaviours, promoting flexibility and agility, optimising processes, automation, supporting learning in innovative technologies
Rajagopal et al., 2022	Strategic decision making - influencing the business environment, accuracy, change in decision making processes and management models, stimulating innovation in products and services, ethical issues - transparency, accountability, AI as a competitive advantage
Diab & El Hajj, 2024	Ethics - barrier to AI implementation, prediction, financial analysis, effective communication

Source: own processing

Artificial intelligence and humans work in harmony with each other wherever possible, fostering a creative and collaborative company culture. Rather than being seen as a threat to job cuts, AI is seen as a tool for developing human capabilities. In such an environment, individuals are open to working with artificial intelligence, creative solutions and new technologies brought about by the digital age (Al Samman, 2024). Artificial intelligence is changing the values and decision-making processes in companies through the implementation of data-driven approach, thus promoting objectivity in decision-making situations. It is a symbol of innovation. It influences the work habits of employees and improves collaboration between technology and people. Through machine learning, language processing and automation, it improves predictive modelling and optimises business processes. It increases transparency and accountability, helping to address environmental and social challenges to promote long-term growth (Rane et al., 2024). It also plays an important role in developing a sustainable corporate culture in terms of influencing values, communication and corporate governance. In addition to providing a multitude of innovations, it helps businesses move towards sustainable development by enabling them to respond flexibly to different challenges (Isensee et al., 2021). Artificial intelligence is changing corporate culture through a data-driven approach in decision making, innovation and collaboration. It is replacing traditional leadership with agile, but it also brings ethical issues such as algorithm bias and transparency. The principle of symmetric culture ensures a trusting and inclusive environment in society as it emphasizes the values of fairness and accountability in integrating AI into society. The automation of routine tasks allows employees to focus on creative work, while open communication minimizes fears of losing their jobs (Maddula, 2018). Artificial intelligence promotes decentralized management and empowers employee autonomy. Traditional management models are being replaced by agile ones, in which AI supports data-driven decision-making at all levels of organizational leadership. This approach leads to better adaptability of businesses in a dynamic market environment. AI is transforming corporate culture, increasing the emphasis on digital literacy,

collaboration and continuous support for continuous learning of employees (Srikanth et al., 2024). Artificial intelligence is transforming the decision-making process of companies by accelerating the analysis of large amounts of data, expanding the range of possible solutions and supporting strategic management. Despite its use, the importance of the human factor still remains to ensure the right ethics, transparency and value anchoring of the decision-making process. The implementation of AI requires adapting the organizational culture to one that supports innovation and digitalization and increasing AI literacy of employees (Rajagopal et al., 2022). Ethics and organizational culture plays a very important role in AI implementation. Unethical management practices can hinder the effective use of AI capabilities, especially in decision-making. AI models accurately predict financial health, but their success depends on the quality of available data and the transparency of the corporate environment. Effective communication and collaboration with IT is essential for the proper implementation and strategic use of AI. A strong organizational culture is an important variable in the adoption of AI in enterprises (Diab & El Hajj, 2024).

Table 2: Review of the research results second study area

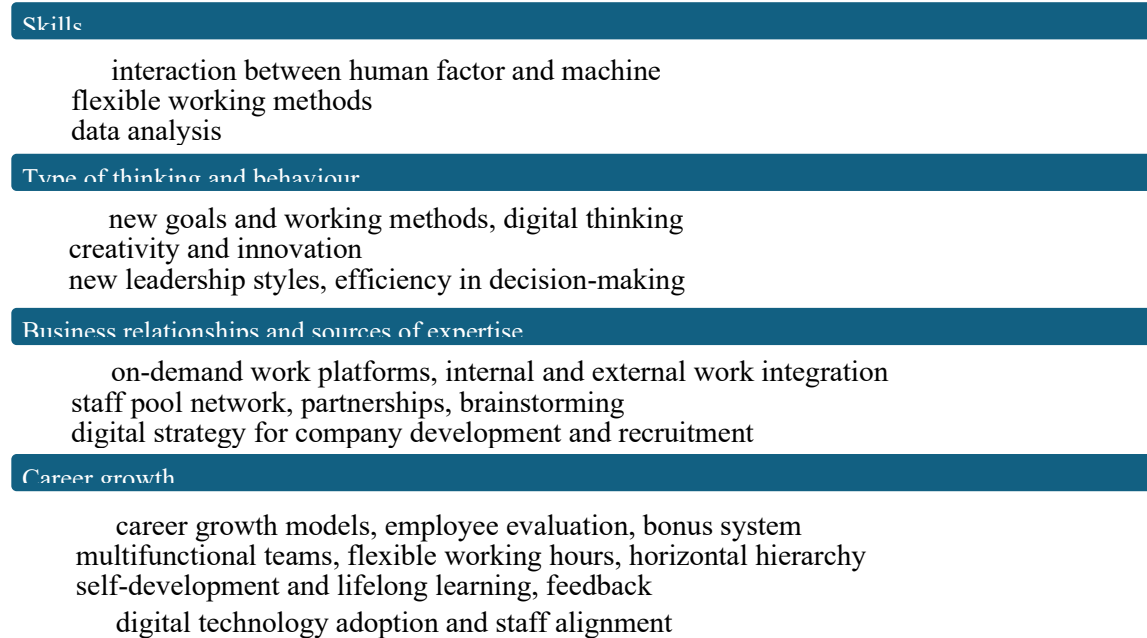
Author, author's collective	Transformation of corporate culture under the influence of digital technologies
Martínez-Caro et al., 2020	Data-driven culture and innovation, connecting with partners through ICT
Deep, 2023	Increasing diversity, more effective decision making, flexibility, increased collaboration, agility, adaptability, change in the way we communicate
Idigova et al., 2022	Internal communication, feedback, change management approaches, fostering innovation retention and employee satisfaction
Trushkina et al., 2020	Changes in corporate philosophy, acquisition of digital skills and competences, customer-oriented approach, new forms of cooperation
Munaf, 2023	Democratising information, personalised communication, changing decision-making processes, fostering innovation
Liu et al., 2023	Corporate performance, customer orientation, data-driven decision making, agile management, learning, digital ecosystem creation
Singh & Atwal, 2019	Fostering employee engagement, culture supports embracing digital change, innovation, openness, feedback, improved communication, competitiveness, effective decision making
Thi Giang, 2024	Culture supporting flexibility, innovation, remote working, digital communication (improved communication) - collaboration, digital skills, work-life balance, safety
Fathony & Hendarman, 2023	Digital leadership, digital culture, digital skills of employees, openness and digital readiness – challenges
El Rashied, 2023	Promoting innovation, changing mindsets, communication, organisational structure or processes

Source: own processing

The digital transformation is not just about technological change. Successful implementation of digital tools also requires a digitally-oriented corporate culture that inherently supports innovation, skills development and the link between technology and society's values. Without a setup like this, the full potential of digital transformation will never be realised. The effectiveness of decision-making processes based on data analytics is contingent on a corporate culture that promotes analytical thinking and adaptation to the digital environment (Martínez-

Caro et al., 2020). According to Trushkin et al. (2020), the key elements in corporate culture in the information economy are digital skills, behaviours, business relationships and expertise, as shown in the figure below:

Figure 5: The Content Structure of Organizational Culture in the Information Economy



Source: own elaboration according to: Trushkina et al. (2020)

Digitalisation requires a new approach to work, building adaptability and effective internal communication using digital tools. This not only gives employees greater flexibility but also the opportunity to work remotely. A well-adjusted company culture can support reducing employee turnover and increasing employee satisfaction, which is crucial in a digital environment. To build a sustainable digital transformation, aligning employee behavior and the company's digital goals is a necessary step (Idigova et al., 2022). In particular, the transformation of corporate culture under the influence of digital technologies includes elements of customer-centricity, data-driven decision-making processes, the advent of agile approaches in corporate governance, the continuous development of employees in digital literacy, and the building of a digital ecosystem of companies. A corporate culture built on shared values, communication and fostering innovation plays a key role in the implementation of digital technologies. Linking corporate culture and digital transformation leads to higher enterprise performance (Liu et al., 2023). Digital transformation significantly affects the corporate culture, which becomes a key element to ensure a successful transformation. Technology brings greater flexibility, more effective collaboration, communication and supports innovation and continuous learning. But they also bring challenges such as a lack of digital skills, a reduction in personal interaction, or a constant sense of disengagement and a reduction in work-life balance (WLB). Therefore, it is important to maintain a balance between digital advancement, corporate values and WLB, in which leadership plays an important role (Thi Giang, 2024). They also influence employee engagement, enable better communication and collaboration through cloud tools, and reduce duplication of work. However, such transformation requires a strong corporate culture of openness, adaptability and data-centricity. The main challenges today are resistance to new technologies, a talent gap and poorly aligned internal communications. Digitalization can improve working conditions and employee satisfaction, but it also risks losing personal interaction (Singh & Atwal, 2019). Leadership and

company culture play an important role in achieving digital transformation. Digital culture drives innovation and openness. Employees' readiness for the digital age is influenced by their digital skills. To successfully adapt to digital transformation, it is important to strategically manage change through corporate leadership. It is essential to develop employee skills and foster a culture of innovation (Fathony & Hendarman, 2023). Digital transformation requires employee engagement. Corporate culture is the foundation for the implementation of digital technologies. Digital culture influences the behaviour, communication or mindset of employees and its development promotes innovation and flexibility. Digitalisation leads to changes in organisational structure, processes and strategy; its success depends on leadership and the adoption of new technologies. The challenge is to overcome employee resistance to change (El Rashied, 2023).

Discussion

The role of artificial intelligence in modern corporate culture

Artificial intelligence (AI) is an important part of modern companies, especially in the process of building corporate culture. It is changing customer interactions, optimizing business process and influencing the strategic decisions of the company. It increases efficiency and competitiveness. According to research, up to 84% of 3000 administrative workers believe that AI can provide a market advantage (Jumani et al., 2021). However, AI can equally replace jobs, which can increase unemployment, which is why it is now crucial to continuously develop employees' digital AI skills. There are also ethical issues regarding algorithm transparency and data security. To successfully integrate AI into business processes requires a strategic leadership approach and adaptation of corporate culture (Srikanth et al., 2024). AI transforms traditional hierarchical management into an agile one and supports data-driven decision making as well as innovation adoption. AI tools streamline daily activities, save time and increase productivity, allowing employees to focus on strategically oriented activities (Randive & Nalkar, 2024). AI and humans work together in building a creative and collaborative corporate culture by not viewing AI as a threat, but instead as a tool for developing human capabilities, which promotes openness to new technologies (Al Samman, 2024). Companies' values and decision-making processes with laid on a data-driven approach, which increases objectivity and promotes innovation. The symbiosis between technology and people improves work habits, optimizes business processes, and addresses environmental and social challenges (Rane et al., 2024). AI contributes to a sustainable corporate culture by influencing values, communication, and the management of the company itself. It enables flexible responses to dynamically changing market environments, thus contributing to sustainable development (Isensee et al., 2021). It replaces traditional hierarchical leadership with an agile approach, but also raises ethical issues such as algorithm bias or transparency. Automating routine activities allows employees to focus on creative work and minimizes the fear of losing their jobs (Maddula, 2018). AI increases the emphasis on digital literacy and thus promotes continuous learning of human capital (Srikanth et al., 2024). Despite the immense use of AI, the importance of the human factor is untouched. Humans provide ethics, transparency, and strongly anchored values in the decision-making process. The implementation of AI requires the adaptation of corporate culture to support innovation and digitalization (Rajagopal et al., 2022).

Transformation of corporate culture under the influence of digital technologies

Digital technologies are changing traditional corporate culture and corporate leadership. Hierarchical models are being replaced by new, dynamic, agile models that support employee participation and data-driven decision-making. However, adapting corporate culture requires continuous learning, flexibility and adaptability. The success of digital transformation depends on sufficiently engaging employees in the change process and providing them with the tools to use digital technologies (Deep, 2023). ERP or CRM systems and cloud platforms improve the accessibility of information. However, technology can eliminate the boundaries between employees' work and private lives, which negatively affects their WLB. On the other hand, effective internal communication promotes performance and teamwork in times of change, which is supported by a corporate culture oriented towards coping with change (Munaf, 2023). Corporate culture is changing significantly. Culture is key to the successful implementation of digital transformation, which involves technology as well as human capital (Hamdani et al., 2021). Therefore, for its successful implementation, enterprises need to embrace cultural change (Phan Y Lan, 2021). Without a digitally-oriented corporate culture that promotes innovation, skills development and the interconnectedness of technology with the values of society, the full potential that digital technologies bring will not be possible (Martínez-Caro et al., 2020). Digitizing culture involves not only customer-centricity but also data-driven decision-making, agile management approaches, digital literacy education and building a digital ecosystem for the company. A culture built on values, communication and fostering innovation is therefore a key element for successful digital adoption (Liu et al., 2023). On the other hand, it also brings challenges such as just not enough employees with sufficient digital skills, decreasing personal touch, negative impact on WLB, resistance to new technologies, talent gap or poorly set internal communication (Thi Giang, 2024; Singh & Atwal, 2019). Therefore, for a company to successfully transition digitally, it needs the right oriented management, leadership and a well-adjusted corporate culture. It is important to strategically manage change and develop employee skills for successful adaptation (Fathony & Hendarman, 2023).

Conclusion

According to the systematic literature review, we can say that digital transformation has an impact on the business environment and corporate culture. Artificial intelligence and digital technologies have the potential to improve business processes, foster innovation and change corporate governance. However, their implementation also brings challenges, such as ethical issues, employee adaptability or its impact on working conditions. The literature collected suggests that the success of linking corporate culture and technology is not guaranteed, but in any case requires a strategic approach, continuous learning and an emphasis on human capital. Although the digital age is bringing big changes, their real impact is related to and depends on how companies are able to implement these technologies in their values and work processes.

This study adds to the current body of scholarly literature on the digitization of corporate culture, but it is important to empirically validate it in different industries so that it can be generally applied. The conclusion is based on a theoretical correlation, but does not demonstrate causality. Adapting to the digital age requires managerial action aimed at cultural change in companies, employee acceptance of the new technology-intensive environment, and addressing ethical issues related to algorithm transparency and individual privacy.

Future research could focus its attention on analysing these aspects in more depth so that a deeper picture of the relationship between technology and corporate culture can be provided.

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Odyssey
Conference

MANAGEMENT

TRACK 2: Managing Innovation and Strategic Adaptation in the Digital Era

PREFACE

MANAGEMENT – TRACK 2: MANAGING INNOVATION AND STRATEGIC ADAPTATION IN THE DIGITAL ERA

In today's dynamic business landscape, shaped by rapid technological advancements and constant socio-economic shifts, organizations face the imperative to rethink traditional models and embrace innovation. This track addresses the profound changes organizations undergo as they adapt to evolving technological, employee, consumer, and governance landscapes. The research highlights how companies are reimagining their strategies and structures to maintain competitiveness and resilience in the digital age, emphasizing organizational agility as a vital capability to respond swiftly to market disruptions. These papers collectively underscore how external disruptions compel businesses to redesign their approaches, embrace flexibility, and align with evolving market demands. The track also explores internal and structural factors shaping successful digital adaptation, including the expanding field of digital entrepreneurship and the critical role of corporate governance and leadership in navigating this transformation, particularly concerning AI disclosures. Together, these contributions offer a forward-looking perspective on how businesses can balance innovation, adaptability, and accountability for sustained growth and societal trust.

Galetić examines how the COVID-19 pandemic reshaped consumer habits and the resulting necessity for supermarket business models to adapt to these new preferences and remain competitive. Georgescu and Lungu provide insights into digital entrepreneurship through a bibliometric study, identifying key concepts and emerging trends within this evolving field. Iveković Tamhina explores organizational agility, reviewing scientific literature to present its evolution and transformative strategies for achieving competitive advantage in today's volatile business environment. Rupčić and Kalıpçı investigate how hotels can foster a culture of continuous learning to achieve competitiveness and viability in the hospitality industry, drawing on institutional theory to explore implemented learning organization practices. Tipurić and Perić analyze AI disclosure practices among Croatian firms, investigating how board composition, specifically formal education in engineering fields and gender diversity, influences transparency and accountability in AI-related reporting.

CHANGES IN CONSUMER HABITS AFTER THE COVID-19 PANDEMIC AND THEIR IMPACT ON SUPERMARKET BUSINESS MODELS

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Abstract

COVID-19 pandemic has drastically influenced lives of all people in Croatia and has brought many challenges in different aspects of society. It has strongly influenced economy, business and business results, everyday people's lives and consumer behavior. Many shoppers are questioning their decisions about grocery purchase and they are either willing or forced to change their usual habits. Based on this fact, there is a need for supermarket chains to change their business models in order to stay competitive on the market. Subject of the paper is to examine the need to adapt business models of supermarkets who are operating on Croatian market so that they remain competitive on the market and that they can satisfy shopper's preferences and needs, based on changes in consumer behavior caused by COVID-19 pandemic. The methodology of this paper is based on primary research. It is quantitative research which studied consumer behavior change on Croatian market after COVID-19 pandemic. The respondents are supermarket shoppers in Croatia. The collected data is analyzed using descriptive statistic methods, in which numerical and Figureical tables are used. Correlation matrix is used for further statistical analysis. The results of primary research show that shoppers have changed their behavior in several areas. Based on that, elements of supermarket business model are identified, in which certain changes are necessary, in order for supermarkets to stay relevant on the market and to maximize their potential in the long run.

Keywords: business model canvas, redesigning, supermarket, consumer behavior, COVID-19

JEL classification: M10, M31

Introduction

The COVID-19 pandemic has greatly impacted the lives of all people in Croatia and has brought numerous changes in various aspects of society. It has strongly influenced the economy, business operations and results, everyday lives, and consumer behavior. Neither consumers nor businesses are sure what will tomorrow bring, nor do they have all the relevant information based on which they are able to assess risks and make decisions. Consequently, established practices and patterns of behavior and action are no longer common for both consumers and businesses. Many consumers are re-evaluating and voluntarily or forcibly changing their decisions in long term about purchasing everyday necessities. In this context, there is a need for changes in the business models of retail chains to remain competitive in the market. The subject of this paper is to investigate the need to adapt the business models of supermarkets operating in the Croatian market to maintain competitiveness on the market and meet customer preferences and needs, based on changes in consumer habits caused by the COVID-19 pandemic.

The aim of this paper is to provide recommendations for redesigning the business models of supermarkets operating in the Croatian market, depending on the results of primary research on changes in consumer habits caused by the COVID-19 pandemic. To achieve this goal, it was necessary to conduct primary research on changes in consumer habits due to the COVID-19 pandemic, to identify and analyze the results, which means to discover changes in consumer habits, and provide recommendations and propose necessary changes in supermarket business models in the Croatian market.

Literature review

Companies' business models and business strategy

Companies' business models represent the backbone of overall strategy of companies. In business models it is described in detail how companies operate, total picture of companies' focus and effort in order to create demand for their products and services and adequately monetizing them. They represent the core of business operations and they are very useful to various stakeholders, from company owners and employees to potential investors. Business models are often used in practice to communicate the essence of a company's operations to stakeholders (Morić Milovanović et al., 2017). The importance of business models is significant as there are explained details of companies' competitive advantage, in other words what the company does differently from competitors to sell its products or services better, aiming to maximize revenue and profit. A business model describes how a company creates, delivers, and captures value (Osterwalder & Pigneur, 2014). Amit and Zott describe a business model as a system of activities showing how a company operates with its customers, partners, and sellers (Amit & Zott, 2010). Mason and Spring conclude that a business model is simultaneously useful at both company and network levels; as a broad organized concept and as a specific statement of revenue flow, products, and services (Mason & Spring, 2011). Undoubtedly, business models are an essential concept for company operations. A good business model remains essential to every successful organization, whether it's a new venture or an established player (Magretta, 2002). Business models are not uniformly defined; different authors define them in different ways. The literature is not consistent regarding the definition or elements of business models (Morić Milovanović et al., 2017). The concept of a business model is still the subject of different viewpoints and opinions of different authors; there is however a general agreement that it represents a framework or a way how companies operate. Popularity of business models is growing during the dot-com era in the late 1990s when the concept of business models was used to explain new business initiatives (Morić Milovanović et al., 2017). Today, the most well-known and accepted business model is the so-called business model canvas. We believe that a business model can best be described based on nine components that indicate how a company intends to make money. These nine components cover four main areas of a company: customers, offer, infrastructure, and financial viability (Osterwalder & Pigneur, 2014). The nine components of the business model canvas are: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partners, and cost structure. Each component provides insight into a specific segment of a company's operations, all crucial for maximizing its goals.

Business strategy and business model are closely related concepts. In every company, these two concepts should complement each other to provide a complete picture of the company's existence, development, future vision, and how the company achieves its goals. Business

strategy should answer how a company behaves and competes in the market, should predict future trends and provide guidelines on how to behave and operate in the future. Strategy should offer a vision for tomorrow's organization; or more precisely, tomorrow should be explained and interpreted by strategy: an envisioned image of a desirable future, basic strategic directions and other strategic actions with which it can be achieved (Tipurić, 2020). The concept of core competences, which is represented by Prahalad & Hamel (1990), defines that companies should focus on their core competencies, which are unique capabilities that provide a competitive advantage, as well.

A business model should fit into a company's business strategy. A business model describes a way how a company achieves its goals, in other words, how it creates value for stakeholders. Simply put, a business model is your profit formula. It is the method you use to reach customers, sell them a product or service, and consequently earn money (Muehlhausen, 2012). A company's strategy can be read from its business model. Also, a company's strategy determines its business model's content. Simply put, a business model answers how a specific company operates, how it satisfies customer needs and desires, in which way it uses resources, and in which way it earns money. Strategy determines a company's competitive advantage and it also predicts future situations that may or may not occur. But a business model is not the same as strategy, although many people use these terms interchangeably today. Business models describe, as a system, how parts of a business work together. But they do not consider one critical dimension of performance: competition. Sooner or later, and it is usually sooner, every enterprise runs into competitors. Dealing with that reality is strategy's job. (Magretta, 2002). Also, business models can influence a company's business strategy. Some strategies will be applied while others will not because they are inconsistent with the company's business model. Some boundary decisions will appear more attractive than other decisions because they represent a better fit with the business model (Foss & Saebi., 2018). Business models and business strategies complement each other in order to provide a comprehensive view of a company's focus.

Sometimes market changes occur that make existing business models no longer perfectly answer how companies should operate. For example, in today's fast-paced business environment with much competition, companies' focus changes. Competing in the modern market is becoming more and more complex and complicated, which is why companies pay more attention to building relationships with consumers instead of focusing on individual transactions. (Kowalska et al., 2021). A business model is a living model that must always align with company strategy. Adapting the design of a business model to overcome certain risk and uncertainty factors can lead to new ones (Brillinger et al., 2020). In case of changes in macro or micro environments, a business model must adapt or redesign to keep up with times. It is necessary to recognize environmental changes promptly and change the business model to maintain competitive advantage. With growing interest in business models' concept and various types of models, comes increased interest in studying how to change existing business model (Morić Milovanović et al., 2017). In times of change, companies must adapt value creation according to market needs. Consumer needs and desires change over time. The assumption of market success is establishing an appropriate relationship between what a company produces, what a company sells and what clients want to buy and actually buy (Vranešević, 2016). Many companies fail to recognize timely importance of redesigning their business models thus losing competitive advantage eventually. In conclusion, business model innovation is important, business model innovation is difficult, and to complicate it even further, business model innovation needs to innovative to stay relevant in the light of current global trends. Hence, we

feel that business model innovation needs a visionary platform that reaches beyond current states and frameworks. (Aagaard & Nielsen, 2021).

Specificities of supermarket business models

Supermarkets are relatively large stores that offer customers a wide range of categories and products in one place and have a broad selection of brands and private labels for most products. The primary group of products sold in supermarkets includes food products, cleaning products and personal hygiene products. These are generally the destination categories for supermarkets, meaning that customers primarily visit supermarkets to purchase food items, cleaning supplies, or hygiene products. Naturally, supermarkets offer a much wider range of categories and products that customers can purchase during their visit. The word ‘supermarket’ is used to denote a large self-service store, selling groceries, dairy products and household goods. Supermarkets are owned and operated by a wide variety of business concerns, from wealthy local individuals to giant, globally active transnational companies (Arda, 2006).

Supermarket operations are complex because they involve a large number of different entities and processes. The entities involved in supermarket operations include customers, retail outlets, transportation systems, warehouse distribution centers, and suppliers. (Steenken & Ackley, 2012). Supermarkets operate in a very competitive environment. It is common to find several supermarkets in a small geographical area, each competing with the other. The task of each supermarket is to attract customers to their store to achieve their primary goal, which is to sell products and thereby generate revenue. A supermarket exists in a competitive environment where it acts as an intermediary adding value between geographically dispersed supplier companies and scattered individual customers who will eventually purchase their products (Steenken & Ackley, 2012). The strategy of a supermarket is to satisfy the needs and desires of the largest possible segment of its target group, in other words, to attract as many customers as possible.

The COVID-19 pandemic significantly slowed not only the retail segment but also the entire global economy. After the pandemic was declared in March 2020, the lifestyle of all people around the world changed. This led to significant turbulence in the market. COVID-19 poses one of the most substantial peacetime challenges facing business and government in the past 100 years (Hall et al., 2021). It was assumed that the corporate world after the COVID-19 pandemic would look different. Trends that emerged during the pandemic will become standards, such as remote learning and working, telemedicine, delivery services, e-commerce, etc. The experiences and changes during this crisis can shape the world for the next decade and serve to reassess some beliefs, attitudes, and dilemmas (Katavić et al., 2020). Individuals are primarily concerned about their health, jobs, incomes and future. They apply their fears to their shopping habits. Due to all of the above, very unusual and unpredictable consumer behavior patterns emerge. Supermarkets, as well as the entire retail sector, also operate in great uncertainty, not knowing what awaits them from suppliers, or from their customers. As around the world, so in Croatia, there are numerous unknowns and challenges in the operation of supermarkets. Instability is visible every day, and changes are becoming unpredictable and faster. It is increasingly difficult to predict how a particular decision will affect business development. Historical decisions and experience are no longer as relevant because the entire environment is changing. Business choices are no longer simple, solutions no longer fit into predefined molds as they did in the past, but new ways of thinking are required. The COVID-19 pandemic has caused significant uncertainty across all aspects of the global economy and society. After the initial shocks, the economy stabilizes, and so does supermarket operations.

Unknowns become fewer, but they still exist. Consumer shopping habits have partially changed, and supermarkets need to adapt to continue being competitive in the retail market.

Consumer behavior

Consumer behavior, as important part of the business model, is an extremely interesting area that answers questions about how consumers behave, what attracts them, and what their purchasing preferences are. Consumer behavior can be defined as a specific type of human behavior in acquiring or purchasing products and services, and it refers to all objectively expressed reactions in the process of buying or consuming. Consumer behavior changes over time depending on various factors. For consumer goods, acceptable price and proved quality are not enough to find their way to the buyers (Petlja et al., 2019). The current situation in which consumers find themselves, which can depend on macroeconomic influences as well as the personal situation of the consumer, plays a significant role. Consumer behavior is subject to change, whether it concerns individuals, groups, or entire societies. It is influenced by various factors, and changes in the circumstances in which purchasing, consumption, or disposal of products occur lead to different consumer behaviors (Grbac & Lončarić, 2010).

Marketing experts in their research tend to capture various factors that can influence purchasing decisions. Recent literature has shown that a perceived scarcity of products can significantly affect consumer choices (Eger et al., 2021). The concept of the customer journey for which Pine and Gilmore (1999) gave the groundwork, among other authors, refers to the complete experience that a customer goes through when interacting with a brand, product, or service, from the initial awareness stage to post purchase evaluation and beyond. Successful business models should optimally satisfy consumer needs and desires at all times, closely monitoring market trends and consumer behavior, and adapting to what has been learned. Consumer behavior is an interactive relationship between cognition, feelings, behavior, and the environment in which the behavior occurs. Marketing experts should know how consumers think, what they feel, and how they behave concerning objects, places, ideas, and other subjects in a specific space and time (Grbac & Lončarić, 2010). Consumer behavior actually describes the needs and desires of customers in the market, which gives companies insight into how to adapt their operations. Satisfying client needs is a central part of the marketing philosophy of business (Vranešević, 2016). Market research plays an extremely important role in defining and tracking consumer behavior trends. The fundamental activity through which companies can obtain information about the market and from the market (consumers and non-consumers, competition, and distribution channels) is market research (Vranešević, 2014). As soon as a deviation in consumer behavior is recognized, the company should consider its business model, whether it still meets consumer needs and desires or if it needs to be adjusted. Retailers and local services are aware that their responses to the emergency will dramatically impact their business, but are scrambling to adapt as they have very little time to take action (Eger et al., 2021). Certain events, especially unexpected ones, can have a long-term impact on consumer behavior. In that case, company business models need to adapt to the new situation. Otherwise, they will no longer be able to maximize their potential and remain competitive in the market. For example, the COVID-19 pandemic has undoubtedly drastically affected not only consumers' lives but also their purchasing habits. Some changes resulting from the COVID-19 pandemic will be long-lasting. Both sellers and buyers must quickly and promptly adapt to the new circumstances. Marketing decisions should be driven by consumer needs and desires (Topolko Herceg, 2021). Any potential change in the business model should be based on research that needs to be conducted in detail and in multiple instances. It is crucial to capture the customers' shopping behaviors at a more mature stage since these behaviors are likely to

follow patterns, which help predict their behaviors in the future (Truong & Truong, 2022). A review of the literature clearly shows that several studies have already been conducted on changes in consumer habits due to the COVID-19 pandemic, especially at the beginning of the pandemic. However, in some cases, clear conclusions could not be drawn due to various market irregularities (Boyle et al., 2022). One of the goals of companies is a high level of customer satisfaction because a customer can at any time decide on another product/service that may potentially provide greater satisfaction (Vranešević et al., 2022). Consumer behavior research is the first step for a company to make necessary decisions.

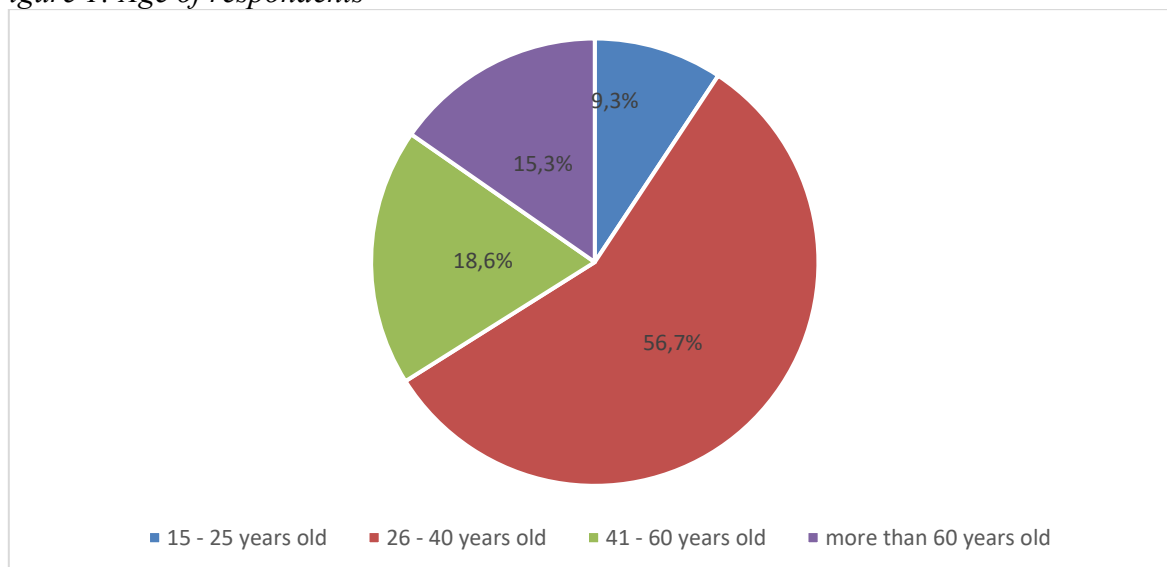
Research methodology

The methodology of this paper is based on conducted primary research. It is a quantitative study that aims to examine changes in consumer habits in the Croatian market after the COVID-19 pandemic. The quantitative approach is appropriate for achieving the objectives of the paper, as it provides a greater understanding of the phenomenon being studied (changes in consumer habits). The primary research was conducted in the form of a survey questionnaire consisting of 26 questions based on examining the elements of the business model canvas (Osterwalder & Pigneur, 2014), which offer insight into individual segments of a company's operations. All the questions are closed-ended, consisting of questions with multiple-choice and intensity-based answers. The questionnaire consists of 7 questions with Likert type scale and 19 questions with multiple-choice answers. The first two questions in the questionnaire examine the age and gender of the respondents to allow for more detailed analyses of the remaining questions based on different age and gender groups. The sample size of the survey questionnaire is 215 respondents. The survey questionnaire was created using an online platform, and the link to the questionnaire was sent digitally to potential respondents. The timing for respondents to answer the survey questionnaire was in February 2023. The collected data were analyzed using descriptive statistical methods, including numerical and Figureical representations. Correlation matrix is used as the statistical analysis.

Results and discussion

The survey questionnaire answered slightly higher percentage of female respondents (56,3%) compared to male respondents (43,7%). The largest share of respondents, 56,7%, are aged between 26 and 40 years. They are followed by the age group of 41 to 60 years, which makes up 18,6% of the respondents. 15,3% of the respondents are over 60 years old, and 9,3% of the respondents belong to the age group between 15 and 25 years.

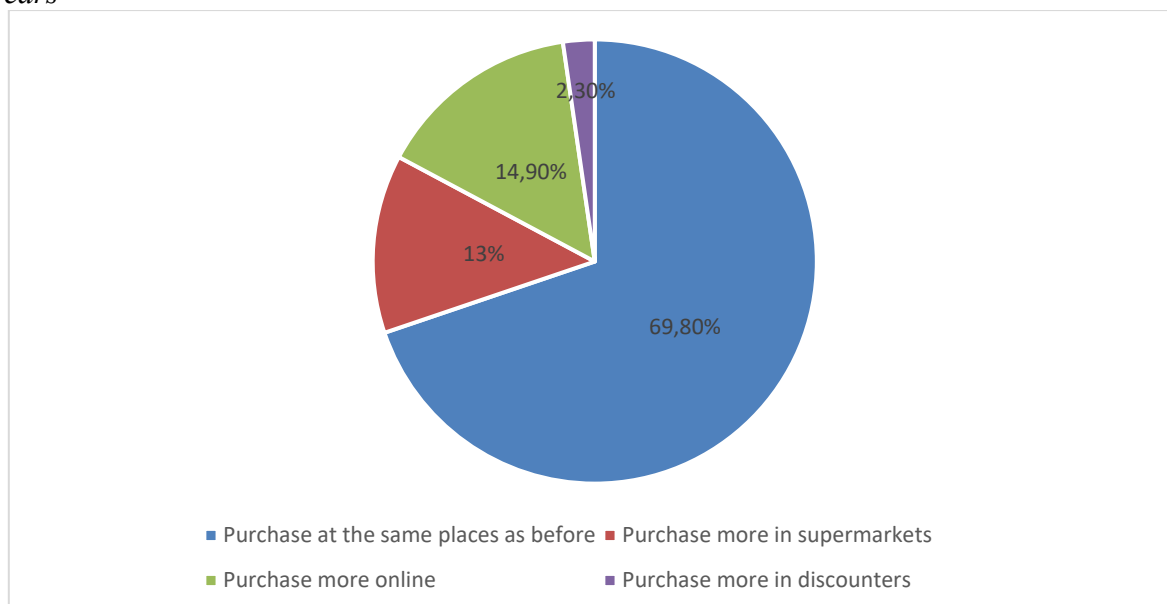
Figure 1: Age of respondents



Source: Author's work

From the respondents' answers it can be concluded that supermarkets are extremely important players in the retail sector in Croatia. Their role is unquestionable, as almost all respondents, 99,5% of them, have shopped in a supermarket in the past three years, and as many as 83% of respondents most often buy consumer goods in supermarkets. Additionally, in the past three years, 13% of respondents have increased their supermarket shopping compared to before, as we can see on the Figure 2. Thus, supermarkets are a significant and indispensable place for shopping in Croatia.

Figure 2: Change in habits related to the place of purchasing consumer goods in the last three years



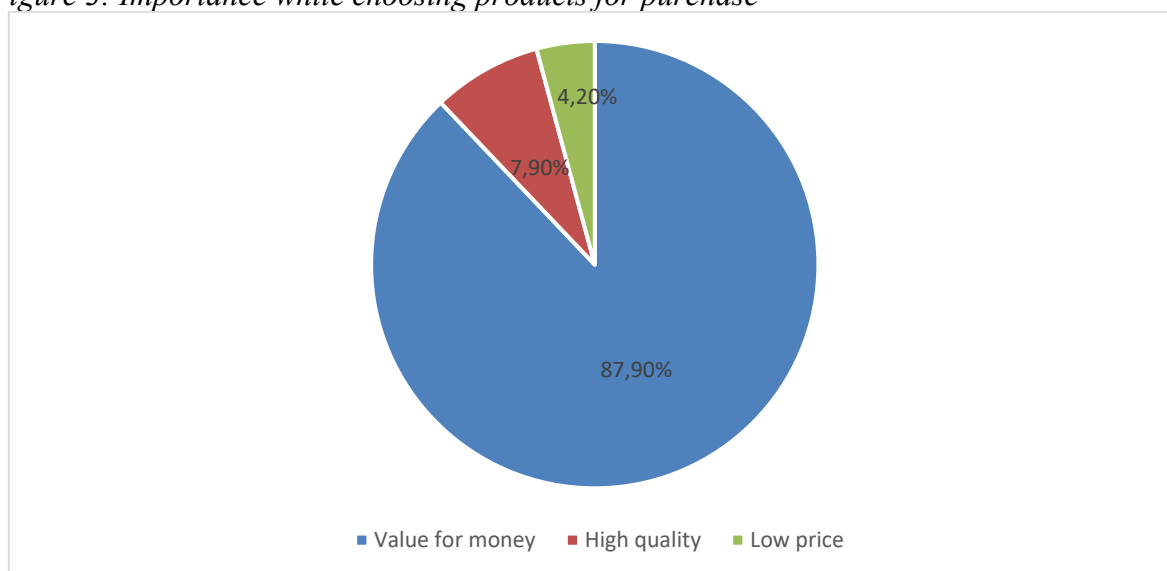
Source: Author's work

Furthermore, 87% of respondents answered that there is a supermarket near them, but more than half of the respondents would still like a supermarket to be closer to them. Considering this from the perspective of supermarket business models, the key activities of supermarkets

should focus more on opening new stores and optimizing existing ones. The survey clearly indicates that there is potential in opening supermarkets closer to the majority of respondents.

On the Figure 3 we can see that respondents clearly indicated that value for money is the most important factor when choosing products, far more important than low price or high quality. From this, it can be concluded that supermarkets should communicate more about the value for money of the products they sell, as this can attract potential customers.

Figure 3: Importance while choosing products for purchase

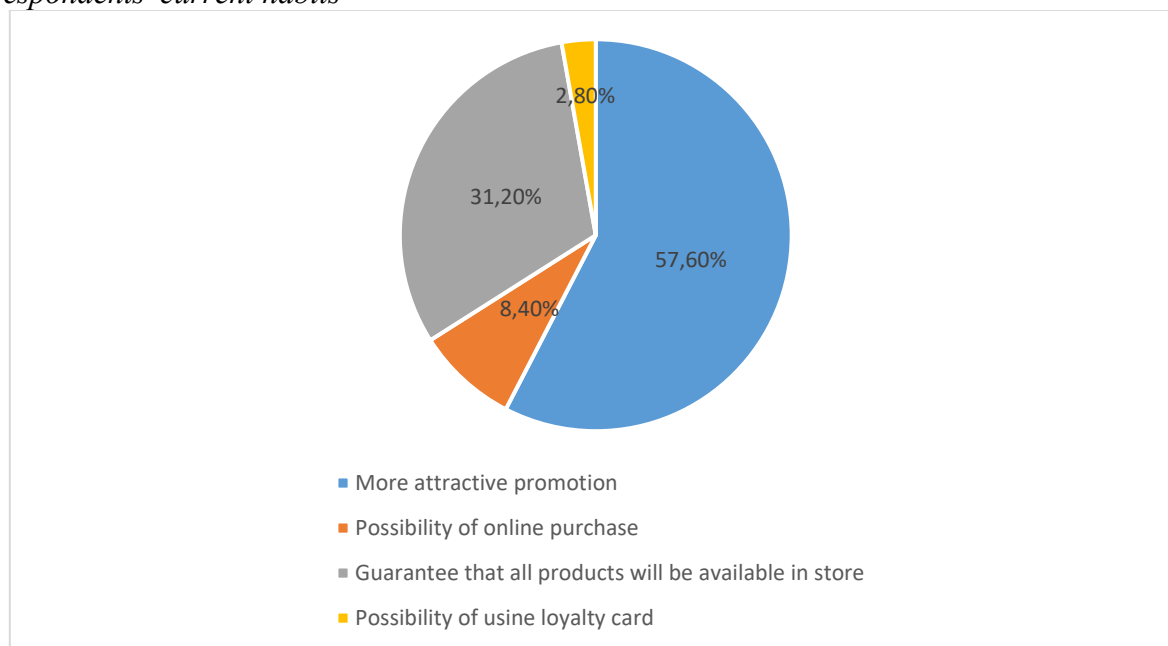


Source: Author's work

Also, 64,2% of respondents stated that they more often buy branded products than private labels, but there is still a third of respondents who more frequently buy private labels. Additionally, 48,4% of the respondents buy private labels more than they did before. Thus, both branded products and private labels have an important role in meeting customers' needs and desires. Supermarkets should therefore focus on both product segments in their value proposition. In their business models, especially in key activities, they should place greater emphasis on negotiating the production of their own private labels if they do not already have them or if they are underdeveloped.

In the survey, respondents also provided insight into their behavior regarding what would most motivate them to purchase products from another retail chain compared to their current habits (Figure 4). 57,6% of the respondents answered that a more attractive promotion would most encourage them to do so, and for 31,2% of them the biggest motivation to purchase products at another retail chain is guarantee that all products will be available in store.

Figure 4: The biggest incentive to purchase products at another retail chain compared to respondents' current habits



Source: Author's work

Additionally, almost 80% of respondents confirmed that in the past three years, it has become more important for a product to be on promotion than it was before. In the table 1 we can see that 63,3% of respondents stated that it is important for the product they want to buy to be on promotion. Therefore, promotions play an essential role in product choice for customers. From the perspective of supermarket business models, supermarkets should place greater focus on communicating promotions on products in their value proposition, and in their key activities, they should focus more on negotiating various and more frequent promotions with suppliers.

Furthermore, the analysis of the survey clearly shows that 48,8% of the respondents more often buy products online and more often use home delivery in the past three years than they did before. Also, as seen in table 1, 37,2% of respondents stated that the possibility of online shopping and home delivery is important to them. Based on the results, in their business models, supermarkets should focus more on online sales channels, opening online shopping platforms. They should also focus on developing online platforms as key resources, and in key partnerships, they should place more emphasis on IT companies that can develop these solutions to avoid losing a segment of customers who want to buy consumer goods online in the long term. This is further supported by the fact that 60% of respondents would be willing to order products online and pick them up at their nearest supermarket, and 26,5% of respondents stated that the possibility of online ordering and picking up purchased goods at the nearest supermarket is important to them. Therefore, supermarkets should also offer this purchasing option in their value proposition.

Furthermore, loyalty cards have proven to be an important factor in customer choice, as 40,4% of respondents indicated this is important for them. Supermarkets should focus more on developing loyalty cards in their customer relationship segment if they do not already have them developed, and on communicating with customers through them. This way, a more personalized approach to customers is achieved, which customers greatly appreciate. Supermarkets should also focus more on timely ordering of products and product availability

at all times in stores in their key activities segment. Namely, 84,2% of respondents consider the availability and accessibility of products at the time of purchase important, while 70,2% have noticed that in the past three years, the product they wanted to buy was not available on the shelf. Based on further results, where 61,9% of respondents stated that they more often buy larger packages of products, and 38,1% of respondents stated that they more often buy smaller packages of products, it can be concluded that both package sizes have their customers and are an essential part of the overall product offering. Therefore, in the value proposition segment, supermarkets should offer both sizes of all products so that customers can buy according to their preferences.

Three survey questions highlighted the importance of friendliness, knowledge, and helpfulness among supermarket employees. While 75,3% of respondents value friendliness and willingness to help, only 41% are satisfied with these aspects. Additionally, 71,2% believe employees should have more product information. This indicates a need for supermarkets to emphasize employee training and adequate staffing in their business models, particularly in customer relationships and key activities. 73,5% of respondents also expressed a desire for more product advertising and information in stores, offering supermarkets an opportunity for additional revenue by selling advertising space to suppliers.

Table 1: Importance to respondents for selected questions

Question	Percentage of respondents by importance (1: not at all important, 5: extremely important)				
	1	2	3	4	5
Q1 - Importance of ability to shop online and have products delivered to home	21,9%	18,1%	22,8%	21,9%	15,3%
Q2 - Importance of the option to select products online and pick them up at the nearest supermarket	27,9%	17,7%	27,9%	18,6%	7,9%
Q3 - Importance of the product to be on sale	3,3%	7,0%	26,5%	38,6%	24,7%
Q4 - Importance of the retail chain to have a loyalty card and offer personalized promotions	14,4%	17,2%	27,9%	25,1%	15,3%
Q5 - Importance of availability of all the products and in stock at the time of purchase	0,5%	2,8%	12,6%	33,5%	50,7%
Q6 - Satisfaction of friendliness and willingness to help of the staff in supermarkets	2,3%	14,4%	42,3%	32,6%	8,4%
Q7 - Importance of friendliness and willingness to help from staff in supermarkets	0,5%	7,0%	17,2%	40,0%	35,3%

Source: Author's work

From the correlation matrix, there are some interesting findings about the connections between different answers. There is a strong positive correlation between question 1 and question 2, and weak positive correlation between question 1 and question 3, as well as between question 1 and question 4. Question 2 is weakly positively correlated to questions 3, 4 and 7. Question 3 is

moderately positively correlated to question 4 and weakly positively correlated to question 5. There are weak positive correlations between question 4 and questions 5 and 7, but between questions 4 and 6 there is a weak negative correlation. Question 5 is weakly negatively correlated to question 6 and weakly positively correlated to question 7. Between questions 6 and 7, there is a weak positive correlation.

Table 2: Correlation matrix

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Q1	1,0000						
Q2	0,6516	1,0000					
Q3	0,2080	0,1996	1,0000				
Q4	0,1525	0,1209	0,4999	1,0000			
Q5	0,0336	0,0314	0,1785	0,3338	1,0000		
Q6	-0,0149	0,0986	-0,0840	-0,1159	-0,1576	1,0000	
Q7	0,0611	0,1355	0,0979	0,1654	0,1227	0,1588	1,0000

Source: Author's work

The responses from the survey questionnaire provided very valuable insights into customer habits and consumer behavior. It can be concluded what is commendable in the existing business model and in which areas there is potential for adaptation and improvement to ensure customer satisfaction and maximize supermarket revenues and profits. Therefore, all of the above results should be continuously monitored and improved.

Conclusion and recommendations for redesigning supermarket business models

Supermarket business models developed in details are crucial for successful market operations. Business models are living elements of the overall strategy that need to be changed and adapted to market changes. In the past three years, the macroeconomic and business environment, as well as customer habits, have significantly changed. The declaration of the COVID-19 pandemic in March 2020 influenced purchasing habits, and the primary research conducted in this paper provided insights into these changes.

From the research results we can see that consumer behavior has changed in many aspects after COVID-19 pandemic, what supports thesis that the authors Hall, Katavić, Grbac & Lončarić, Eger, Truong & Truong have stated in the theoretical part of this paper. As companies in those circumstances must have good relationships with customers and satisfy their needs and wishes, it is necessary to change the business model (Kowalska, Brillinger, Morić Milovanović, Topolko Herceg). This approach enables them to stay competitive on the market.

Consequently, elements of supermarket business models have been identified that require modifications to remain competitive and maximize their long-term potential. The research results indicate potential adaptations in all nine areas of the business model canvas.

Table 3 provides a summarized view of the business model elements that supermarkets should focus on to maximize their potential and retain existing customers while also attracting new ones.

Table 3: Proposal of supermarkets' focus areas

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
IT companies	Online sales	On-line shopping possibility	Communication through loyalty cards and personalized offers	On-line shoppers who use home delivery
	Ensuring product availability	Home delivery possibility		
	Staff training	Possibility of in-store pickup of ordered products	Better staff communication with customers	On-line shoppers who pick up ordered products in-store
	Producing private labels	Communicating value for money		
	Opening new stores and optimizing existing stores			
	Key resources	More frequent promotions communication	Channels	Loyalty card users
	Online platforms		Online stores	
Cost Structure			Revenue Streams	
Cost of training existing and new employees			Selling advertising space in stores	
Cost of maintaining online platforms				

Source: Author's work

In the area of customer segments, supermarkets should focus on online shoppers, customers who use home delivery, customers who pick up ordered products in-store, and loyalty card users. In customer relationships, greater emphasis is recommended on communication through loyalty cards, personalized offers, and better staff communication with customers. In value propositions, supermarkets should include online shopping, home delivery, in-store pickup of ordered products, communicating value for money, and more frequent promotions. In key activities, potential adaptations include producing private labels, opening new stores, optimizing existing stores, online sales, ensuring product availability, and staff training. In key partners, there is potential in partnering with IT companies. In sales channels, online stores show clear potential, and key resources should include the development of online platforms and programs. In cost structure, supermarkets should consider the costs of training new employees and maintaining online platforms. As an additional revenue source, supermarkets should consider selling advertising space in stores.

By designing the proposal of supermarkets' focus areas in their business model, depending on the results of primary research regarding changes in consumer habits caused by COVID-19 pandemic, the aim of this paper is achieved. By adapting their business model supermarkets would maintain competitiveness on the market and meet customer preferences and needs, based on changes in consumer habits caused by the COVID-19 pandemic. To succeed this the business model innovation needs, according to Aagaard & Nielsen, a visionary platform that reaches beyond current states and framework. In other words, the business model innovation should fit into a supermarkets' business strategy.

As business model and business strategy are closely interdependent, the results of this research can not only help companies to adjust their business model, but also to develop competitive

advantage on the market. This findings also support theoretical assumptions by Tipurić, Magretta and Foss & Saebi about connection between business model and business strategy.

Limitations of the paper and future research directions

Main limitation of this research is the fact that the questionnaire should have been answered online what may not be suitable for older population. As well, the group between 15 and 25 years old live with their parents and may not have enough experience in supermarket purchase. For the future research it would be useful to use qualitative research to gain more detailed information about habits and needs of customers.

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NAVIGATING DIGITAL ENTREPRENEURSHIP: INSIGHTS FROM A BIBLIOMETRIC STUDY

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Abstract

The integration of digital technologies has contributed to the reconfiguration of the entrepreneurial process and, consequently, to the development of digital entrepreneurship as a new field of academic research. As this trend is still insufficiently debated, the main aim of this research endeavor is to bring to the fore the most relevant concepts associated with digital entrepreneurship, taking into consideration the most cited papers published in the Web of Science database. To this effect, a bibliometric analysis was performed using the VOSviewer software to identify the main trends in academic literature, based on the 105 most cited papers published between 2015-2024. The findings can be summarized into four distinct clusters that allow for a better understanding of digital entrepreneurship. Each of these clusters highlights the connections between the keywords, assuming major aspects such as innovation, digital transformation, entrepreneurial ecosystems, business models, dynamic capabilities or strategies in performing via digital platforms. Accordingly, one can state the major impact of digital transformation on entrepreneurial activities. Furthermore, we have concluded that most of the published papers are signed by authors or co-authors with USA affiliations, followed by Italy, England, and China. Overall, these findings may have different implications for policy makers, mainly by creating a framework for stimulating digital entrepreneurship, while for entrepreneurs and researchers it can be seen as a starting point in identifying and exploring new opportunities in the field.

Keywords: digital entrepreneurship, entrepreneurship, digital transformation

JEL classification: L26, O33

Introduction

Nowadays, the integration of digital technologies has become integral to harnessing entrepreneurial opportunities (Kraus et al., 2019) and to remaining competitive on the market (Garrido-Moreno et al., 2024; Morobito, 2022). Recognized in the academic literature as *digital entrepreneurship* (Nambisan, 2017; Sussan & Acs, 2017; Sahut et al., 2019), this trend is actually a reshaping of traditional entrepreneurship (Elia et al., 2020) in response to a new dynamic context, where technology has become mandatory for survival (Lungu et al., 2021). Hence, the digital entrepreneurial ecosystem is defined by the mix of “digital infrastructure

governance, digital user citizenship, digital entrepreneurship, and digital marketplace” (Sussan & Acs, 2017). This process of creating digital value through entrepreneurial endeavors utilizes socio-technical digital enablers to make it easier to obtain, process, distribute, and consume digital information efficiently (Sahut et al., 2019).

Despite the rapid advancement in this field, the academic research addressing this topic remains insufficient (Kraus et al., 2019; Lungu et al., 2024). Although interest in digital entrepreneurship is increasing, the existing research is still quite fragmented, featuring varying conceptualizations and overlapping themes. To address this gap, we agree that a comprehensive bibliometric review, based on quantitative mapping and qualitative synthesis, can offer a cohesive understanding of the intellectual framework of digital entrepreneurship. Under these circumstances, our study addresses the following research question: *What are the dominant research trends, knowledge clusters, and geographic influences shaping the digital entrepreneurship scholarship?* Therefore, this research paper seeks to identify the main trends in academic literature related to the topic of digital entrepreneurship and to cover the gap in the academic literature. The authors performed a bibliometric analysis (Donthu et al., 2021) on the topic of digital entrepreneurship, based on the most cited papers available in the Web of Science database, and defined the following research objectives:

- (1) To analyze the evolution of the number of publications related to digital entrepreneurship available in the Web of Science database.
- (2) To identify the main cited papers relevant for the topic.
- (3) To identify the authors’ areas of interest in the field of digital entrepreneurship, taking into consideration their country of origin, number of the documents, and citations.
- (4) To group the most frequently associated keywords using a cluster approach.
- (5) To run a systematic analysis on the topic of digital entrepreneurship based on the most frequently cited papers on this subject.
- (6) To provide a graphic representation of the relationships between associated keywords using a network map.

The first part of this paper offers a comprehensive explanation of the methodological approach to the bibliometric study. This is followed by an exploration of the results and a discussion about the clusters. Finally, the conclusions are presented, together with the limitations and the future research directions.

Methodological approach

The aim of this research paper is to identify the main trends in the academic literature on the topic of digital entrepreneurship by running a bibliometric analysis, a method that has recently become very popular for exploring various topics (Donthu et al., 2021). To this effect, we have conducted an analysis on the papers published between 2015 and 2024 in the Web of Science database, which is widely recognized as one of the most representative sources for academic research (Carracedo et al., 2021) and is also frequently used for bibliometric studies (Zupic & Čater, 2015), particularly due to its rigorous citation indexing (Öztürk et al., 2024). The selection of the timespan was conditional upon the selection criteria, as the first paper that met the criteria was published in 2015.

Several steps were undertaken to perform the bibliometric analysis. Firstly, we queried the Web of Science database by using the following Boolean interrogation: TS=*digital entrepreneur** OR TI=*digital entrepreneur** OR AB=*digital entrepreneur**, where the asterisk (*) was used

for including derivative terms and providing a broader scope for the search. The highly cited paper criterion was also applied, to prioritize influential contributions within the field, even if this approach may exclude emerging perspectives and critical debates (Donthu et al., 2021). The database query returned a total of 105 documents that met the criteria, comprising articles and review articles published in English. Subsequently, we proceeded to export all the information about the selected research materials in .txt format.

Secondly, after importing the selected research materials into VOSviewer, version 1.6.20 (van Eck & Waltman, 2023), a screening process was conducted. A full counting co-occurrence analysis was performed using the software, with a minimum threshold of five occurrences per keyword. Afterwards, the terms were standardized by merging similar keywords and reconciling spelling variations. Additionally, connectors, journal names, and other irrelevant entries were removed. As a result, out of the 745 keywords, only 45 achieved the established threshold. These keywords were categorized into four clusters, reflecting their interconnections. In addition to the above, we have proceeded to investigate the available data to highlight the evolution of the number of publications, the most cited papers, and the authors' country of origin.

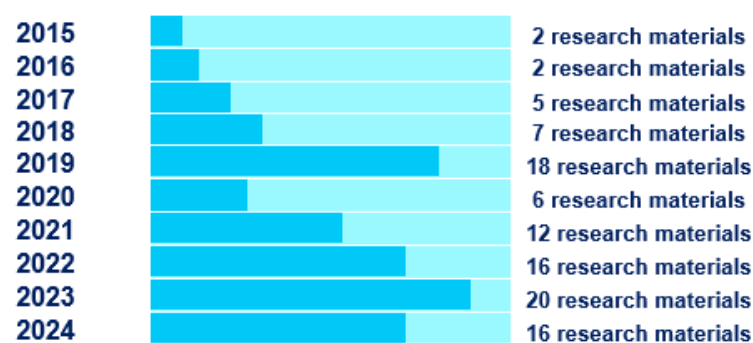
Finally, the clusters were examined and discussed through the lens of the academic literature, providing insights into the key themes and trends associated with digital entrepreneurship. This step provided a better understanding of the connections between the identified keywords and their relevance within the broader research context.

Results and discussions

Digital transformation has changed the *entrepreneurial ecosystem*, which includes institutions, resources and new value creation (Cavallo et al., 2019). This dynamic has led to new approaches. Particularly, the effect of digital transformation on the entrepreneurial process is known as *digital entrepreneurship*.

Since 2015, the field of *digital entrepreneurship* has experienced significant growth in the academic literature. Based on our research goal, we will focus on the most cited papers. In this regard, *Figure 1* illustrates the evolution of the number of publications that met the selection criteria, as explained in the methodological approach section. Building on the available data, 2023 is a milestone year for the analyzed topic, with 20 publications meeting the selection criteria – all ranking among the most cited papers in their field.

Figure 1: Evolution of the number of publications



Source: own processing

Table 1 groups the Top 5 most cited papers on the topic of digital entrepreneurship, as published in the Web of Science database. Out of the 5 most cited papers, 4 are authored or co-authored by Satish Nambisan from Case Western Reserve University of Ohio, United States, which highlights this author's role in developing the field.

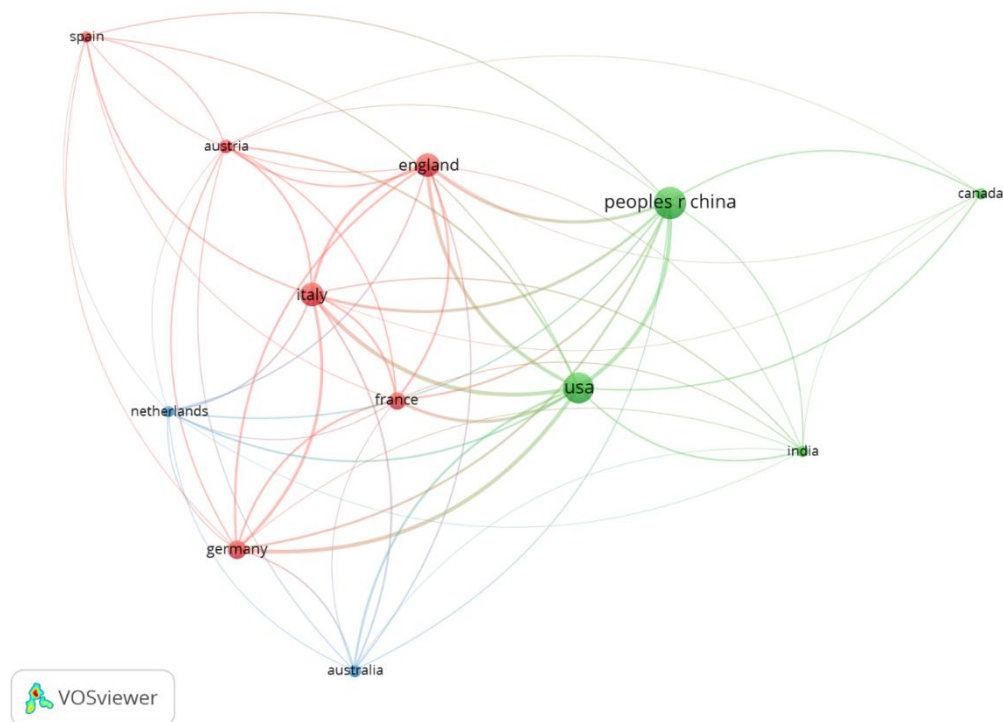
Table 1: Top 5 most cited papers on the topic of digital entrepreneurship, as published in the Web of Science database

Title of the paper	No. of citations in Web of Science
Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). <i>Digital innovation management</i> . MIS quarterly, 41(1), 223-238.	1,498
Nambisan, S. (2017). <i>Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship</i> . Entrepreneurship theory and practice, 41(6), 1029-1055.	1,304
Warner, K. S., & Wäger, M. (2019). <i>Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal</i> . Long range planning, 52(3), 326-349.	1,268
Nambisan, S., Wright, M., & Feldman, M. (2019). <i>The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes</i> . Research policy, 48(8), 103773.	1,159
Autio, E., Nambisan, S., Thomas, L. D. W., & Wright, M. (2018). <i>Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems</i> . Strategic Entrepreneurship Journal, 12 (1), 72–95.	788

Source: own processing

Based on the records, we have established the connections between the cited papers, taking into consideration the authors' country of origin, assuming a minimum of 5 documents per country. Out of the 41 countries, 8 meet the threshold. The results are depicted in Figure 2.

Figure 2: Authors' country of origin



Source: VOSviewer output

According to *Table 2*, most of the published papers are authored or co-authored by authors with USA affiliations, followed by Italy, England, and China. Their impact on the field of digital entrepreneurship is evident in the number of citations, as extracted from the Web of Science database.

Table 2: Authors' country of origin, number of documents and citations

No.	Country	Documents	Citations
1.	USA	30	12,062
2.	Italy	17	3,187
3.	England	17	4,378
4.	China	32	4,807
5.	Germany	11	3,535
6.	France	10	1,491
7.	Austria	6	1,678
8.	Australia	5	833

Source: own processing

The results of the bibliometric study on digital entrepreneurship highlight the interconnection between the fields of entrepreneurship and technology (Sussan & Acs, 2017) (Nambisan, 2017). This relationship emphasizes the way digital technology is increasingly influencing business models, innovation processes, and entrepreneurial behaviors. These aspects are also illustrated by the most significant terms associated with digital entrepreneurship, as identified through the VOS Viewer analysis and shown in *Table 3*.

Table 3: The 15 most significant terms associated with digital entrepreneurship, as identified through VOS Viewer analysis

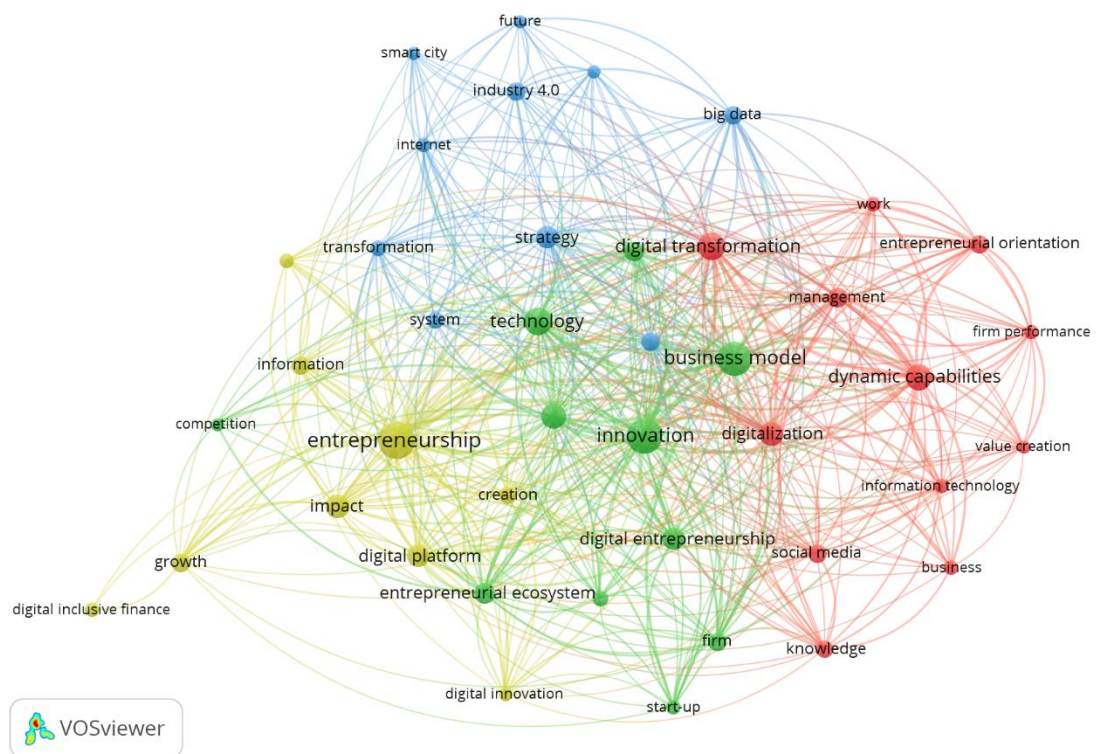
No.	Term	No. of occurrences	Total link strength
9.	Innovation	178	32
10.	Business model	169	32
11.	Entrepreneurship	159	36
12.	Digital transformation	118	21
13.	Dynamic capabilities	113	19
14.	Technology	113	21
15.	Digitalization	107	16
16.	Digital platform	82	14
17.	Performance	81	17
18.	Strategy	79	14
19.	Impact	68	16
20.	Entrepreneurial ecosystem	67	12
21.	Management	66	11
22.	Digital entrepreneurship	64	13
23.	Firm	54	9

Source: own processing

As expected, when exploring the topic of *digital entrepreneurship*, the most frequently used keywords are *innovation*, *business model*, and *entrepreneurship*, reflecting the permanent change of the market process in a context of *digital transformation*. Specifically, these emphasize the reconfiguration of the way in which businesses are created and imagined (Elia et al., 2020). Hence, it can be stated that digital transformation has recently emerged as a strategic approach to achieving competitive advantages and enhancing company differentiation (Ferreira et al., 2019), influencing both the structure and the nature of the goods and services

(Nambisan et al., 2017). Adapting an *entrepreneurial ecosystem* to digital transformation requires entrepreneurial actors to develop *dynamic capabilities*, as an ability to permanently reshape the firm's resources (Zahra et al., 2006), and a *strategic* renewal of the organization (Warner & Wäger, 2018). The integration of *technology* in firm activities has led to a rapid advancement of *digital platforms*, with an *impact* on *management* and *performance*. However, the impact of process *digitalization* on companies' dynamic capabilities and performance remains unclear (Ferreira et al., 2019). Under these assumptions, a more in depth analysis of the research could provide a better understanding of how digital entrepreneurship is perceived. To find out more, the main themes, connections, and trends will be highlighted as we carefully examine each of the clusters found in the bibliometric research, using the information provided in Figure 3 and Table 4 as a starting point.

Figure 3: Keywords Co-occurrence Map



Source: VOSviewer output

Table 4: The most relevant terms of each cluster

Cluster	The main keywords based on occurrence thereof
1 (red)	Digital transformation, dynamic capabilities, digitalization, management entrepreneurial orientation, information technology
2 (green)	Innovation, business model, technology, performance, entrepreneurial ecosystem, digital entrepreneurship
3 (blue)	Strategy, digital technologies, big data, transformation, industry 4.0
4 (yellow)	Entrepreneurship, digital platform, impact, creation, information, growth

Source: own processing

According to the results of the bibliometric analysis, **four clusters** were identified, each grouping different terms and represented in distinctive colors. Considering the weight of each

keyword, the nodes show the relationships between them. Every cluster has several nodes, and a closer relationship between terms is shown as a shorter distance, whilst a weaker relationship is indicated as a greater distance (van Eck & Waltman, 2023).

The **first cluster**, graphically represented in **red**, groups terms that bring to the fore the need for *dynamic capabilities* in the context of *digital transformation*. The integration of new digital technologies has become one of the greatest challenges that businesses and society are faced with nowadays, with no sector or organization remaining immune to their impact (Jafari-Sadeghi et al., 2021). According to the literature, entrepreneurial orientation has a significantly beneficial impact on disruptive innovation (Kraus et al., 2023). The COVID-19 pandemic accelerated this transformation process for businesses; under these circumstances, different researchers investigated the entrepreneurial orientation of employees at the organizational level (Ritala et al., 2021). In response to these challenges, a model based on resilience capability was proposed to help businesses adapt and thrive (Khurana et al., 2022), which is consistent with other empirical results that support resilience and innovation as key dynamic capabilities (Garrido-Moreno et al., 2024). It is also worth noting that digital competences positively affect digital entrepreneurial intention (Bachmann et al., 2024), while digital literacy is a must in order to reap the benefits of the digital economy (Zhou et al., 2024). Overall, the concepts within this cluster reaffirm the theoretical foundation that continuous adaptation constitutes an imperative for organizational survival (Warner & Wäger, 2018). Subsequently, these ideas align with evolutionary theories of the firm that suggest adaptability as the fundamental aspect between thriving and declining enterprises in a dynamic market. However, the findings of this cluster highlight also a major challenge for Resource-Based View (RBV) theory: while RBV traditionally focuses on tangible resources, digitalization involves a fundamental reconsideration of intangible resources' value (e.g., data, algorithms, digital skills).

The second cluster, illustrated by green, highlights the intersection of innovation, business models, and technology within the entrepreneurial ecosystem. It emphasizes how digital entrepreneurship drives performance and transformation, shaping the *entrepreneurial ecosystem* through *innovation* and *technology*. Recent studies demonstrate a significant number of digital startups are employing agile methods like Lean Startup approaches (Ghezzi & Cavallo, 2020), with adopters demonstrating higher performance metrics (Peng & Tao, 2022) (Garrido-Moreno et al., 2024). This evolution has led to the development of *digital entrepreneurship* as a distinct field that integrates entrepreneurship and digital transformation (Sussan & Acs, 2017) (Sahut et al., 2019). This new approach is seen as a significant vector in economic and social contexts (Bejjani et al., 2023) and has conducted to the development of related areas of study, such as digital academic entrepreneurship (Rippa & Secundo, 2019). For instance, Lean Startup Approaches can be used as agile methods to facilitate *business model* innovation within digital entrepreneurship (Ghezzi & Cavallo, 2020), with a positive impact on firms' performance (Peng & Tao, 2022) (Garrido-Moreno et al., 2024) (Zhai et al., 2022). Mainly, the actual dynamic of the market process suggests that the competition is not only between firms, but between platforms (Nambisan & Baron, 2021).

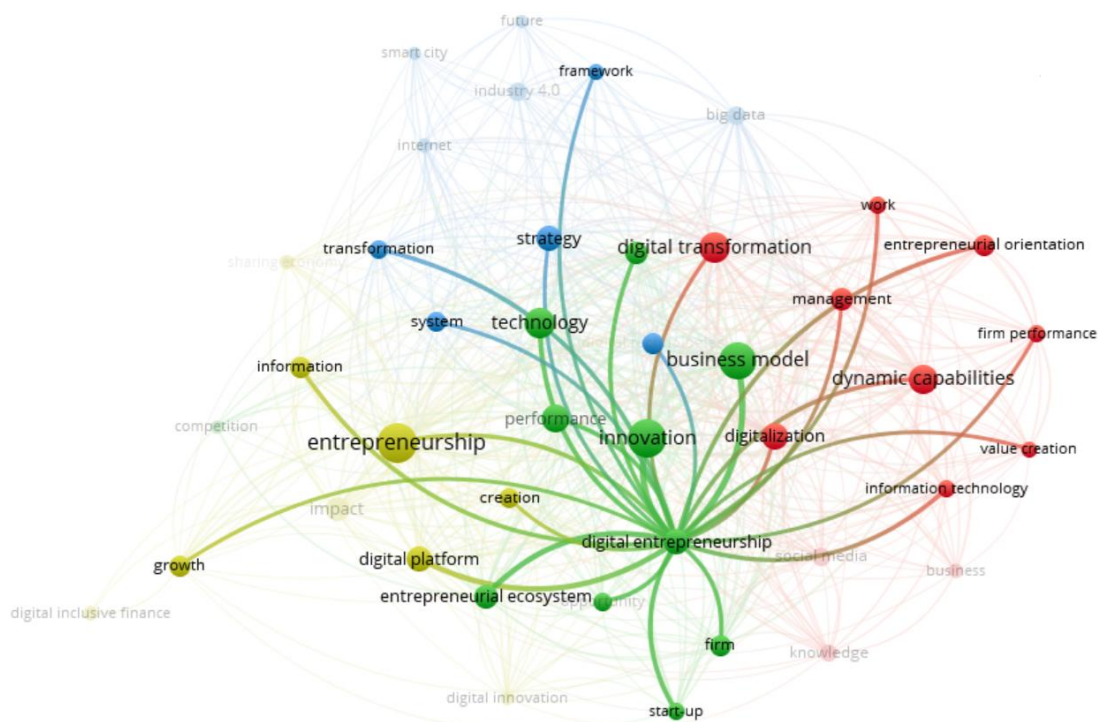
The blue cluster focuses on the *strategic* integration of *digital technologies*, *big data*, and *Industry 4.0*, driving transformation across industries. In other words, it illustrates the process of digital business transformation (Gupta & Bose, 2022) and the development of different types of dynamic capabilities, such as Big Data Analytics Capabilities (Ciampi et al., 2021). The emergence of different digital technologies has led to integration in the existing businesses – e.g., in agriculture (Li et al., 2023) – and to new entrepreneurial opportunities in various fields such as healthcare, entertainment, e-commerce, etc. (Modgil et al., 2022). Overall, these

changes are strongly related to the evolution of smart cities (Marchesani et al., 2023), which are seen as digital economy hubs (Li, 2018). The results bring to the fore digital transformation as a new framework for creating entrepreneurial value, in which the boundaries between physical and digital enterprises essentially merge. In this context, the cluster illustrates platform dependencies and hybrid models that require a reconstruction of the entrepreneurial debate for the Industry 4.0 period.

The yellow cluster highlights the *impact* of digital technologies on *entrepreneurship*. The rapid growth of *digital platforms* has led to a network effect, where success is strongly related to a dynamic competition (Fernandes et al., 2022). In this context, digital platforms and their associated ecosystems create an appropriate environment for entrepreneurship. However, in some cases, the phenomenon of platform-dependent entrepreneurs emerges (Cutolo & Kenney, 2021). Notably, while digital platforms offer significant advantages to entrepreneurs and new ventures (Nambisan & Baron, 2021), they also create a reliance on digital platform capabilities (Cenamor et al., 2019). Nevertheless, different business models that integrate information technologies, such as Alibaba, were on the rise (Li et al., 2018). Subsequently, digital platforms have evolved from simple transactional environments into comprehensive innovative ecosystems that actively influence entrepreneurial possibilities and limitations. Overall, these results define platform ecosystems as the modern institutional framework for entrepreneurial activities, with challenges and opportunities.

In general, the academic work has demonstrated the interconnections between entrepreneurship and digital technologies under the umbrella of digital entrepreneurship, as it is visually represented in *Figure 4*.

Figure 4: The relationship between digital entrepreneurship and associated keywords



Source: VOSviewer output

Overall, the four clusters illustrate the frequently addressed topics related to digital entrepreneurship, mainly based on the relationship between technology, innovation, and organizational performance. The heterogeneity of digital technologies and their implications for the market process are usually associated with the future, particularly with smart cities (Marchesani et al., 2023) or the reconfiguration of traditional business models. Different concepts linked to innovation – such as digital transformation, business model development, and value generation – highlight the dynamic characteristics of value creation within digital ecosystems. Under these circumstances, it can be stated that technological tools such as big data, internet infrastructure, and information systems create the framework to underpin these changes.

Conclusions

The research findings bring to the fore the complexity of digital entrepreneurship as a field of study, positioned at the intersection of two major areas, i.e. entrepreneurship and technology. To examine the current state of this topic, we proceeded to an interrogation of the Web of Science database, using a specific Boolean search and selecting highly cited papers as a key criterion.

After performing the bibliometric analysis using the VOSViewer software, four distinct clusters were identified, illustrating the relationship between the most relevant keywords. The cluster depicted in red grouped together terms associated with digital transformation and dynamic capabilities. The implications of digital transformation for entrepreneurial orientation are reshaping the businesses and managerial approaches, especially through the integration of social media and information technologies. The green cluster describes digital entrepreneurship as a result of the innovation on business models. The entrepreneurial ecosystem is integrating different technologies that are leading to a significant increase in firms' performance. The blue cluster emphasizes the strategic dimension of adopting digital technologies in developing smart cities, assuming tools such as big data and the internet. Finally, the yellow cluster groups the debates on the impact of information technology on growth, particularly through digital innovation and digital platforms. Overall, the four clusters are putting together the most relevant debates in the academic literature related to digital entrepreneurship.

The research limitations primarily arise from the use of a single database and the selection of only the most cited papers, which may not fully capture emerging contributions to the field. To address these limitations, we will extend our study by including other databases, providing a more diverse and comprehensive dataset. Also, we will conduct an in-depth analysis of the resulting clusters to provide an integrative landscape of digital entrepreneurship. Furthermore, our research will include related terms and concepts associated with digital entrepreneurship, allowing for a better understanding of its theoretical and practical implications. By refining our methodology and broadening our scope, we aim to provide a more holistic and representative perspective on the topic.

In terms of the implications of our research, this bibliometric analysis can serve as the starting point in understanding the impact of digital transformation on entrepreneurial activities, both in theory and in practice. For researchers, the main topics identified as clusters to improve our understanding of digital entrepreneurship can be further developed and analyzed in order to bridge the gap in the literature. Policymakers can use the results of this research to provide an integrative framework for digital entrepreneurship, while the business environment can

discover new entrepreneurial opportunities in related areas. In particular, policymakers can enhance digital entrepreneurship ecosystems by promoting digital infrastructure, education, and regulatory frameworks that stimulate innovation and the growth of startups. Conversely, entrepreneurs can utilize insights from the recognized clusters to embrace new technologies, improve digital skills, and create flexible business models that adjust to the ever-changing digital environment. Overall, the research contributes to the understanding of how digital transformation influences entrepreneurial ecosystems and practices by aligning academic insights with practical strategies.

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EMBRACING ORGANIZATIONAL AGILITY: TRANSFORMATIVE STRATEGIES FOR CREATING COMPETITIVE ADVANTAGE IN THE CORPORATE WORLD – LITERATURE OVERVIEW

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Abstract

In today's volatile, uncertain, complex, and ambiguous (VUCA) world, companies must rapidly adapt to unpredictable market changes or risk obsolescence. Since 2000, over half of the Fortune 100 companies have disappeared, while agile organizations that adjust their business models now dominate. Larger companies have become vulnerable because their transition processes often struggle with slow digital transformation. Smaller companies and startups have a clear advantage here, based on real-time user feedback and a strong focus on customer experience. Change is the only constant, and being an agile organization becomes crucial for competitive advantage in the turbulent business environment. We carried out a systematic review of the scientific literature on organizational agility to gain deeper insights into leadership and management within agile organizations. The objective of the paper is to provide a historical overview of the organizational agility evolution and to present a systematic review of the literature to help managers enhance organizational agility and serve researchers to further explore agile transformation models.

Keywords: Agile, organizational agility, competitive advantage, VUCA world, agile companies

JEL classification: M14, M16, M21, L66

Introduction

In a world characterized by rapid change and uncertainty, transitioning to an agile operating model has become imperative for thriving during disruption and gaining a competitive advantage. This transition is particularly challenging for larger multinational companies, which are deeply rooted in rigid structures and inefficient processes. Despite these challenges, successful agile transformation models have essential common elements that can guide enterprises on their journey.

The theory of corporate agility started in the early eighties and has become a trend, particularly during the last decade of the 21st century. Initially focused on corporate responsiveness to company objectives, the concept advanced into agile production and manufacturing and evolved into an agile organization. Most recently, it has been used as a guiding principle for improving corporate culture and efficient workforce planning. Agility is an important capability for organizations, and its mindset is necessary among top management and across the entire organization, from a top-down to bottom-up approach. The idea of agility is highly relevant for

large multinational organizations characterized by complex structures and diverse operations. “Agility embraces two main directions: (1) the fast response to changes (anticipated or unexpected) in proper ways and in due time; and (2) utilizing changes and leveraging them as opportunities “(Hernaes et al., 2020:87).

Traditional organizations and big corporations have long been structured around rigid hierarchies, characterized by siloed departments and top-down decision-making processes. In contrast, agile organizations thrive as dynamic networks of teams, operating within rapid learning cycles that emphasize iterative progress and decentralized decision-making within flat organizations. These organizations align their entire structure around a common purpose and empower the teams closest to the information with decision rights, leveraging real-time data and a bottom-up approach that fosters innovation, responsiveness, and consumer centricity. This shift requires a fundamental change in thinking and mindset at all levels of the organization. Rather than attempting to deploy control from the top down, in the traditional way, companies must empower employees at all levels to make decisions. Organizations should balance by combining the speed and adaptability learned from start-ups with the stability and efficiency that they possess. These are the crucial characteristics that define agile organizations, where agility becomes synonymous with flexibility in today's VUCA world.

An organizational agile transformation demands a wide-ranging and iterative approach. It should be widespread in scope, touching upon every part of the organization, from strategy and structure to people, processes, and technology. Simultaneously, it must be iterative, acknowledging that not everything can be anticipated or planned from the outset. Continuous learning, consumer feedback, and adaptation become core components of this transformation journey, allowing organizations to improve their practices as they evolve. As companies begin their journey towards agile transformation, they must be ready for a continuous commitment to significant cultural and operational changes. By adopting agility, organizations set themselves up not only to survive but to excel in an uncertain and rapidly evolving business environment, becoming resilient and, above all, competitive forces in their industries.

This paper provides an overview of current literature on organizational agility, focusing on how these concepts are defined and how they can help big corporations to evolve and remain competitive. Our review highlights key drivers such as the need for flexibility, collaboration, and rapid adaptation in dynamic and turbulent business environments. The insights gained from this overview offer practical guidance for managers to boost organizational agility, while also serving to researchers seeking to further explore agility and support companies in their agile transformation process.

Literature overview

This paper is grounded in literature that examines the progress of organizational agility over the last few decades and presents examples and best-case learnings to support the growth of agility initiatives in a business environment. Several studies, notably Margherita et al. (2021) with its comprehensive holistic approach, compared to others, have intended to review and categorize different perspectives on organizational agility. This overview enhances our understanding of how organizations can advance their agility when faced with volatile and unpredictable business environments.

Baramichai et al. (2007) developed the Agile Supply Chain Transformation Matrix (ASCTM), a tool that was created for quality function deployment (QFD) and analytic hierarchy process (AHP) techniques. Their research suggests that improving agile capabilities starts with evaluating the business ecosystem and any variations impacting the supply chain and its processes. This assessment highlights areas requiring focus by outlining specific response strategies and approaches, which help determine the business practices and infrastructures necessary to enhance the company's responsiveness to change.

Bernardes and Hanna (2009) provided a theoretical review concerning flexibility, agility, and responsiveness. They proposed a conceptual distinction between these three terms, defining agility as a methodology for facilitating quick system reconfiguration when faced with unpredictable changes. According to Braunscheidel and Suresh (2009), agility is primarily achieved through various originators, including cross-functional teams and external assimilation within the organization. Dyer et al. (2009) examined organizational agility through the perspective of science complexity, emphasizing elements like interactions, self-organization, and co-evolution. Gunasekaran (1998) describes agility in terms of manufacturing, distribution, partnership development, engineering processes, integrated information systems, and e-commerce. Karwowski et al. (2007) carried out an analysis of enterprise agility's concepts, frameworks, and attributes. The study highlights the common characteristics of agility that are relevant across all areas of an organization, such as flexibility, responsiveness, speed, cultural transformation, integration, high-quality and consumer-focused products, and the leveraging of core competencies. Leyburn (2013) outlined an agile business management approach that focuses on four key 'domains' where changes are necessary to achieve agility: the roles, responsibilities, and operational methods of management; the organization's relationship with customers; the organizational context and human resource management; and the tools and techniques used to optimize workflows, leverage changes, and are consumer centric.

Preiss et al. (1996) examined four vital steps that could help an enterprise develop agility. The initial step involves understanding the business environment and its changes. The second step focuses on identifying the organizational attributes that help assess internal enablers or obstacles to responding to these changes. The third step involves establishing the necessary infrastructure to promote and implement agility. Finally, the fourth step involves identifying and leveraging business processes essential for the organization to maintain its competitive advantage. Wendler (2013) systematically examined agility frameworks across agile manufacturing, agile software development, agile organizational structures, and agile workforce. The study found that there is a lack of consensus on the concepts and constructs that are used, and they sometimes appear unclear and overlapping.

Zhang & Sharifi (1999) developed a conceptual model of organizational agility with three main components: agility drivers and environmental changes; agility capabilities and organizational strengths; and agility enablers. Their approach emphasizes assessing current and required agility levels by analyzing drivers and identifying gaps, which leads to four possible agility degrees—from no need for agility to urgent adoption. The process involves change detection, capability identification, strategy formulation, defining initiatives, measuring performance, and taking corrective actions. Later studies by the authors further explored agility assessment, the factors necessitating agility, and determining the appropriate level of agility for organizations aiming to become agile.

The literature review by Margherita et al. (2021), summarized in Table 1, identifies seven key focus areas for further studying and implementing organizational agility. These areas include: (1) External and internal drivers of organizational agility, (2) Agility strategy and goals, (3) Agility capabilities and required competencies, (4) Technology enablers of organizational agility, (5) Human resource enablers of agility, (6) Processes for agility, and (7) Agility performance measurements. Here we can observe the upgrade in comparison to previous models, which provides a comprehensive framework for organizational agility by focusing on strategy, action, and performance across the entire organization, rather than concentrating on individual functions.

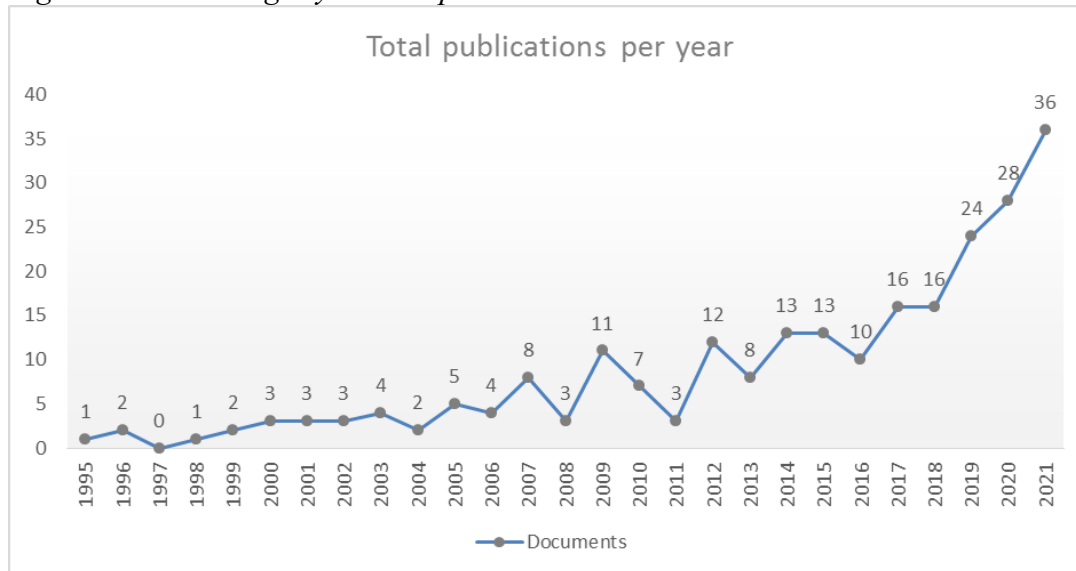
Table 1: Source: Agility-related focus areas

AUTHOR	AGILITY CONCEPT	FOCUS AREA
Gunasekaran 1999. Gunasekaran and Yusuf 2002. Hallgren and Olhager 2009. Sherehiy et al. 2007. Yusuf et al. 1999. Zhang and Sharifi 2007	Change Factors Agility Drivers Environmental Analysis Organizational Factors	Internal and external drivers of agility
Dove 1999. Meredith and Francis 2000. Sambamurthy et al. 2003. Sanchez and Nagi 2001. Sherehiy et al. 2007. Zhang and Sharifi 2007.	Current and Desired Level Exploitation Exploration Gap Goal Response Strategy	Agile strategy and goals
Bottani 2010. Braunscheidel and Suresh 2009. Dove 1999. Eshlaghy et al. 2010. Gunasekaran 1998. Power et al. 2001. Sangari et al. 2016. Sherehiy et al. 2007. Swafford, et al. 2006. Tseng and Lin 2011. Vazquez-Bustelo et al. 2007. Zhang and Sharifi 2007.	Antecedents Capabilities Critical Success Factors Competencies Organizational Abilities Prerequisites	Agility capabilities and competencies
McGaughey 1999. Mondragon et al. 2004. Overby et al. 2006. Karwowski et al. 2007. Waarts et al. 2006. Zhang and Sharifi 2007.	Information Systems Infrastructure Providers, Structures Technology	Technology enablers of agility
Breu et al. 2001. Layer et al. 2007. Thong and Chan 2009. Zhang and Sharifi 2007.	Human Resource Practices Intelligence, Motivation Organizational Culture, Organizational Learning People, Workforce	Human resource enablers of agility
Flidner and Vokurka 1997. Preiss et al. 1996. Raschke 2010. Sherehiy et al. 2007. Upton 1995. Vokurka and Flidner 1998. Zhang and Sharifi 1999. Zhang and Sharifi 2001. Zhang and Sharifi 2007.	Actions, Business Processes, Collaboration, Cooperation, Coordination, Product Customization, Innovation, Integration, Plant Change, Project	Processes for agility
Adarsh et al. 2017. Charbonnier 2011. Li et al. 2009. Lin et al. 2006. Tsourveloudis and Valavanis 2002.	Assessment Feedback Market Maturity Index Performance Measurements Product, Quality Resiliency Responsiveness	Agility performance measurements

Source: Margherita et al. (2021)

In the recent literature overview (Franco et al. 2024), there has been an increasing trend in publications about agility per year, showing a slightly exponential trend. The number of publications has grown from 3 per year at the beginning of the 21st century to 36 in 2021, as illustrated in Figure 1. This trend highlights the growing interest and importance of agility in various fields.

Figure 1: Source: Agility-related published articles



Source: Franco et al. (2024: 137)

According to the same author, Europe is the continent with the largest number of publications on agility, totaling 61. The UK stands out with 36 papers, followed by Germany with 15, and Finland with 10. In terms of individual countries, the USA leads with 51 publications, followed by India (20), Brazil (14), China (12), Australia (11), Malaysia (10), and Taiwan (10). This data is provided in Table 2 of the article. Interest in organizational agility is growing, with a marked increase in academic publications, particularly in Europe and the USA. Research clusters focus on people, strategy, technology, value delivery, and organizational structure as main topics, as summarized in Table 2.

Table 2: Source: Top 10 countries in publishing

Country	Documents	Links	Total link strength	Avg. publications year
UK	36	10	36	2014
USA	51	10	27	2012
Germany	15	5	17	2018
Malaysia	10	6	11	2017
China	12	4	8	2016
Taiwan	10	3	8	2018
India	20	4	6	2015
Australia	11	2	4	2014
Brazil	14	2	2	2017
Finland	10	1	2	2011

Source: Franco et al. (2024:138)

Table 3: Source: Top authors with the highest link strength

<i>Author</i>	<i>Documents</i>	<i>Citations</i>	<i>Total link strength</i>
Gunasekaran A.	7	1559	21
Yusuf Y.Y.	4	1096	15
Sarhadi M.	1	776	2
Leih S.	1	636	2
Peteraf M.	1	636	2
Teece D.	1	636	2
Ives B.	1	504	1
Piccoli G.	1	504	1
Papadopoulos T.	3	449	10
Childe S.J.	3	368	9

Source: Franco et al. (2024:140)

The theoretical background is as follows: Organizational Agility is a people-centered and organization-wide capability that enables the organization to create value in the context of an environment increasingly characterized by a VUCA world. Agility is achieved through inspiration and creativity in the ways of working, with collaborative integration of the organization's people to achieve its central objective. Agile organizations are stable and dynamic at the same time. They design stable structural elements that evolve slowly and hold dynamic resources that can easily adapt to new challenges and opportunities (Wangsa et al., 2022). Based on the results obtained, this review contributes to the literature on agility by identifying its relationship with competitive advantage, which represents an important contribution to the field of business strategy. The contribution also results from the identification of clusters associated with specific areas of knowledge in management: people, strategy, technology, processes, value delivery, and organizational structure.

An agile organization is characterized by its ability to quickly and efficiently adapt to both internal and external market changes. This adaptability allows the organization to meet evolving customer needs and the dynamics of its operating systems. The focus on agility enables the organization to react fast to changes and anticipate them, ensuring consumer-centricity, productivity, and cost-effectiveness. Agile organizations maintain the highest standards of quality even as they evolve and innovate, ensuring customer satisfaction and business integrity. This requires a culture of continuous learning, open communication, and a flexible approach to processes and structures within the organization.

The main objective of agile organizations is to continually maintain a competitive advantage over their competitors in the marketplace. Modern organizations must follow agile practices in their business activities, as the future is unpredictable, and there is a strong forecast of disruptive technology constantly upgrading, meaning that customer needs and requirements are becoming increasingly uncertain. Organizations that adopt agile practices can adapt more quickly, delivering and creating value regularly, testing the environment, and maintaining customer focus.

Examples of agile transformations

There are various approaches to adopting organizational agility among big corporations. Some organizations are inherently agile, utilizing an agile operating model from the outset. For others, the journey to agility can be broadly categorized into three types: (1) a company-wide commitment to embrace agility, involving multiple waves of agile transformation; (2) a systematic and more gradual approach; and (3) an emergent, bottom-up approach.

Here are some successful examples of Agile Transformation in MNCs, as found on companies' websites and among the recent Fortune Top 100 list:

- Amazon has implemented rapid innovation cycles and automation of delivery systems, allowing it to stay ahead in the competitive e-commerce market.
- Microsoft has adopted iterative development and strong agile principles, enabling it to continuously improve its software products and services.
- Google uses agile principles through canary releases and pyramidal testing, ensuring that their products are thoroughly tested and refined before full-scale deployment.
- Apple incorporates iterative design and development processes, along with customer feedback, to create innovative products that meet consumer needs.
- Wayfair has applied agile methodologies to its software development and testing processes, enhancing its ability to deliver high-quality products quickly.
- Tesla's rapid innovation in the automotive and energy sectors is driven by agile practices, allowing it to stay at the forefront of technological advancement.
- Philip Morris International transformed its business model to agile, triggered by the launch of innovative smoking alternatives and a "smoke-free" vision of the future.

The Agile Transformation of many of the above-mentioned companies is driven by change, often initiated by the launch of innovative products or a new vision for the future. For successful agile transformations, it is crucial to have strong and aligned leadership from the top, with a high level of aspiration from the top team. A compelling, common understanding and a jointly owned aspiration are essential for success and for fostering a mindset shift, which is also the common factor of all these stories.

For example, the company, long known for its traditional tobacco products, mainly cigarettes, faced increasing pressure when global smoking rates began to decline, and regulatory measures strengthened significantly. Their vision was to prevent smoking and reduce it to zero. To address these challenges, they embarked on a mission to transform their business model, embracing an agile approach focused on and triggered by innovative products, their flagship heated tobacco system. The major challenge was the reduction in global cigarette consumption that posed a significant threat to the company's traditional business model, forcing a shift towards reduced-risk products. The company needed to innovate quickly and effectively to maintain leadership in the evolving market landscape.

Here are the most important elements and steps that were crucial for its transformation to become successful, especially in the multinational environment:

Support from the highest management. Transformation Strategy needs to be driven from the very top of the company; the visionary shift and commitment should start with the CEO and top management, who should announce a transformational vision to steer the company towards the future, focusing on research and development of innovative products or services.

Research and Development Investment: Companies should make significant investments in scientific research, establishing a dedicated R&D center to drive innovation.

Agile Prototyping and Testing: By adopting agile methodologies, companies will be able to speed up the development cycles of innovation, incorporating iterative feedback from both consumers and employees.

Organizational change management and Cultural Adaptation: Companies should endorse a cross-functional project team by integrating SMEs (subject matter experts) from different departments like R&D, marketing, sales, finance, and regulatory affairs to streamline innovation rollout.

Empowered Teams: Companies should create agile teams with the autonomy to make quick decisions, fostering experimentation and nurturing an entrepreneurial culture within the company based on consumer feedback and ideally design thinking methodology.

Consumer-Centric Development: Companies and their employees need to be directly engaged with consumers during early product testing phases, refining the brand based on consumer feedback to better meet and understand consumer needs in the early phases of the consumer journey.

Strategic Market Introductions: Before a full-scale global launch, they need to implement a phased introduction strategy for the brand, starting in selected pilot markets, where high consumer acceptance is predicted and fewer regulatory barriers provided as ideal environment for its initiative, should collect all consumer feedback and learnings to apply immediately on other markets.

KPIs and measurement: Setting clear KPIs and measurements for tracking the development and success of Agile transformation is crucial. They need to introduce some kind of Market Maturity Measurements, and every year, to evaluate the progress of this important organizational and mindset shift. It should include several questions about important elements of Agile transformation and related KPIs, e.g., people trained, % of project-based organization vs. traditional, NPS (net promoting score) among employees related to company culture and satisfaction, data-based decision-making impact on strategy (bottom-up approach).

Organizational agile transformation must be both comprehensive and iterative. This means it should encompass all aspects of the organization. At the same time, it must be iterative, recognizing that not everything can be anticipated or planned from the outset. Continuous learning and adaptation are essential components of this journey, together with the consumer journey, allowing organizations to refine their practices as they evolve. By adopting a holistic approach and remaining flexible, companies can navigate the complexities of transformation and achieve sustainable success. This balanced approach ensures that the transformation is systematic, addressing every critical area while also being adaptable to changes and new consumer insights that emerge along the way to build a competitive advantage.

The agile transformation demonstrates that even the largest corporations can experience cultural and structural changes. By embracing an agile mindset and practices, these companies have become more responsive to new market needs and technological advancements, ensuring their competitive edge for the future. Key elements of this transformation are highlighted in the McKinsey study on *The Journey to Agile Organization* and the model presented in Figure 2.

Figure 2: Key elements of transformation according to McKinsey



Source: McKinsey (May 2019:2)

The transformation shifts organizations from rigid hierarchies to flexible, cross-functional teams, empowering employees to collaborate, build new skills, and take greater ownership of outcomes based on data-driven decision making, addressing all facets of organization – strategy, people, processes, technology, and structure.

Conclusion

In a VUCA world, expressed by volatility, uncertainty, complexity, and ambiguity, the ability to adapt quickly is synonymous with success. Change is inevitable, and corporate businesses must transform their business models to become more resilient, and organizational agility is essential for maintaining a competitive advantage.

The path to agility is fundamentally anchored in cultural transformation and a dedication to ongoing change. It's crucial to recognize that agile is not merely a methodology but a mindset. Without the right agile mindset, even with all structures and systems in place, companies may still find it challenging to gain substantial benefits. Agile practices can easily turn into routine tasks rather than avenues for true innovation and adaptability.

By embracing an agile mindset, the groundwork is set for a strong agile operating model to naturally evolve. A shared commitment to agility fosters an environment where a clear and aspirational vision can catalyze transformative change, enabling organizations to pivot efficiently and capitalize on new opportunities as they arise.

Therefore, the importance of cultivating an agile mindset across all levels of an organization cannot be overstated. It involves investing in a culture of continuous learning, open communication, and collaboration, where teams are empowered to experiment, learn from failures, and iterate towards better solutions.

To truly embed agility, organizations must concentrate on leadership development that reinforces these values. Leaders play a pivotal role in championing and modelling agile principles, thereby fostering an atmosphere of trust and psychological safety where innovation can thrive, and people are empowered and motivated.

In summary, becoming an agile organization is a constant journey rather than a destination. By embracing an agile mindset and culture, organizations can do more than just respond to change—they can proactively shape it, maintaining long-term relevance, a focus on customers, people empowerment, and a strong competitive position in the global market.

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LEARNING ORGANIZATIONS FOR VIABILITY IN THE HOSPITALITY INDUSTRY IN THE CONTEXT OF INSTITUTIONAL THEORY: A STUDY OF HOTELS IN ANTALYA, TÜRKİYE

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Abstract

This study addresses the intricate interplay of learning organization practices within the framework of institutional theory in the hotel industry to provide perspectives on how hotels can foster a culture of continuous learning and achieve competitiveness and viability. It is a qualitative exploratory study of hotels in Antalya, Türkiye, focusing on the implemented learning organization practices. Eleven hotel managers participated in semi-structured interviews to provide qualitative information, which was then analyzed thematically. The findings of the study point to the importance of learning organization practices in achieving the goals of competitiveness and viability, with managers acting as key actors in shaping such practices based on organizational value systems, culture, mental models, and behavioral routines, as postulated by institutional theory. Practical implications relate to the importance of strategic leadership in shaping the learning environment and implementing learning organization practices to achieve the goals of competitiveness and viability. Hotel management should prioritize opportunities for continuous learning, encourage communication and implement measures that enable employees to work towards a common goal. This study fills a gap in previous research by providing insights into how hotels can achieve viability goals by implementing learning organization practices based on strategic management for learning as postulated by institutional theory.

Keywords: learning organizations, viability, institutional theory, hospitality industry

JEL classification: L83, D83, M12, M14

Introduction

An organization that understands the importance of developing knowledge and skills for both individual and organizational adaptation, development and transformation and actively promotes and facilitates continuous learning and growth of employees is considered a learning organization (Kenny, 2006; Chadwick & Raver, 2015; Odor, 2018). In the context of the hospitality industry, the idea of a learning organization has attracted great interest because it can promote creativity, flexibility, and environmentally friendly practices through continuous learning and improvement based on stakeholder orientation (Tajeddini, 2011; Kalıpçı, 2023b).

According to Köseoglu et al. (2016), hotels must constantly strive to differentiate themselves from the competition and maintain a competitive advantage. Due to the emergence of new technologies, demographic shifts and changing customer behavior, the hotel industry is also especially susceptible to changing consumer preferences (Sharma et al., 2022). In order to cultivate a creative and adaptive learning culture that can help hotels stay ahead of the curve and anticipate the needs and preferences of their guests, it is critical that they evolve into learning organizations (Marquardt, 2011). Hotel managers have a responsibility to create an environment that supports organizational learning as the hospitality industry is constantly changing (Furunes, 2005). A culture of continuous learning and development can therefore help hotels to take an advantageous position to survive in an extremely competitive environment (Fraj et al., 2015).

This study contributes to the ongoing academic debate on how the learning organization philosophy influences the adoption of learning organization practices in the hospitality industry that can ensure sustainability and profitability by using the framework of institutional theory. To better understand how learning organization concepts are integrated into hotel operations and organizational culture to promote innovation, adaptability, and continuous learning, this study explores a range of learning organization practices from the perspective of hotel managers, such as communication strategies, collaborative practices, opportunities for continuous learning, and strategic leadership. In this way, attention is drawn to the nuances that are sometimes overlooked in hotel managers' understanding and application of learning organization practices to improve their performance and achieve the goals of profitability and competitiveness. This study therefore attempts to answer two research questions:

1. Do hotels implement learning organization practices and to what extent?
2. Does the implementation of learning practices contribute to the achievement of goals of competitiveness, viability, and sustainability of hotels?

Literature review

The theory of the learning organization proposes the implementation of specific practices that promote continuous improvement, adaptation and sustainability. Special attention is given to the continuous discovery and creation of learning opportunities by providing various learning experiences, e.g. formal training programs and mentorships, action learning, experiential learning, non-formal and informal forms of learning through self-directed sources, etc. (Argyris & Schön, 1978). Learning is also stimulated by problem solving, which is supported by experimenting with new approaches when different tools, methods and techniques are tested to solve different problems and find improvements (Garvin, 1993). In learning organizations, members are also encouraged to learn from past experiences, i.e. to reflect on successes and failures in order to gain insights and improve, but also to learn from others internally and externally and adopt their best practices (Garvin, 1993). In learning organizations, knowledge is also shared within the organization, so knowledge sharing and transfer is another important practice of the learning organization (Garvin, 1993). A special place is devoted to creating a psychologically safe environment in which employees can express their opinions, engage in dialogs and reflect critically, take risks and make mistakes without fear of punishment (Argyris & Schön, 1978; Edmondson, 2018). Therefore, encouraging inquiry and dialog is another important practice of the learning organization.

The literature highlights the benefits of implementing learning organization practices, including improving operational efficiency, decision-making capabilities and employee engagement

(Khodabandelou et al., 2023). By implementing learning practices, learning organizations continuously improve and innovate their processes, products and services, making them better able to adapt to changes in the market and environment, which increases their adaptability and competitiveness (Feeney et al., 2023). Even though companies operating as learning organizations are subject to external regulations, they manage their own practices based on their stakeholder orientation, which is the path to viability (Rupčić, 2024). Learning organizations promote a learning culture that fosters responsible innovation in environmental practices such as waste reduction, energy conservation and efficient resource management (Dzhengiz, 2020). Learning organization practices supported by stakeholder orientation help organizations to remain agile, innovative and competitive, suggesting that the relationship between learning organization practices and competitiveness and sustainability is positive and significant (Zgrzywa-Ziemak & Walecka-Jankowska, 2021; Feeney et al., 2023).

Learning Organization in the Hospitality Industry

Learning organizations are agile in customer-centric, rapidly evolving industries such as hospitality (Anning-Dorson & Nyamekye, 2020), where organizations must constantly innovate and adapt to changing consumer preferences and market trends (Olsen & Connolly, 2000; Poretti et al., 2024). Through the process of learning, tourism organizations can improve their performance in the market, increase customer satisfaction and even develop new products (Foris et al., 2020; Khassawneh et al., 2024). Hospitality organizations that are culturally inclined to learn can meet the diverse and dynamic needs and desires of their customers (Khalid et al., 2023). The literature shows that developing a learning culture can improve innovation and value creation in companies in the travel industry (Andreassen et al., 2018). Service innovation in companies is closely linked to learning, as Kalıpcı (2023b) states. This enables travel companies to develop new products and increase customer satisfaction (Chen et al., 2017).

The agility of companies committed to learning is useful to meet the challenges that arise in the market, including supporting sustainable development. Tourism companies can therefore contribute to maintaining the sustainability of destinations by effectively managing resources and minimizing negative impacts on the environment (Liu, 2003), as well as keeping up with the latest trends in the industry and adopting best practices (Daily & Huang, 2001). Finally, the ability to acquire and apply knowledge makes a big difference in the current environment and is a clear indication of the importance of learning related to sustainability in the hospitality industry (Alonso Almeida et al., 2015). Therefore, tourism organizations can improve the sustainability of their activities by ensuring that learning and information sharing is a regular activity in the organizations (Åberg, 2020). Members of tourism groups can work together to design and formulate sustainable tourism strategies that benefit all members of the industry by sharing best practices and experiences (Halme, 2001). This can lead to the formation of sustainable tourism destinations that are environmentally, socially and economically sustainable (Liu, 2003).

Institutional theory in tourism

The complexity and changing processes in the tourism industry can be understood through the lens of institutional theory (Lavandoski et al., 2016). Institutional theory, when applied to the tourism industry, is referred to as “Tourism Institutional Theory” (De Grosbois, 2016) and it can help explain the complexity and dynamics of the tourism industry (Lavandoski et al., 2016). Institutional theory emphasizes the importance of norms and rules for organizational behavior.

According to institutional theory, management plays a central role by acting as a link between the internal and external environment by scanning the environment for new information and knowledge, interpreting it and disseminating it within the organization. They then shape organizational routines and practices to ensure the viability and legitimacy of the organization (Aldrich, 1999). In learning organizations, managers design organizational routines in the form of learning practices that promote individual learning, knowledge sharing, and the translation of new knowledge into value creation and innovation. This is particularly important for the hospitality industry. Hotels can improve their operations by providing learning opportunities that align with institutional expectations for sustainable practices (Kronenberg & Fuchs 2021). This not only strengthens the reputation of hotels in the industry but also promotes a sustainable environment that meets the demands of today's consumers.

Research has shown that by fostering a learning culture that enables hotels to engage more effectively in viability and sustainability through the process of organizational learning, hotels are incentivized to adopt practices that align with industry norms and regulatory standards, as well as other influencing factors such as competition (Fong et al., 2018). By aligning with institutional expectations for sustainable practices, hotels can benefit from being provided with opportunities for continuous learning (Kronenberg & Fuchs, 2021). This not only increases the efficiency of hotels, but also their reputation in the industry as stakeholders increasingly prioritize sustainability-oriented initiatives leading to greater legitimacy and viability. Therefore, the context of institutional theory helps to bridge the research gap and highlight the link between learning organizations and legitimacy efforts and create an understanding of this dynamic within the hospitality industry.

Methodology

The implementation of learning organization practices to achieve the goals of sustainability and viability was examined using the exploratory approach, presenting the exploratory study of hotels in Antalya, which is known as the tourism capital of Türkiye. Purposive sampling was used to ensure that participants were selected with the necessary skills, backgrounds, and perspectives to offer deep insights into the phenomenon under study (Palinkas et al., 2015). In this study, managerial roles, previous experience in the hospitality industry, and familiarity with learning organization practices were among the selection criteria considered when choosing participants. Open-ended, semi-structured interview questions were used to encourage open discussion of respondents' opinions and feelings. The questions in this interview guide were mainly taken from Yeung et al. (2007). A total of 16 hotel managers were pre-interviewed, 11 of whom gave their consent to the interviews. Subsequently, 11 face-to-face interviews were conducted with managers of 11 five-star hotels in Antalya, Türkiye, between November 21, 2022, and December 27, 2022. Each interview was transcribed and then the raw data was subjected to first and second order analysis. As part of this analysis, the material was categorized according to emergent themes, which were then integrated into themes that were considered relevant and congruent with the interviews from a theoretical perspective. Units that shared a common meaning were grouped together and separated from those that did not. The aim was to identify patterns through congruence, differences or similarity (Charmaz, 2006). For the data analysis, the digital recordings of the interviews were converted verbatim into text. The analysis was conducted in parallel with the questions and new data was explored iteratively using a technique that guided the interviews and generated ideas for further research. The web toolbox provided by Voyant Tools was used to illustrate the analysis of the interview data in

various ways. Voyant Tools was used to identify the frequency of use of words for all questions in the coding process and the word frequencies for each question (Table 1).

Table 1: Codes for Questions

Codes for Q1			Codes for Q2			Codes for Q3			Codes for Q4-A			Codes for Q4-B			Codes for Q4-C			Codes for Q4-D			Codes for Q4-E		
Code	Count	%	Code	Count	%	Code	Count	%	Code	Count	%	Code	Count	%	Code	Count	%	Code	Count	%	Code	Count	%
hotel	13	18	learning	18	21	learning	17	24	learning	8	17	staff	6	12	work	11	23	training	8	14	vision	14	20
staff	9	12	organization	14	16	education	17	24	training	4	8	dialogue	6	12	team	8	16	job	6	10	hotel	14	20
guests	8	11	organizational	8	9	course	10	14	opportunities	4	8	questioning	5	10	training	4	8	learning	5	8	year	5	7
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Findings

The results of the thematic analysis are presented next.

Importance of information and knowledge in managerial work

The respondents emphasized the importance of communication, information exchange and knowledge for the accomplishment of their tasks.

“P-11: My role in the hotel is to provide the connection between senior management and my sub-management. “

“P-7: A manager who is aware of his/her responsibilities and has the necessary knowledge and skills to fully fulfill his/her duties and use his position effectively. “

The respondents emphasized the importance of organizational agility based on learning and knowledge sharing which is crucial for organizational survival, transformation and viability. Respondents said the following:

“P-5: In my opinion, a learning organization helps a hotel or a company to deal with the positive or negative events to which it is exposed and to continue its operations as unscathed as possible.”

“P-3: Organizational learning is the process used in an organization to create, retain and transfer knowledge. An organization changes as it gains experience over time. This event has the potential to produce knowledge. This vast body of knowledge encompasses any topic that could improve an organization.”

Respondents distinguished between education and learning and emphasized the continuity of the learning process in life and in organizations through a variety of sources, but with a focus on its effective implementation.

“P -4: Education takes place at a certain age but learning lasts until the end of life. Normal life teaches you more things. The lessons you learn in universities are limited, within the framework of a certain book and within the framework of applications, but in life many things come at you from different directions, learning is a very diverse concept. We learn while we live until we die.”

“P -5: Yes, of course there is. For example, we offer training in the field of work. We teach how to do a job properly. Learning is limited to the information we impart, but education means putting what we learn into practice by applying and interpreting it.”

Implementation of learning organization practices

Respondents were asked about the practices of the learning organization, including the continuous creation of learning opportunities for employees, practices that encourage constant questioning of reality and promote dialog between employees and management, practices that promote team collaboration and learning, systems that enhance knowledge management through learning and knowledge sharing, practices that empower employees to achieve the collective vision, assessments of the external environment and its influence on organizational behavior, and the availability of strategic leadership to promote learning.

The initial inquiry focused on the availability and creation of learning opportunities. Respondents emphasized the importance of continuous learning to better adapt their companies to current trends and requirements and to foster innovation within their organizations.

“P-8: Yes. Continuous learning is essential for innovation and adaptation to development. Learning opportunities are continuously provided to employees to gain new knowledge and be open to innovation.”

Respondents were asked about the practices they use to promote continuous critical reflection, questioning and dialog. They confirmed the importance of dialog and questioning the current reality, especially during training and social events, while pointing out that there is room for improvement and further implementation of such practices in everyday organizational life.

“P-2: To encourage dialog, we have many meetings with our employees throughout the year, but they are mostly social events, for example, we have evening meetings with our employees, we have a social committee, etc. We also encourage questioning through our internal audit systems, especially during training sessions.”

“P-4: Of course, we encourage dialog and questioning. We do this above all when we train our colleagues. As an organization, we are constantly learning and growing.”

Next, respondents were asked to identify practices that foster collaboration and team learning. They emphasized the importance of collaboration, solidarity, team learning, and training.

“P-5: We often work in cooperation and as a team. One person alone can't achieve and complete every task, but if everyone does their tasks as a team, the work is done faster, and we are less tired and relieve each other a little.”

“P-7: Yes, teamwork is often possible and necessary, followed by training for individuals to overcome their deficits in weekly training sessions that involve teamwork. “

“P-8: Meetings and training sessions are essential at the beginning of the work, as is the team spirit that requires solidarity during work and better collaboration.”

Further exploration focused on practices that promote learning and knowledge sharing. Respondents emphasized the importance of work-based learning and the sharing of knowledge among colleagues.

“P-1: As far as learning is concerned, our hotel naturally gathers our employees once a month and offers job-related training, the topics of which can be the induction of new employees, addressing the guest or language courses. These are the main topics on which we offer training. Employees are then encouraged to discuss their learning outcomes with their colleagues.”

“P-6: Our hotel's HR management has created the necessary systems for our new, eager-to-learn colleagues and put them into practice. They can easily access the available learning modules.”

Respondents were also asked about the shared and collective vision and its implementation by all organizational members. They emphasized the importance of ensuring that everyone is familiar with the company vision.

“P-1: Our vision is to make every guest happy, from the moment they enter the hotel to the moment they leave, and to welcome them in the best way and offer them the best service we can as the departments most involved with the hotel's guests. Every employee is made aware of this vision at every training session.”

“P-5: We strive to be a hotel where even the simplest things are considered to provide the best service for customer satisfaction. We inform the staff of all this, including the importance of a smiling face and personalized attention.”

The investigation focused next on whether the organization learns about its external environment through continuous assessment of its characteristics. Respondents demonstrated awareness of the external environment's importance and emphasized the significance of social responsibility and sustainability.

“P-8: The factors that link the organization to the external environment are the technological, demographic, natural, cultural, economic and social environment. These factors are evaluated. We pay particular attention to social responsibility and the sustainability of our business and inform our employees about the necessary measures.”

The inquiry also examined whether managers strategically guide employees in their learning efforts. Respondents confirmed the importance of strategic leadership for learning and noted that specific training is provided to support this.

“P-4: Although some say leadership is innate, our company emphasizes leadership training to best support employees in their work and help them learn continuously so that we can achieve our vision and mission together.”

Respondents emphasized the importance of practices that facilitate learning, such as learning by doing, as well as the availability of learning content.

“P-1: The best way to facilitate learning in our departments is to consult with the supervisor at work, because we must be active all the time. So, if we don't have much free time, it makes the most sense for us to learn spontaneously.”

“P-8: To facilitate learning in our hotel, face-to-face training sessions with written and visual support from educational institutions will be held before the peak season. Thereafter, the learning process continues throughout the season by viewing, applying and implementing new learning content.”

It was determined that special policies regarding learning are in place. Respondents highlighted the importance of completing the annual training plan, measuring training outcomes, and assessing future training needs.

“P-2: We strive for 100% compliance with the annual training plan so that technical, legal, personal and organizational training is provided, and everyone has the same right to training (e.g. English content and interpreter support when needed). Training outcomes are measured through testing and training needs assessments are routinely conducted.”

The study sought to determine whether and how learning activities and their outcomes are controlled and monitored in the surveyed hotels. The respondents indicated that there is room for improvement in these areas.

“P-2: Learning outcomes are mainly monitored through daily operational checks (first line supervisor in the department) or our performance in internal and external audits. However, we can say that we do not yet have an effective monitoring method in this regard.”

The study also aimed to determine whether the hotels took steps to implement the knowledge gained, particularly that from experience, in their future actions through further staff training.

“P-2: We evaluate annually what we have learned and what has happened. We place particular emphasis on the mistakes we have made. If something has gone wrong, this is analyzed and training is offered, followed by discussions to prevent a recurrence. In rare cases, sanctions may also be imposed.”

The study also aimed to determine whether and how employees share knowledge and experience with each other and with their superiors. The establishment of a platform for knowledge sharing could further facilitate this process.

“P-2: They can share it with their department head or colleagues. They can pass it on at meetings. If he/she is in the position of boss or above, he/she can personally teach his/her team what he/she has learned. However, we do not yet have a platform for knowledge sharing.”

Link between learning practices and organizational competitiveness and viability

The study aimed to determine the correlation between implemented learning practices and organizational competitiveness and viability. Respondents identified a clear link between these factors.

“P-6: We observe where and how our employees find it easier to learn and facilitate their work so that they can adapt more quickly and continue to learn. These practices strengthen our position compared to other hotels with which we compete in terms of service.

P-8: The employees of the facility share their experiences with each other during working hours, in the form of mutual warnings when they discover deficiencies or when experienced employees train and teach inexperienced employees. In this way, we ensure continuity in our improvement and development and secure our market position.

P-10: These practices are important for learning. Recognizing the value of educated and cultured individuals and their influence on employees, we also value peer learning. We emphasize hands-on learning and having face-on-face conversations with employees to help them practice. In this way, the hotel's customer satisfaction and service quality reach the highest level, creating continuity and helping us to thrive. “

Discussion

Promoting open communication, providing strategic leadership and supporting continuous competence development are necessary to develop hotels as learning organizations (Gephart *et al.*, 1996). In the hotel industry, the term learning organization refers to the facility's ability to innovate, adapt and continuously improve its operations (Kalıpcı, 2023a). It is about creating an environment where learning is deeply embedded in the organizational culture so that the hotels can effectively adapt to changing customer demands and market conditions (Tajeddini & Trueman, 2014). For example, in a study of five-star hotels in the Antalya region of Türkiye, the importance of leadership in promoting a learning culture was emphasized (Kalıpcı, 2023b). Establishing a learning culture in their hotels is something that hotel managers are instrumental in driving (Gjelsvik, 2002). They are responsible for creating the organizational climate and helping to apply the principles of the learning organization (Fraj *et al.*, 2015). The results of this study show the importance of developing a strong learning culture in line with the learning organization philosophy to achieve the goals of competitiveness, sustainability and viability. The results of this study show the importance of many learning organization practices that support the learning culture of the organizations studied.

Understanding the dynamic nature of learning in the hospitality industry requires knowledge of this dichotomy (Kolb & Kolb, 2005). This study confirmed the importance of continuous learning through the constant provision of learning opportunities for adaptation and continuous improvement, innovation and development. Similarly, according to the study by Smith *et al.* (2007), opportunities for continuous learning arise in various ways, e.g. through formal education, unstructured learning, self-directed learning and on-the-job training. Easily accessible learning opportunities, ongoing opportunities to apply information, and a culture that supports learning through sustainable practices are essential components of continuous learning (Candy, 1996; Sewell *et al.*, 2017). Training is an important determinant of the quality of employees in the tourism industry (Şimşek & Kalıpcı, 2023). A collaborative environment is fostered through practices that encourage team collaboration and learning, which ultimately improves operational efficiency and innovation (Kalyar & Rafi, 2013). In addition, the hotel's competitive advantage is maintained through strategic leadership for learning, which ensures that it remains flexible and sensitive to changes in the hotel industry (Fraj *et al.*, 2015).

In the hotel industry, techniques that encourage inquiry and discussions are being developed to improve relationships with visitors and employees (Dredge & Gyimóthy, 2015). In the hospitality industry, good communication is emphasized as crucial for an excellent guest experience (Mistry *et al.*, 2022). Effective communication is also essential for collaboration and team learning, which was determined by this study. Collaboration and teamwork are crucial for adapting to ever-changing customer needs, as well as talent development, employee retention and innovation that lead to sustainable and socially conscious business practices in the hotel industry (Wikhamn, 2019; Fu *et al.*, 2020; Limna & Kraiwanit, 2023).

Strategic leadership for learning is needed in the hotel industry. This includes offering specific leadership skills and attributes for hospitality managers as well as training programs for employees aspiring to management and supervisory positions (Baum, 2019; Bavik, 2020). This study has shown the importance of strategic leadership, but also of leadership training, which can help support employees in their work and help them to continuously learn to achieve the collective mission and vision. The industry has recognized that maintaining exceptional customer service and a consistent corporate image requires communicating a clear vision and principles, training and empowering employees, and supporting their development (De Chernatony & Segal-Horn, 2003). These initiatives demonstrate the hospitality industry's commitment to strategic leadership for learning and growth.

Hotels use a range of organizational structures, including knowledge-sharing platforms, cross-functional teams and mentoring programs, to support learning (Donate *et al.*, 2023). These organizational models are designed to promote knowledge sharing, skill development, and problem solving among employees (Yang, 2008). The importance of learning and knowledge exchange platforms, especially for new employees, was also confirmed in this study. Hotels can successfully harness the collective wisdom of their employees and adapt to changing market conditions by incorporating these types of systems and techniques (Nieves *et al.*, 2014).

To promote continuous learning and information sharing, hotels often rely on strategies such as cross-training, action learning and communities of practice (Yang, 2015). Through these practices, employees can learn a variety of skills, apply their knowledge in practical situations, and collaborate with colleagues to solve difficult problems (Kamau & Waudu, 2012). By incorporating these approaches, hotels can develop a dynamic learning ecosystem that promotes organizational performance and resilience (Melián-Alzola *et al.*, 2020). However, it is important that these processes are continuously evaluated so that they can be redesigned, improved or completely modified and replaced with new learning programs and initiatives.

Hotels use a variety of techniques, such as knowledge repositories, debriefings and storytelling sessions, to preserve experiences and insights (Harris-Smith & Palmer, 2022). The importance of monthly meetings, collective sense-making and discussing learning outcomes with colleagues was emphasized in this study. Hotels ensure that important information remains within the organization by collecting and sharing these insights and documenting past experiences. This allows future employees to learn from the past and make good decisions (Okumus, 2013).

Using institutional theory as a framework, the study shows how the institutionalization of learning practices and routines shapes the organization's behavior and how it responds to external influences. By adopting learning practices and initiatives, fostering communication and knowledge sharing, and emphasizing teamwork, supported by appropriate strategic leadership for learning, hotels can improve their adaptability and responsiveness to change in

the external environment. The results of this study underscore the importance of critical elements that shape the learning culture: continuous learning, communication and knowledge sharing, and leadership that helps hotels align with institutional goals and promote sustainability and viability. This study identifies leadership as a key driver and emphasizes its role in determining learning culture and strategic direction. Competent hospitality leaders should cultivate a culture that encourages continuous education, learning, knowledge sharing and creativity to ensure sustainability and viability. This process is guided by the postulates of institutional theory so that these actions support the overarching goals of sustainable development and are aligned with external expectations. In this context, Dewi et al. (2019) have shown that institutionalization is the first step in the process of organizational learning in the hotel industry. Hotels can ensure their long-term success and viability in the hospitality industry by incorporating these components into their organizational fabric. In this way, they can anticipate and adapt to future difficulties while meeting current sustainability and viability requirements.

Implementing a learning organization requires strong leadership, which is also critical to developing a learning culture. However, many organizations are often overwhelmed by immediate tasks, leaving them little time and space to devote to learning, critical reflection, and knowledge sharing. Inadequate infrastructure can further hinder the spread of new ideas and knowledge. Finally, employees may be fearful of changes that may require new learning-based initiatives, contributing to their resistance to both learning activities and change. Establishing a learning culture that is not supported by strong leadership can lead to cultural resistance when it comes to learning new behaviors.

Conclusion

The findings of this study demonstrate how the interplay of learning organization practices, especially those pertinent to its key component learning culture, lead to sustainability and viability in the hotel industry through the lens of institutional theory by examining how routines, practices, and structures established by management drive employee behavior (Scott, 2005). The results of this study show how such practices, routines and structures pertinent to the concept of the learning organization have emerged in the organizations studied, how they have spread and what role they have played in aligning employee behavior with competitiveness, sustainability and viability goals, confirming the research questions. In this way, this study enriches the academic debate on learning organizations in the hospitality industry and creates a basis for further research on the importance of the theoretical framework of institutional theory for the implementation of the postulates of the learning organization in the hotel environment. Learning processes based on stakeholder management and supported by a learning culture can help management choose optimal strategic and operational approaches to improve sustainability and create long-term value while balancing their economic, environmental, and social responsibilities.

Limitations and future research

The limited generalizability of the study may be because it is based on a small sample of 11 hotel managers. Larger and more diverse samples could improve the external validity of the results in future studies. The exclusive focus of the study on a specific area or group of hotels may have limited the transferability of the results to other geographical settings. Extending the

study to other locations could lead to a more thorough knowledge of regional differences. Subjective biases may arise from the fact that the study is based on self-reporting by hotel managers. To reduce bias, future studies could use multiple methods, such as employee surveys and objective performance measures. Although the study focuses on the hotel industry, learning organizations, sustainability and viability in other industries could be the subject of future research. Future studies can also take a longitudinal approach to assess the long-term impact of learning organization practices in terms of sustainability and viability. Comparative studies involving different sectors of the hospitality industry could also provide further insights.

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AI DISCLOSURES AND BOARDS: ANALYZING THE ROLE OF FORMAL EDUCATION AND GENDER DIVERSITY

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Abstract

The research investigates artificial intelligence (AI) disclosure practices among Croatian firms listed on the CROBEX 10 index in relation with formal education in engineering fields and board gender diversity. By conducting a quantitative content analysis of annual and sustainability reports from 2019 to 2023, the study evaluates the extent, frequency, and determinants of voluntary AI-related disclosures to shareholders and stakeholders. The analysis is based on a coding framework informed by established literature, categorizing AI disclosures into three categories: (1) Digital Awareness, Transformation, and Capabilities; (2) Integration into Products and Services; (3) Information Challenges and Cybersecurity Threats. The collected data were processed using MAXQDA 24 software for coding and quantitative analysis, while regression analysis was applied to test hypotheses regarding governance-related determinants of AI disclosure. The findings reveal that board diversity plays a significant role in shaping disclosure practices. Specifically, board gender diversity and the formal education in engineering fields show a statistically significant positive correlation with the extent of AI-related disclosures. These results support theoretical perspectives that link board diversity with improved governance quality and accountability. Despite certain limitations, such as the sample size and market specificity, this research offers valuable insights for regulators, corporate boards, and investors. It contributes to the growing body of literature on AI and corporate governance by demonstrating the influence of board diversity on transparency practices. The findings highlight the importance of diverse and well-qualified boards in promoting disclosure related to emerging technologies. This study serves as a foundation for future research, emphasizing the need for improved corporate transparency regarding AI to support informed stakeholder decision-making. Future investigations should focus on comparative analyses across different markets, the impact of regulatory frameworks on AI disclosure practices, and investor perceptions of AI-related information.

Keywords: corporate governance, disclosures, artificial intelligence, gender diversity, formal education

JEL classification: M14, G34, D83

Introduction

The role of artificial intelligence (AI) is progressively expanding within contemporary business environments, fundamentally transforming traditional business models, communication

dynamics, decision-making processes, and approaches to corporate governance. Although AI offers considerable potential to enhance organizational efficiency and stimulate innovation, its integration also presents significant challenges, particularly in relation to privacy, human rights, and social responsibility (Bonsón & Lavorato, 2021; Omar et al., 2017). Conversely, organizations that choose to postpone or forego AI implementation cannot remain unaffected by its widespread influence. As noted by Dörfler (2022), AI is not a discretionary technology, as it reshapes how organizations understand their strategic positioning and external context. Accordingly, companies that fail to adopt AI may face competitive disadvantages, especially as customers increasingly anticipate its deployment.

Regardless of whether a company adopts artificial intelligence, it is essential to establish a transparent and accountable corporate governance framework that incorporates the disclosure of AI-related information within corporate reporting. Such an approach is critical for maintaining stakeholder trust and ensuring alignment with ethical principles and regulatory requirements.

Croatian corporate governance operates under a two-tier system that distinctly separates the roles of the supervisory and management. The supervisory board plays a pivotal role by providing essential oversight of the management's functions, particularly in the reviewing and assessing the corporate reports to ensure compliance with established standards and regulations (Tipurić & Cindrić, 2024). Thus, incorporating both perspectives enables the study to recognize the management as the source of data while acknowledging the supervisory board's critical contribution to establishing its credibility and quality.

Although the European Union encourages innovation in AI, the disclosure of information on its usage remains voluntary, leading to inconsistent practices across organizations (Bonsón et al., 2021). In Croatia, as in many other countries, companies have the discretion to decide whether and how to include AI-related information in their corporate reports. That is why it is crucial to investigate how corporate governance influences transparency. Understanding this relationship provides valuable insights into the mechanisms that enhance disclosure practices and mitigate information asymmetry. Such research is essential for developing effective governance structures that promote accountability, protect stakeholder interests, and contribute to market efficiency.

Previous research indicates that board characteristics, such as diversity, may significantly influence the scope of non-financial disclosures (Ben-Amar & McIlkenny, 2011). Despite the increasing importance of AI in corporate strategy, the link between board diversity and the extent of AI-related disclosures within Croatian companies has yet to be comprehensively examined. Given the voluntary nature of these disclosures, it is essential to explore the factors that encourage greater transparency and accountability in corporate reporting.

This study aims to investigate the relationship between board gender diversity and the formal education in engineering fields and the extent of AI-related disclosures in the annual and sustainability reports of Croatian companies. Transparent and timely reporting on AI can enhance stakeholder trust, attract investors, and improve corporate reputation. On the other hand, insufficient or poorly communicated disclosures can harm corporate reputation and have negative financial consequences (Hasan et al., 2023). Understanding the role of boards in this process is crucial for improving AI-related corporate communication. The central research question posed was: Does board educational and gender diversity exert a statistically significant

influence on the propensity for AI-related disclosures in corporate reports issued by firms listed on the Zagreb Stock Exchange?

The research applies a quantitative methodology, following established approaches from prior studies (e.g., Omar et al., 2017; Bonsón et al., 2021; Finkenwirth, 2021; Shiyyab et al., 2023; Alkaraan et al., 2022). Regression analysis is employed to assess the relationship between board diversity and the frequency of AI-related disclosures. The sample comprises Croatian companies listed on the CROBEX 10 index, with data collected from their annual and sustainability reports for the period 2019–2023.

This study provides new insights into how board diversity influences AI-related disclosure practices in Croatia. It contributes to the growing body of literature by offering practical recommendations for improving transparency and accountability in corporate reporting on AI.

Research framework and hypothesis

Literature background

According to Solomon (2007), transparency constitutes a fundamental element of an effective corporate governance system, with corporate disclosure serving as the primary mechanism through which transparency is realized. Insufficient disclosure can undermine stakeholder trust and contribute to organizational failure, as transparency functions as an important monitoring tool. Enhancing corporate transparency has been a key focus of corporate governance reforms, as highlighted in the Cadbury Report (1992): *"The lifeblood of markets is information, and barriers to the flow of relevant information represent imperfections in the market... The more transparent a company's activities, the more accurately its securities will be valued."*

In the realm of AI, transparency similarly plays a critical role in ensuring accountability and maintaining trust. As Russell and Norvig (2022) argue, stakeholders must be confident that AI systems operate in a fair, unbiased, and reliable manner. In this regard, transparency serves as a key intersection between responsible AI adoption and corporate governance practices.

In the context of global corporate governance, voluntary disclosure of AI information in annual and sustainability reports is gaining increasing importance (see Table 1).

Table 1: Empirical evidence of the increasing prevalence of AI-related disclosures

Country	Companies/Institutions	AI disclosure prevalence	Source
Malaysia	Public enterprises	Fewer than 20 companies mention AI	Omar et al., 2017
Spain	All companies	704 mentions of AI	Bonsón et al., 2021
Germany	Financial institutions	31% of companies mention AI in annual reports (2019)	Finkenwirth, 2021
Jordan	Banks on the Amman Stock Exchange (ASE)	Increase from 73 mentions (2014) to 733 (2022)	Shiyyab et al., 2023
United Kingdom	Publicly traded companies	Growth in disclosures from 2013 to 2018	Alkaraan et al., 2022

Source: Authors

This practice primarily aims to improve transparency, reduce information asymmetry between companies and stakeholders, and strengthen stakeholder trust (Bonsón et al., 2021; Meiryani et al., 2022). Companies using AI technologies often highlight their positive effects to attract investors and strengthen their market position (Healy & Palepu, 2001; Nandi & Ghosh, 2012). At the same time, providing information on AI can enhance the perception of corporate accountability and compliance with regulatory requirements, thereby reducing potential reputational and legal risks (Nguyen & Dang, 2023; Lakshan et al., 2021).

Board diversity is expected to contribute to increased transparency in disclosed information (Adel et al., 2019; Majumder et al., 2017; Chan et al., 2014). Eng and Mak (2003) argue that disclosure can act as a substitute for other corporate governance mechanisms. Pigé (2002) highlights the key role of the board as an intermediary in the flow of information between stakeholders and management. However, an open question remains as to the extent to which boards genuinely contribute to greater transparency, given the possibility that management may use disclosure as a tool to steer stakeholder perception.

Ultimately, voluntary AI disclosure is a multifaceted issue in modern corporate governance. Transparent reporting can build stakeholder trust, reduce information asymmetry, and enhance corporate accountability. However, companies must navigate diverse regulatory environments and potential competitive disadvantages. While board diversity is key to authentic transparency, disclosure can also be strategically managed to influence stakeholder perceptions. Therefore, developing standardized, globally harmonized AI reporting frameworks that account for the complexities of corporate governance and associated risks is essential to maximizing benefits and minimizing drawbacks.

Theoretical approach and hypothesis

Previous research on voluntary disclosures has been grounded in various theoretical perspectives (Cotter et al., 2011). The similarities and differences among these theories stem from distinct paradigms related to the incentives, costs, and benefits of information disclosure. The choice of theory depends on the type of information examined and the targeted stakeholders, thereby providing a framework for analyzing the motives and impacts of voluntary disclosures.

The fundamental theories that provide a framework for analyzing the motives and impacts of such disclosures are as follows: agency theory (Jensen & Meckling, 1976) underscores transparency as a way to mitigate conflicts of interest between managers and shareholders; stakeholder theory (Freeman, 1984) assigns firms the responsibility toward all relevant interest groups; signaling theory (Spence, 2002) explains how firms use information disclosure to reduce information asymmetry and attract investors; and legitimacy theory (Suchman, 1995) emphasizes disclosure as a means to align with societal norms and strengthen reputation.

Thus, the voluntary disclosure of information regarding AI in annual reports and sustainability reports can be theoretically explained through different approaches to corporate governance. Among the most relevant are stakeholder theory and signaling theory, which best explain the motivation of firms to disclose AI information and the role of the board in this process.

Stakeholder theory (Freeman, 1984) emphasizes that firms have responsibilities toward a wide range of stakeholders, including shareholders, employees, customers, and regulatory bodies (Garcia-Torea et al., 2016). Transparent disclosure of AI information enables companies to

maintain stakeholder trust (Bonsón et al., 2021) and adapt to increasing social and regulatory demands. Gender diversity on boards is associated with greater attention to socially responsible business practices, including transparency and the ethical use of AI, as evidenced by previous research demonstrating that higher female representation on boards increases the focus on sustainability and social responsibility, which may result in a greater extent of voluntary disclosures regarding AI technologies (Bonsón et al., 2021). Firms seeking to maintain a positive reputation among stakeholders strive to transparently report on the application of artificial intelligence, thereby confirming their commitment to responsible business practices.

According to legitimacy theory (Suchman, 1995), firms seek to align their activities with societal norms and expectations to gain legitimacy and secure access to resources (Deegan, 2022). Transparent reporting on AI can help companies demonstrate their social responsibility and alignment with stakeholder expectations (Bonsón et al., 2021). In this context, gender diversity within the board can contribute to a more favorable public perception of the firm and enhance its legitimacy, while technical expertise allows for more precise and reliable information regarding AI technologies.

Based on the foregoing, the primary hypothesis is as follows:

H1: There is a positive relationship between board gender diversity and the total number of AI disclosures in corporate annual reports.

Signaling theory (Spence, 2002) explains how firms use information disclosure to signal their technological readiness, innovativeness, and compliance with regulatory requirements (Connelly et al., 2011; Bonsón et al., 2023). According to this theory, profitable firms are more inclined toward transparent reporting as it confirms their stability, strengthens stakeholder trust, and improves financial performance (Albitar et al., 2020; Hassanein et al., 2019; Alkaraan et al., 2022). Boards that are more technically proficient and experienced are better able to understand the complexities of artificial intelligence and are therefore more inclined to provide extensive disclosures on AI to signal their technological capacities and innovative potential to the market. Firms with such boards aim to attract investors and reduce information asymmetry (Bertomeu et al., 2011; Albitar et al., 2020). Enriques & Zetsche (2020) emphasize that technical expertise within the board plays a key role in overseeing the implementation of artificial intelligence, particularly in the context of AI disclosures in annual and sustainability reports. Bini et al. (2023) note that firms with high-quality boards often disclose more information, including details regarding the application of new technologies such as AI. Boards with a higher proportion of experts in AI and digital technologies exercise stronger control over AI implementation strategies and are more inclined to promote voluntary reporting on AI. Voluntary disclosure of AI information serves as a signal to regulatory bodies, investors, and the public that the firm is proactively managing technological challenges and ethical issues (Campbell et al., 2003). Ultimately, the expertise and experience of board members, particularly in technological domains, are essential for the effective management of artificial intelligence in a corporate setting, which directly influences how firms report on AI applications and mitigate associated risks.

Building upon this theoretical foundation, we posit our second hypothesis:

H2: There is a positive relationship between board members with formal education in engineering fields and the total number of AI disclosures in corporate annual reports.

Oliveira et al. (2022) emphasize that board engagement in digital technologies, such as AI, influences corporate decision-making, and consequently, the way firms communicate AI information in their reports. In conclusion, stakeholder theory explains the motivation for increased transparency in firms with greater gender diversity, whereas signaling theory explains why technologically adept boards are more likely to disclose AI information. These hypotheses will be empirically tested through an analysis of firms that voluntarily report on AI in their annual and sustainability reports. This theoretical approach is applied in the study as the combination of these two theories may help provide a comprehensive interpretation of voluntary artificial intelligence disclosures.

This research builds upon existing studies by examining the impact of corporate governance on the extent of voluntary disclosures. Emphasis is placed on the relationship between the proportion of women and formal education in engineering fields within corporate governance structures and the extent of voluntary information disclosure.

Metodology

Methods

In accordance with the defined hypotheses, this study adopts a quantitative content analysis. Multivariate regression analysis is utilized to evaluate the relationship between board diversity and the frequency of disclosures related to artificial intelligence. The research employs a methodology that aligns with established frameworks from previous studies (e.g., Omar et al., 2017; Bonsón et al., 2021; Finkenwirth, 2021; Shiyyab et al., 2023; Alkaraan et al., 2022).

Variables

The dependent variable was the total number of AI-related terms. The independent variables included board gender diversity, measured as the proportion of female board members, and the proportion of board members with formal education in engineering fields.

Table 2: Variable Operationalization

Variable category	Variable	Variables' description
Dependent	AI_Total	frequency of AI-related terms in corporate reports
Independent	FEM_Board%	percentage of women on corporate boards
Independent	ICT_Edu%	percentage of board members with the formal education in engineering fields

Source: Authors' own work.

Sample size and data collection

The research population includes all companies listed on the Zagreb Stock Exchange (ZSE) as of November 2024. Among the 119 domestic organizations listed on the exchange, a purposive sampling method was applied, focusing on the ten Croatian firms included in the CROBEX 10 index. Purposive sampling, a non-probability technique, was selected to prioritize firms with high market capitalization, liquidity, and compliance with the updated European regulatory

frameworks (NFRD). These companies are assumed to be industry leaders in digital technology adoption, including artificial intelligence (Etikan et al., 2016).

The final sample comprises ten firms observed over a five-year period (2019–2023). Although the potential sample size was 50 observations (10 firms × 5 years), due to incomplete data for two firms, these were excluded from the analysis, resulting in a balanced panel dataset of 40 firm-year observations. Missing data were addressed through listwise deletion to maintain dataset consistency.

Information on board members' characteristics (e.g., formal education) was collected through curriculum vitae (CV) analysis, generating 426 individual observations. The data sources included annual reports and official corporate websites. In total, 49 corporate reports were analyzed, encompassing integrated non-financial reports, annual reports, and sustainability disclosures, depending on the availability for each firm. Tables 3 and 4 show sample distribution by years and industries.

Table 3: Sample by years

	2019	2020	2021	2022	2023	TOTAL
<i>total firms</i>	8	8	8	8	8	40
<i>total board members</i>	65	77	91	93	100	426
<i>total reports</i>	9	9	10	10	11	49
<i>total AI related disclosures</i>	151	143	226	233	318	1071

Source: Authors' own work

Table 4: Sample by industries

	Manufacturing industry	Financial Services and Insurance	Accommodation and Hospitality Services	Information and Communication	TOTAL
<i>total firms</i>	15	10	5	10	40
<i>total board members</i>	220	98	68	40	426
<i>total reports</i>	18	11	5	15	49
<i>total AI related disclosures</i>	217	211	41	602	1071

Source: Authors' own work

To identify AI-relevant content, a comprehensive keyword-based nomenclature was developed, aligned with recent studies in the field (Elmarzouky et al., 2021; Karim et al., 2021; Alkaraan et al., 2022; Bonsón et al., 2021; Smili et al., 2022; Bednárová & Perea, 2023). The quantitative content analysis was conducted using MAXQDA 24 software. The frequency of AI-related keywords was counted for each firm-year observation, and the results were aggregated into the three disclosure categories as outlined in Table 5. The most frequent AI related disclosures were “Digital Transformation” (185), “Robotics” (129), “Information Security” (127) and “Artificial Intelligence” (113). This data was then used to construct the dependent variables for the regression analysis.

Table 5: Frequency of AI related disclosures

Category/Word	2019	2020	2021	2022	2023	TOTAL
Artificial Intelligence - Digital Awareness, Transformation, and Capabilities	85	67	99	126	150	527
Digital Infrastructure	4	3	6	10	9	32
Digital Strategy	3	8	7	2	2	22
Digital Transformation	38	21	32	47	47	185
Internet of Things (IoT)	11	5	12	9	8	45
Modern Technology	7	0	6	10	12	35
Latest Technology	10	8	6	8	6	38
Advanced Technology	3	7	11	9	10	40
Machine Learning	1	1	4	6	5	17
Artificial Intelligence	8	14	15	25	51	113
Artificial Intelligence - Information Challenges and Cybersecurity Threats	3	29	31	44	85	192
Information Security	1	27	21	31	47	127
IT Security	0	0	6	4	4	14
Cybersecurity	2	2	3	8	32	47
Cybercrime	0	0	0	1	2	3
Cyber Risks	0	0	1	0	0	1
Artificial Intelligence - Integration into Products and Services	61	49	96	63	83	352
Digital Services	4	20	17	11	24	76
Digital Banking	4	1	3	4	4	16
Mobile Application	5	15	15	27	33	95
Mobile Banking	3	5	6	4	7	25
Mobile Payment	0	0	1	1	1	3
Robotics	44	7	51	15	12	129
Robotic Automation	0	1	0	1	1	3
Virtual Assistant	1	0	3	0	1	5
Total Sum	149	145	226	233	318	1071

Source: Authors' own work

Results

To test the hypotheses, multiple linear regression models were employed. The regression models were estimated using the ordinary least squares (OLS) method. To address potential issues of heteroscedasticity and autocorrelation, robust standard errors were calculated. Additionally, the models were tested for multicollinearity, and no significant issues were identified.

As Table 7 suggests, the model demonstrates moderate explanatory power, with a Pearson correlation coefficient of 0.6926 and a coefficient of determination (R^2) of 0.4797, indicating that approximately 47.97% of the variance in AI-related mentions can be explained by the board diversity variables. This suggests that while board diversity factors significantly influence corporate AI discourse, other unmeasured variables likely account for the remaining variance.

Table 7: Regression statistics

Multiple R	0,6926
R Square	0,4797
Adjusted R Square	0,4516
Standard Error	17,5341
Observations	40

Source: Authors' own work

Since the statistical parameter significance $F = 5.63 \times 10^{-6}$, which represents the p-value associated with the statistical parameter $F = 17.0558$, is lower than the predetermined significance level $\alpha = 0.05$, it can be concluded that the regression model is statistically significant. This implies that at least one of the predictor variables FEM_BOARD%, representing the proportion of women on boards, or ICT_EDU%, representing the proportion of board members with engineering education, has a statistically significant effect on the dependent variable AI_TOTAL, which measures the frequency of mentions of artificial intelligence-related terms in annual non-financial reports. Details are presented in the Table 8.

Table 8: Anova

	Df	SS	MS	F	Significance F
Regression	2	10487,5	5243,74	17,0558	$5,63 \times 10^{-6}$
Residual	37	11375,5	307,446		
Total	39	21863			

Source: Authors' own work

According to Table 9., the estimated regression equation is:

$$AI\_TOTAL = -3,8952 + 0,6685 FEM\_BOARD\% + 0,7529 ICT\_EDU\% + \varepsilon$$

Both predictor variables demonstrated statistically significant effects on AI-related discourse. The proportion of women on corporate boards (FEM_BOARD%) showed a significant positive relationship ($\beta = 0.6685$, $p = 0.0074$), as did the proportion of board members with engineering education (ICT_EDU%) ($\beta = 0.7529$, $p = 0.0001$). These results indicate that for each percentage point increase in women's board representation, there is an associated increase of 0.6685 in AI-related mentions, *ceteris paribus*. Similarly, a one percentage point increase in of board members with engineering education corresponds to a 0.7529 increase in AI-related mentions, controlling for gender diversity.

Table 9: Regression coefficients

	Coefficients	Standard Error	t Stat	P-value
Intercept	-3,8952	6,939	-0,5614	0,5779
FEM_BOARD%	0,6685	0,2359	2,8339	0,0074
ICT_EDU%	0,7529	0,1711	4,3992	0,0001

Source: Authors' own work

These findings provide empirical evidence that both gender diversity and engineering education at the board level are positively associated with the extent of AI-related disclosure in corporate reporting. The slightly stronger coefficient for ICT_EDU% (0.7529) compared to FEM_BOARD% (0.6685) suggests that engineering education may have a marginally greater

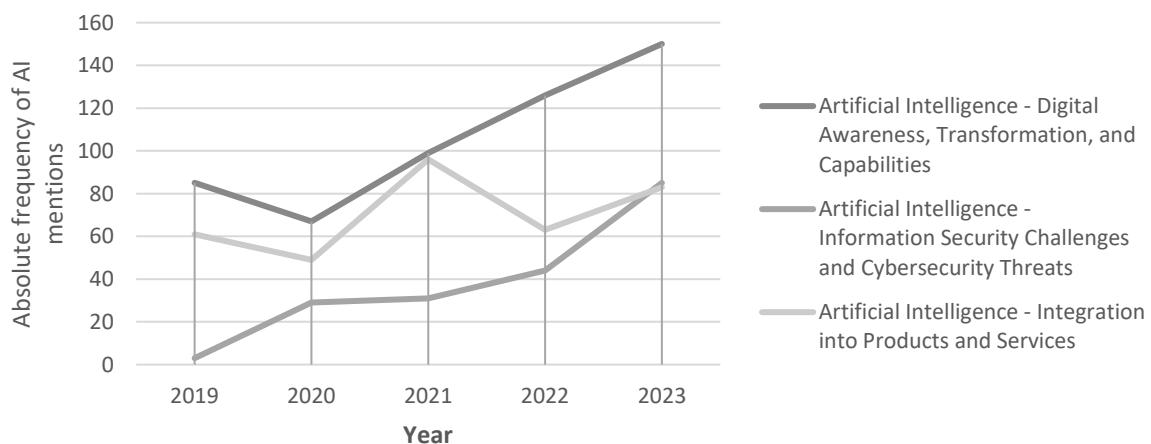
impact on AI-related corporate discourse than gender diversity, though both factors remain significant predictors.

Discussion

The study results provide a comprehensive understanding of organizations' strategic priorities in AI, encompassing key trends, challenges, and communication practices. The final interpretation of the data and its critical analysis enhance the comprehension of corporate practices in this domain, while identifying opportunities and constraints associated with the implementation of AI in business operations.

The frequency of disclosures related to AI in the observed five-year period shows a steady increase. All categories experienced growth, except for *"Integration into Products and Services,"* which reached its peak in 2021. The *"Digital Awareness, Transformation, and Capabilities"* category has grown exponentially starting in 2020, indicating that companies increasingly recognize the importance of AI and digital technologies. Meanwhile, the *"Information Security Challenges and Cybersecurity Threats"* category saw a significant increase since 2022, suggesting that companies are placing greater emphasis on discussing risks associated with AI. This trend highlights a shift toward prioritizing risk awareness in corporate rhetoric, likely reflecting efforts to address stakeholder and regulatory concerns.

Figure 1: Absolute frequency of AI mentions by year



Source: Authors' own work

The empirical evidence presented in Table 10 demonstrates that disclosures contained in *"Digital awareness, transformation, and capabilities"* category constitute a predominant proportion (49.21%) of artificial intelligence-related corporate disclosures. This finding suggests that organizations within the sample frame have strategically emphasized their digital transformation trajectories as a means of competitive differentiation. However, comparative analysis with recent scholarship examining Jordanian financial institutions (Shiyyab et al., 2023) reveals a distinct disclosure pattern: while digital transformation-related terminology comprises 24.09% of disclosures, information security and cybersecurity considerations represent 42.58% of total disclosures. This marked divergence in disclosure priorities indicates potential gaps in risk management approaches among Croatian enterprises that warrant further consideration.

Table 10: Relative frequency of AI-related terms/words

AI-Related Terms/Words	Frequency	Percentage %
<i>AI digital awareness, transformation, and capabilities</i>	527	49.21%
<i>AI application, product, service, and process</i>	352	32.87%
<i>Information and cyber security</i>	192	17.93%
Total	1071	100.00%

Source: Authors' own work

The regression analysis results provide empirical support for the hypotheses. The findings indicate that board gender diversity and the proportion of the formal education in engineering fields are positively and significantly associated with the extent of AI-related disclosures. These results are consistent with the theoretical perspectives of stakeholder theory, legitimacy theory, and signaling theory.

Stakeholder theory suggests that diverse boards, with a greater representation of women, are more likely to prioritize transparency and accountability, leading to more extensive AI-related disclosures. This aligns with the observed positive relationship between board gender diversity and the level of AI disclosure. Legitimacy theory further explains how diverse boards can enhance the public perception of the corporation and increase its legitimacy, which may incentivize more comprehensive AI reporting.

Signaling theory provides insights into the role of the formal education engineering fields. Boards with a higher proportion of members with relevant technical qualifications are better equipped to understand the complexities of AI and its implications. These boards are more inclined to disclose AI-related information to signal the corporation's technological competence and innovation potential to the market, thereby attracting investors and reducing information asymmetry.

The results highlight the important role of board diversity in Zagreb Stock Exchange-listed companies as determinants of corporate governance quality. Enhancing AI disclosure transparency can deliver significant long-term benefits for the capital market, including increased investor confidence in AI-adopting firms and a stronger evidence base for developing future regulatory frameworks.

Conclusion

The primary objective of this study was to examine the relationship between board diversity and the extent of artificial intelligence information disclosure among companies listed on the Zagreb Stock Exchange. Consequently, the central research question posed was: Does board educational and gender diversity exert a statistically significant influence on the propensity for artificial intelligence related disclosures within firms listed on the Zagreb Stock Exchange?

For the purposes of this empirical investigation, the study sample comprised companies included in the CROBEX 10 index. Data were collected from their publicly available annual and sustainability reports for the period spanning 2019 to 2023. Statistical analysis of the data revealed significant positive correlations between board gender diversity and the level of AI disclosure, as well as between the proportion of board members possessing educational backgrounds in technical or engineering disciplines and the volume of AI-related disclosures.

This research makes a significant theoretical contribution by deepening the understanding of established frameworks within the context of voluntary non-financial disclosure, specifically as they apply to the growing field of artificial intelligence.

The study provides a critical examination of the relevance and explanatory power of legitimacy theory, agency theory, signaling theory, and stakeholder theory in understanding the nascent domain of corporate AI disclosure.

The study also raises important considerations for companies regarding the strategic adaptation of board diversity. Organizations may need to adjust board structures to better reflect and oversee strategies related to AI, as communicated through corporate reports. Additionally, the findings offer empirical insights for policymakers, corporate executives, and capital market participants, emphasizing the importance of diversity and expertise in corporate governance. As AI disclosure becomes an increasingly critical aspect of corporate transparency, it may significantly influence future investment decisions.

Future research should focus on conducting comparative analyses across different international markets, exploring the impact of evolving regulatory frameworks on AI disclosure practices, and assessing investor perceptions of AI-related information. Additionally, qualitative studies are recommended to provide deeper insights into the content and contextual nuances of AI disclosures.

Acknowledgement on the use of AI

During the preparation of this work authors used Chat GPT tool to check for language improvements. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the paper.

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MANAGEMENT

TRACK 3: Sustainability and Emerging Business Models

PREFACE

MANAGEMENT – TRACK 3: SUSTAINABILITY AND EMERGING BUSINESS MODELS

This track focuses on the critical interplay between innovation, sustainability, and the transformation of business and infrastructure models in response to contemporary global challenges. As industries seek to remain competitive while addressing environmental concerns and resource limitations, integrating sustainable practices into core business strategies is paramount for long-term success. The contributions here examine how various types of innovation influence firm performance, particularly in traditional sectors, underscoring the necessity of adapting innovation strategies to specific industrial contexts. Beyond firm-level dynamics, the track explores how sustainability principles are embedded into broader strategic frameworks and public infrastructure planning, highlighting how innovation and sustainability can mutually reinforce each other in shaping future-ready businesses and resilient communities.

Baković, Mihalić and Mihalić examine the role of different innovation types (product, process, business model) in influencing firm performance within traditional sectors, specifically the Croatian metal processing industry. Kress and Schaeperkoetter explore how servitization can reinforce sustainability management, proposing an approach to evaluate sustainable business models by integrating ecological effects into customer lifetime value calculations, with a case study in agricultural machinery. Sigurjonsson and Gudmundsdottir investigate the strategic integration of sustainability in business, addressing challenges in measuring impacts and highlighting the role of digitalization in transforming sustainability from compliance to a core strategic function. Szemere and Surman present an evaluation framework for e-scooter integration into city infrastructure, analyzing initial results from Hungary across dimensions like regulation, infrastructure, design, and education, to inform data-driven urban mobility policies.

THE ROLE OF INNOVATION IN THE CROATIAN METAL PROCESSING INDUSTRY: EXAMINING THE IMPACT OF INNOVATION TYPES AND FIRM PERFORMANCE

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Abstract

The critical role of innovation in driving company success has been accepted as a consensus view by both theory and practice. Innovation fosters competitive advantage, enhances productivity, and facilitates adaptation to rapidly changing market conditions. However, in the face of increasing global instability and external shocks—such as supply chain disruptions, economic downturns, and geopolitical uncertainties—it is essential to reassess whether this positive correlation between innovation and firm performance still holds, particularly in traditional mature industries like metal processing. This study addresses several key research questions related to innovation in the Croatian manufacturing industry. First, it investigates the role of different types of innovation: product, process, and business model innovation, and their respective impacts on firm performance. While product innovation has traditionally been associated with revenue growth and market expansion, process innovation plays a critical role in cost reduction and operational efficiency. Business model innovation, on the other hand, allows firms to reconfigure value creation mechanisms in response to shifting market demands. Secondly, this research explores the emphasis Croatian manufacturing firms place on different types of innovation. This question is especially important for traditional industries that offer little room for product innovation. Understanding these dynamics is crucial for policymakers and business leaders aiming to foster a resilient and innovation-driven manufacturing sector. The research question for this paper is: What is the role of product, process and business model innovations in improving business performance for mature industries like metal processing. The study draws its conclusions from a survey conducted among Croatian manufacturing firms in the second half of 2024. The main findings suggest process innovation plays a key role in mature industries like metal processing while product innovation offers no significant contribution to firm performance. On the other hand, business model innovations impact on firm performance is significant and this area can be used for stimulating the results of Croatian metal processors.

Keywords: innovation, manufacturing industry, small open economy, product innovation, process innovation, business model innovation, Croatia

JEL classification: O31, L60, L25

Introduction

The rapid advancement of technology, increasing global competition, and shifting geopolitical landscapes are profoundly reshaping the manufacturing sector. In this evolving environment, innovation is no longer optional—it is essential for survival and competitiveness (Prester & Rašić Bakarić, 2017). As the manufacturing industry transitions into the era of Industry 4.0, companies must actively integrate new technologies and innovative strategies to remain relevant in an increasingly digitalized economy (Obradović et al., 2021). At the core of this transformation are three key dimensions of innovation: process innovation, product innovation, and business model innovation. Process innovation focuses on adopting advanced digital manufacturing technologies such as automation, artificial intelligence (AI), the Internet of Things (IoT), and cyber-physical systems to enhance efficiency, optimize resource allocation, and reduce costs (Frank et al., 2019). Product innovation enables firms to design and develop intelligent, data-driven, and customized products, leveraging smart materials, real-time data processing, and embedded sensors (Kagermann, 2015). Meanwhile, business model innovation is redefining how firms generate and capture value, moving toward platform-based ecosystems, servitization strategies, and digital marketplaces (Schuh et al., 2020). For small and open economies like Croatia, technological progress and innovation adoption present both opportunities and challenges. While digital transformation allows for enhanced productivity and global market access, high investment costs, skills shortages, and infrastructure limitations can create barriers to implementation (Obradović et al., 2021). Nevertheless, the successful adoption of Industry 4.0 technologies and innovation-driven strategies can position manufacturing firms as key players in global supply chains, fostering sustainable economic growth and long-term industrial resilience. As manufacturing continues to evolve, firms that effectively leverage innovation, digitalization, and new technologies will be best positioned to adapt to disruptions, improve productivity, and maintain a competitive edge in an increasingly dynamic market. The main aim addressed by research in this paper is to determine what type of innovation plays crucial role in improving firm performance for a mature industry like metal processing. The research question that can be derived from this aim is: What is the role of product, process and business model innovations in improving business performance for mature industries like metal processing.

Overview of innovation management and innovation types

The rapid evolution of digital technologies, global competition, and shifting industrial policies is redefining the landscape of manufacturing. The emergence of Industry 4.0, characterized by advanced automation, artificial intelligence (AI), and interconnected cyber-physical systems, is transforming industrial processes, products, and business models (Weking et al., 2020). For firms operating in small and open economies like Croatia, the challenge lies in integrating these technologies effectively to ensure long-term competitiveness.

Process innovation in Industry 4.0 is centered around optimizing efficiency, productivity, and automation. Smart factories, supported by IoT, big data analytics, and cognitive automation, facilitate real-time decision-making, predictive maintenance, and flexible production systems (Vještica et al., 2022). Industry 4.0 also plays a role in green process innovation, helping reduce resource waste and enhance environmental sustainability (Liu & Giovanni, 2019). Digital transformation in manufacturing enables firms to enhance operational flexibility and respond

more effectively to changes in market demand, which is particularly relevant for economies seeking greater integration into global production networks.

Product innovation within Industry 4.0 is shifting manufacturing from mass production toward mass customization. Smart products equipped with embedded sensors and data analytics allow firms to adjust to changing consumer needs dynamically (Rosário & Dias, 2023). The concept of Operator 4.0 integrates AI-driven support for human workers, improving product design and enhancing human-machine collaboration (Li et al., 2020). In a small economy context, the ability to develop niche, high-value-added products through technological advancement can provide a competitive advantage.

Business model innovation is also undergoing significant transformation. Companies are moving from traditional manufacturing toward platform economies, servitization, and ecosystem-driven strategies (Müller et al., 2020). The combination of servitization and Industry 4.0 is enabling firms to shift from selling standalone products to offering data-driven, customized services (Frank et al., 2019). For small and open economies, business model transformation through digitalization and servitization could allow firms to participate in global value chains despite limited production scale.

While Industry 4.0 presents opportunities, challenges remain in implementation. High investment costs, digital infrastructure limitations, and workforce skill gaps are barriers to widespread adoption (Santos & Martinho, 2019). However, evidence suggests that companies proactively investing in digital transformation and fostering innovation ecosystems can improve industrial resilience and global market positioning. Firms that leverage smart production technologies and align their innovation strategies with Industry 4.0 principles are more likely to sustain competitive advantages in increasingly automated and data-driven industries.

The connection between innovation and business performance: literature review

Numerous authors demonstrated the positive relationship between quality and export performance (Ariamanesh et al., 2020; Tan et al., 1998; Barringer et al., 1999; Nega, 2022; Imbriani, 2015; Wagner, 2014). It has to be taken into consideration that quality management represents a broad field with numerous applications. So there is many research connecting different aspects of quality management to exports. Lages et al. (2009) found a positive relationship between product quality and export performance. Imran et al. (2018) found a positive impact of applying total quality management on firm performance in international markets. There are also previous studies analyzing the effectiveness of institutional quality who found this factor to be more important for small and new firms (LiPuma et al., 2013).

Research on the relationship between quality, innovation and export performance has developed significantly over the past twenty years. Early research on this topic presented conceptual models of the relationship between quality and innovation (Franceschini & Rossetto, 1995). Traditional understandings of the relationship between quality and innovation suggest that quality management, which focuses on standardization and consistency, can hinder innovation, especially radical innovation, which requires creativity, experimentation and risk-taking. A company's focus on innovation can negatively affect quality performance due to the conflict between their goals (Blank & Naveh, 2014). Leavengood et al. (2012) explain that quality and

innovation go hand in hand, but only if there is an organizational culture that encourages continuous improvement and innovation. Otherwise, TQM can become an obstacle to radical innovation, because too much standardization can limit creativity and experimentation.

Baković (2011) in his work on the impact of quality and innovation on the business of companies in the Croatian manufacturing industry states that for a company to operate sustainably on the market, simultaneous investments in innovation and quality are necessary. Companies cannot afford to neglect innovation or quality, both components of business are equally important and support each other. Without stable quality-driven business, constant revenues that can finance innovation cannot be expected, and without innovation, the requirements of the quality system cannot be met. This especially refers to meeting customer needs and continuous improvement, which implies innovation. In companies that have a high level of information exchange, a focus on quality and a simultaneous focus on innovation can have a positive impact on performance. Through a culture of information exchange aimed at meeting quality and innovation requirements, quality management system practices can complement innovation efforts by providing structural support for innovation. In this way, companies can simultaneously achieve a high level of quality performance and encourage radical innovation, thereby resolving the traditional tension between these two key goals (Blank & Naveh, 2014).

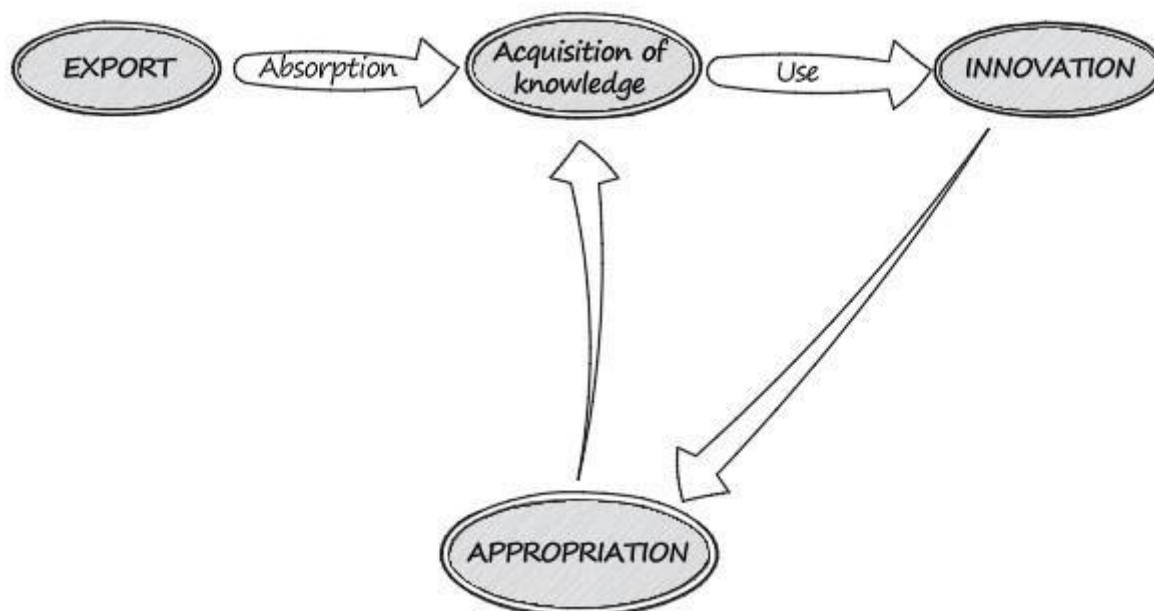
Some other research on the link between quality and innovation has begun to include export performance. Zou et al. (1998) presented the "EXPERF" scale, which was designed as a generalized tool for measuring export performance, applicable to different countries, including the USA and Japan. The scale is based on three dimensions of export performance:

1. Financial export performance: measuring exports through revenue, sales growth and profitability.
2. Strategic export performance: evaluation of performance is based on global competitiveness, strategic position and market share.
3. Satisfaction with export: the success and satisfaction that the company has with the export venture is evaluated.

Research that included export success in addition to the relationship between quality and innovation shows that quality and innovation influence each other and their relationship has an impact on export success. Investing in management capabilities increases production innovation and quality, which results in better export performance (Lages et al., 2009). Organizational innovations, such as changes in managerial practices, structures and processes, have a direct and positive impact on export results. These innovations help companies adapt to challenges in foreign markets and improve their overall export strategy (Azar & Ciabuschi, 2016). Innovation activities are key to achieving competitive advantage and export success (Bicakcioglu-Peynirci et al., 2019; Kafetzopoulos et al., 2015; Caldera, 2010). Innovations and export strategies are complementary and create a circle in which they support each other. Exporting promotes learning and innovation, while innovation helps firms enter new markets, increase product quality, and improve their export performance (Golovko & Valentini, 2011). Small and medium-sized enterprises especially benefit from access to knowledge from foreign markets, which they can integrate into their innovation processes. This effect of learning through exporting enables small and medium-sized enterprises to develop better products and improve processes, thus strengthening their competitiveness and further strengthening the innovation and export cycle. Empirical evidence shows that SMEs that are innovative and export their products and services simultaneously achieve higher revenue growth. This supports

the claim that the presence of one activity enhances the returns to the other, confirming the complementarity between these strategies as shown in Figure 1. (Golovko & Valentini, 2011).

Figure 1: Supporting cycle of export and innovation



Source: Golovko & Valentini (2011).

Research has shown that innovations, especially combined with quality improvement, positively affect the export potential of companies (Imbriani et al., 2015). The mutual relationship between innovations and export behavior was considered, with production innovations having the greatest impact (Tuhin, 2016). Recent research has proven that production innovations lead to increased export prices and increased quality (Dzukou et al., 2024). Since innovations bring news to the market, it can be said that innovations have a positive impact on future revenues, and quality has an impact on current revenues of the company (Baković, 2011). Additionally, organizations can refine their quality model concept to achieve innovation goals (McAdam & Mitchell, 2006). Different types of innovation can have different impacts on export intensity and aspects. Technological innovation, either in terms of radicality (how revolutionary the innovation is) or scope (number of innovations introduced), mediates the relationship between organizational innovation and export performance. However, the extent of technological innovation, not its radicalness, significantly improves export performance (Azar & Ciabuschi, 2016).

Role and importance of manufacturing industry in Croatia

The manufacturing sector plays a fundamental role in generating economic value, fostering employment, and enhancing productivity across industries, ultimately contributing to economic growth and global competitiveness (Prester & Rašić Bakarić, 2017). The Croatian manufacturing industry has a long tradition and many of today's companies have successfully emerged from the transition from former state-owned companies founded in completely different circumstances. Over time and with the change in the business/political system from a planned to a market economy, companies have encountered new challenges and rules that apply

in the business world of Western countries. The transition was not easy, nor quick. Unfortunately, many companies failed to adapt and had to declare bankruptcy. Companies that manage to achieve the goal of a satisfied consumer can survive in the market (Kano, 1995). In search of an answer to the question of how to achieve consumer satisfaction, many entrepreneurs turn to quality and innovation as a key factor. The impact of quality on consumer satisfaction and the competitiveness of companies makes it a crucial factor for the survival of companies (Karić, 2008). In addition to quality, numerous studies also cite innovation as the next important factor in achieving a company's competitive advantage (Chaithanapat et al., 2022; Garcia-Fernandez et al., 2022). In addition to the importance of quality and innovation for a company's competitiveness, it is also necessary to briefly review the role of exports. Namely, exports represent one of the key predictors of a company's long-term success (Putninš, 2013; Leonidou, 2004; Hiller et al., 2013).

Only companies that are willing to change and adapt can survive in the demanding international market (Gligović et al., 2021). Today, there are various "niches" in the metal processing industry, and numerous Croatian companies have managed to adapt to changes and improve their way of doing business, achieving success in the domestic and foreign markets. According to the NKD 2007, the classification of the metal processing industry in Croatia is as follows (HGK, 2015):

- C24 Manufacture of metals
- C25 Manufacture of fabricated metal products
- C28 Manufacture of machinery and equipment
- C29 Manufacture of motor vehicles, trailers and semi-trailers
- C30 Manufacture of other means of transport
- C32 Other manufacturing
- C33 Repair and installation of machinery and equipment

In short, companies from the above sectors have a total of 82,941 employees, 7,848,262,631.46 EUR in total revenue, of which as much as 56.45% is achieved through exports (HGK, 2023). Such results would certainly not be possible without investments in the areas of quality and innovation. Companies in the Croatian metal processing industry often base their results on segmentation, i.e. the selection of specialized niches in which they can be competitive on the foreign market. The conditions that companies must meet in order to compete in foreign markets differ from domestic ones, and require flexibility.

In international markets, of which the EU is a good example, compliance with norms and standards is of utmost importance. The best example is Germany, which despite its long-standing membership in the European Union insists on the application of national norms, or national supplements to EU norms, and attaches great importance to the certification of manufacturing companies by German institutions in accordance with the system developed for the needs of the German market (Pedrotti et al., 2023). Croatian companies in the metal processing industry can request certification from German institutions and thus improve their position in the market, which is very demanding. After the implementation of an internationally recognized quality system, no one on the market will ask whether the manufacturer knows what a certain norm prescribes and whether it behaves in accordance with it. This is understood and brings great benefits to the company, because no one doubts the quality of products and services (Kolaković & Lazibat, 2004).

The metal processing industry in the Republic of Croatia is still largely a labor-intensive and low-profit industry. The Croatian metalworking industry is not at the same level of development in terms of machine park compared to countries with a high level of metalworking industry development, such as Germany, Italy and France. Despite this fact, Croatian companies manage to place their products on the domestic and foreign markets, especially products that require a relatively large amount of human labor and cannot be fully automated (HGK, 2021). In order for a company to survive in this industry, it must constantly reduce production costs per unit of product, refine the product in such a way that it gains new added value, continuously work on improvements, and thus try to gain a competitive advantage (HGK, 2015). A positive way to reduce costs per unit of product is to increase output with equal or slightly increased fixed costs. Modernization of machines and innovations that accelerate the production process are certainly a good way to increase output, but increasing output poses a problem in placing products on the market. A favorable price is not enough to encourage consumers to buy and use the product. Additional elements are certainly the quality of the product and the reputation of the provider on the market. The quality of products and services has a positive effect on a company's export performance (Barringer et al., 1999; Imran et al., 2018; Imbriani et al., 2015).

The quantitative survey of innovation types and performance in Croatian manufacturing industry

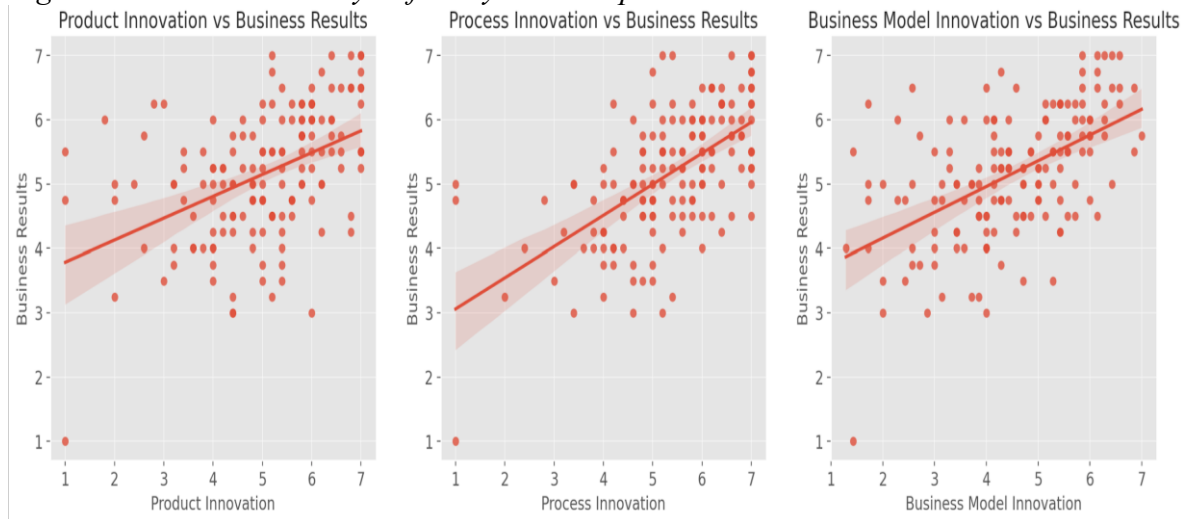
To measure the export performance of a company, the EXPERF measurement scale developed by Zou et al. (1998) was used. The proposed measurement instrument divides export performance into three key categories, namely: financial performance, strategic performance and satisfaction with the export venture. Within each variable, there is a set of 3 statements with which respondents will express their degree of agreement using a Likert scale of 1-7, where 1 is strongly disagree and 7 is strongly agree. As for independent variables scales were adopted from different authors (Alegre et al. 2006, Damanpour 2010, Zott & Amitt 2010).

The survey for this paper was distributed among Croatian metal processing companies in October 2024. For contacting the manufacturers, we used contacts gathered by Croatian Chamber of Commerce. After sending the questionnaire to a list of 3000 manufacturers twice, 160 acceptable questionnaires were collected. That approximates the rate of return of about 5.3% which is usual in using such publicly available contact information.

Table 1: Descriptive statistics for key variables

Variable	Mean	Standard Deviation
Product Innovation	5,00875	1,596671581
Process Innovation	5,32125	1,402857244
Business Model Innovation	4,476280323	1,669218903
Business Results	5,1515625	1,284491848

Figure 2: Correlation analysis for key variable pairs



Source: authors' own work.

This study examines the relationship between different forms of innovation—product innovation, process innovation, and business model innovation—and their impact on business results within the Croatian metal processing industry. Using ordinary least squares (OLS) regression, we assess the predictive power of these innovation types in explaining variations in business performance. A multiple regression model was employed, where Business Results served as the dependent variable, while Product Innovation, Process Innovation, and Business Model Innovation were included as independent predictors. The model was tested on a sample of 160 firms, and the analysis was conducted using the least squares estimation technique. The regression results indicate a statistically significant relationship between Process Innovation and Business Model Innovation with Business Results. The overall model explains 41.1% of the variance in business performance ($R^2 = 0.411$, Adjusted $R^2 = 0.399$, $F = 36.24$, $p < 0.001$).

Table 2: Regression analysis

Variable	Coefficient	Std. Error	t-Statistic	P-Value	Significance
Intercept	2,336320376	0,285341	8,187814	0	Significant
Product Innovation	-0,002734929	0,065538	-0,04173	0,966	Not significant
Process Innovation	0,351410182	0,068557	5,125787	0	Significant
Business Model Innovation	0,214344279	0,060916	3,518698	0,001	Significant

When interpreting the results of regression analysis these are the main findings:

- Process Innovation has the strongest positive effect ($\beta = 0.3514$, $p < 0.001$) on Business Results, indicating that improvements in manufacturing or operational efficiency contribute significantly to overall firm performance.
- Business Model Innovation also demonstrates a significant positive impact ($\beta = 0.2143$, $p = 0.001$), suggesting that rethinking how firms create and deliver value is an essential driver of business success.

- Product Innovation, contrary to expectations, does not show a statistically significant effect ($\beta = -0.0027$, $p = 0.967$), implying that merely introducing new or improved products does not necessarily translate into better business performance.

These results have both scientific and practical implications. First of all, they confirm the importance of business model innovations as an important predictor for business results as stated by previous research (Bashir et al. 2024, Jean et al. 2024, Dong et al. 2023). Previous research has dominantly focused on the role of business model innovation for company survival (Dong et al. 2023) related to start up scene, new technologies and dynamic industries while in this case business model innovation is also confirmed as an important factor for traditional industries like metal processing. The results for product innovation are contrary to previous research that mostly defined positive connection between product innovation and business results (Saraswati & Sudarmiotin 2024, Munawar et al. 2023, Hadi 2023). Again it is important to emphasize old mature industries that are not affected much by new technologies do not rely on product innovations. However certain authors like Chang (2015) found positive relationship for product innovation and business performance while others suggest for mature industries focus generally shifts from product to process innovation (Shuai & Bo 2010).

Conclusion

This study underscores the pivotal role of process innovation and business model innovation in enhancing business performance within the manufacturing sector, particularly in the Croatian metal processing industry. While product innovation remains a key component of overall innovation strategy, our findings suggest that its direct impact on business performance is relatively constrained in this context. These insights hold significant implications for both business leaders and policymakers seeking to bolster firm competitiveness through strategic innovation investments.

A notable observation from our study is the limited impact of product innovations on business results in the Croatian metal processing industry. This phenomenon can be largely attributed to the high maturity level of metal processing as an industrial sector, where the pace of product innovation is inherently slower. Unlike industries characterized by rapid technological advancements and frequent product disruptions, the metal processing sector predominantly operates with standardized product offerings, competing mainly through cost efficiency and pricing strategies. As a result, firms in this sector tend to prioritize process innovations, which directly contribute to cost reduction, operational efficiency, and price competitiveness—key factors for sustaining a competitive edge in such a mature market.

Additionally, the industry's emphasis on quality management standards and process optimization further reinforces the centrality of process innovation. Given that firms in this sector must adhere to stringent regulatory and quality assurance frameworks, continuous improvements in production efficiency, waste reduction, and compliance with industry standards are often more impactful than incremental product modifications.

Business model innovation also emerges as a critical driver of performance, albeit through a different mechanism. Unlike process innovations, which primarily optimize internal operations, business model innovations require fundamental structural changes at the organizational level. These innovations focus on reconfiguring value propositions, revenue streams, and market engagement strategies, often by modifying key partnerships, distribution channels, or customer

interactions. The strategic rethinking of business models allows firms to create additional value beyond mere cost savings, positioning themselves more competitively in the global market.

Despite the contributions of this study, several limitations must be acknowledged. First, the findings are based on data from the Croatian metal processing sector, which may limit their generalizability to other industries or broader manufacturing contexts. Second, the study relies on self-reported data, which may introduce response bias, potentially influencing the robustness of our conclusions. Third, while the study identifies key innovation strategies, it does not fully account for external moderating variables such as firm size, market dynamics, or digital transformation adoption, all of which could influence the relative effectiveness of different innovation approaches.

To build on these findings, future research should employ longitudinal data analysis to capture the long-term effects of different innovation types on firm performance. Furthermore, incorporating comparative studies across multiple industries would provide a broader perspective on the interplay between innovation strategies and market conditions. Additionally, further investigation into the role of digital technologies in enhancing process and business model innovations could yield deeper insights into how firms can leverage Industry 4.0 tools to maintain competitiveness in mature industrial settings.

In conclusion, while process and business model innovations have emerged as dominant drivers of competitiveness in the Croatian metal processing sector, product innovation's limited impact underscores the unique challenges faced by mature industries. Firms in such sectors must continuously adapt their innovation strategies, balancing cost efficiency, process optimization, and strategic business model transformation to sustain long-term success.

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SUSTAINABILITY MANAGEMENT REINFORCED BY THE SERVITIZATION - AN APPROACH TO EVALUATING SUSTAINABLE BUSINESS MODELS

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Abstract

Sustainable management is omnipresent both in the corporate world as well as in applied business research. There is hardly any measure, project or investment that does not have this focus. This paper seeks to combine approaches from different scientific disciplines to make sustainability efforts measurable as part of the transformation process of manufacturing companies into providers of integrated solutions. To this end, after a brief motivation for sustainability efforts in the manufacturing industry, the focus is on the megatrend servitization. Instead of selling capital goods, the aim here is to offer product-service systems that solve the customer's problem. New disruptive business models form the basis for positive economic and ecological effects in this sector. The transfer and adaption of the customer-lifetime value concept from the area of customer-relationship management is then proposed. This extended calculation can be used to determine the value of the customer relationship and thus also of the product-service system. Ecological effects are included in the calculation as virtual payments. A concrete case study from the agricultural machinery industry accompanies the explanation of this transformation process and valuation.

Keywords: Sustainability, servitization, business models, customer-lifetime value, case study

JEL classification: L80, M41, O32, Q55, Q56

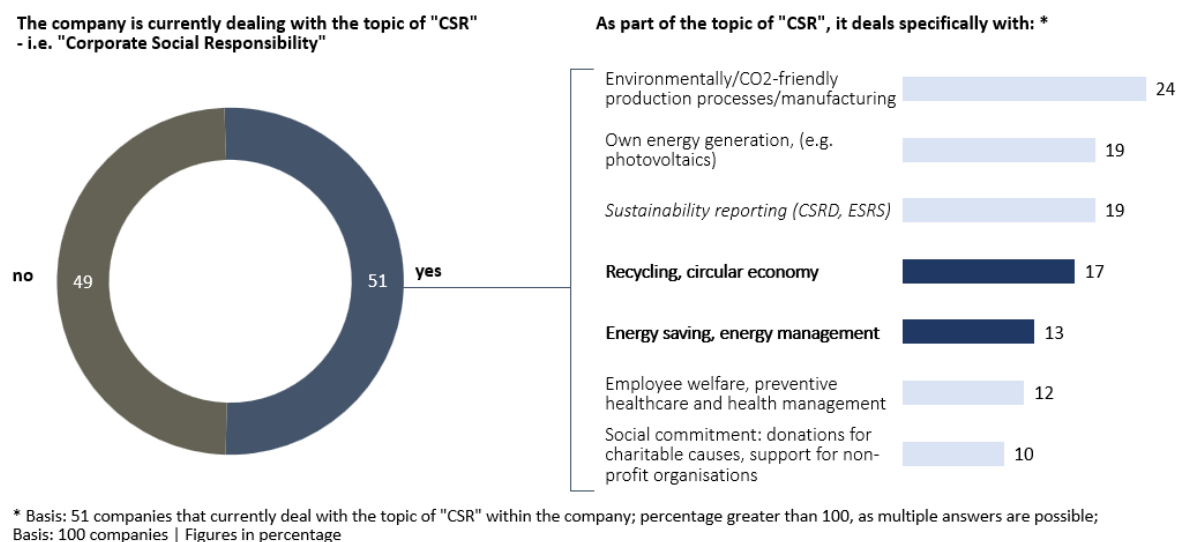
Introduction

Referring to the Green Deal the European Commission promotes sustainable behaviour to achieve climate neutrality. The manufacturing industry in Germany, producing among other products, capital goods is now facing this challenge. This sector is responsible for around a quarter of the total gross value added in Germany (24%) in 2024 (Federal Statistical Office, 2024, p. 18). Many of these companies' products are the result of an energy-intensive production and are material-intensive. A recent CSR survey in North Germany (Kress & Bertenrath, 2024, p. 291) of these companies concluded that quite one in five companies (17%) for which CSR is currently an issue are generally concerned with sustainability measures such as recycling or circular economy and 13% with concrete actions for energy saving (see figure 1). 23 of the 100 manufacturing companies surveyed already use sustainability key performance

indicators. After the CO₂ footprint, probably the most important measure in this area, the waste recycling rate is the second most frequently used key figure.

On the other hand, servitization is one of the latest megatrends in the manufacturing industry. The concept of servitization has gained a lot of attention over the last two decades where companies are trying to add value with different forms of service beyond the physical product. This also leads to a change in business models of manufacturer of capital goods. With these business models, it is possible, for example, that the manufacturer retains ownership of assets throughout the whole lifetime (Estarrona et. al., 2019, p. 110). Applying this concept, it is already foreseeable, that a majority of capital goods will no longer be owned by B2B customers, rather accessed. They don't want to own products through the whole lifetime, preferring to having instead access to the latest version of the product on their current demand (Bauer, 2023). Before discussing this megatrend, the increasing importance of the service industry in Germany should first be briefly explained.

Figure 1: Application of CSR in manufacturing companies and measures



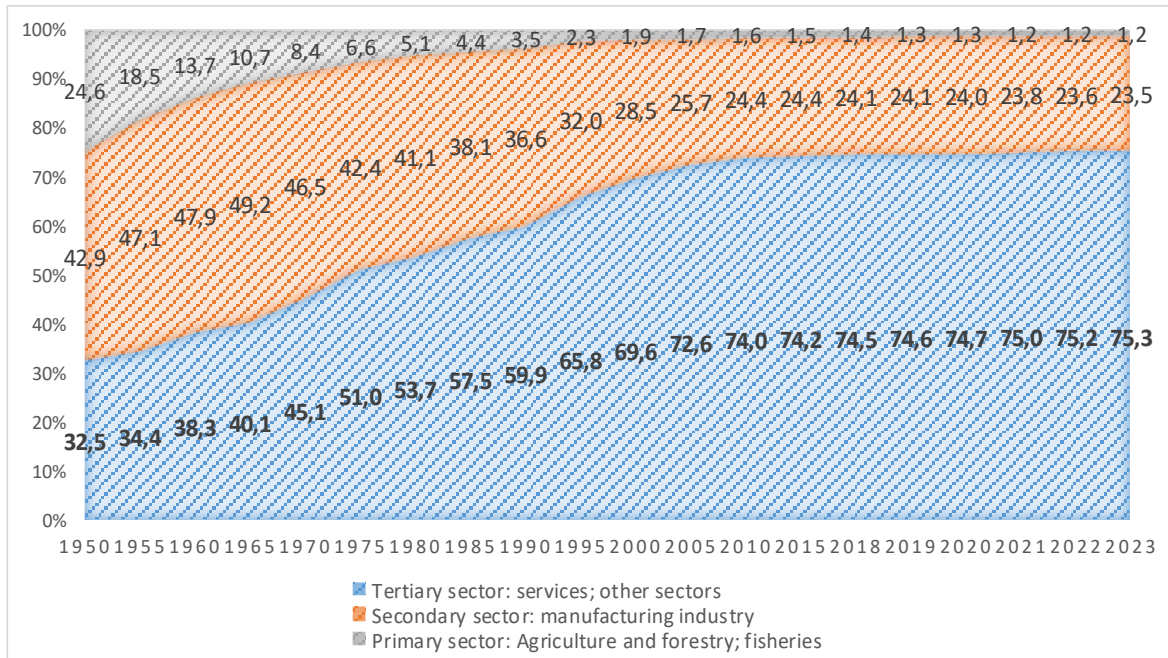
Source: Own illustration according to Forsa survey 2023 on behalf of the Jade University of Applied Sciences and according to (Kress & Bertenrath 2024, p. 291)

Growth in the importance of the service sectors in Germany

As shown in figure 2, the tertiary sector, which includes public and private services, accounts for more than $\frac{3}{4}$ of total employment in the Federal Republic of Germany. In addition to the obvious increase in importance of the tertiary sector in the course of the trend to a more service-oriented society, a shift between the sectors must also be considered in the context of the outsourcing or externalization theory. Externalization is the process of industrial companies outsourcing service functions to service providers in order to achieve cost advantages (Goe, 1991, p. 118 ff.). An example is the chemical industry in Germany, which has focused on its core functions of development and production since the 1980s and has outsourced the service areas to companies, which operate as site and service providers (Seuring, 2003, p. 1213 ff.). Services, originally part of the industrial sector, are now shown in the tertiary or service sector's statistic. Since the beginning of the century, this growth has been reinforced by the megatrend servitization. This trend and the path towards it, which has massive implications for the

understanding and the business models of capital goods companies, will be examined in the following.

Figure 2: Share of economic sectors in total employment in the Federal Republic of Germany from 1950 to 2023



Source: Own illustration, data based on Statista (2024), <https://de.statista.com/statistik/daten/studie/275637/umfrage/anteil-der-wirtschaftsbereiche-an-der-gesamtbeschaeftigung-in-deutschland/>

Theoretical background: From product-related service to servitization

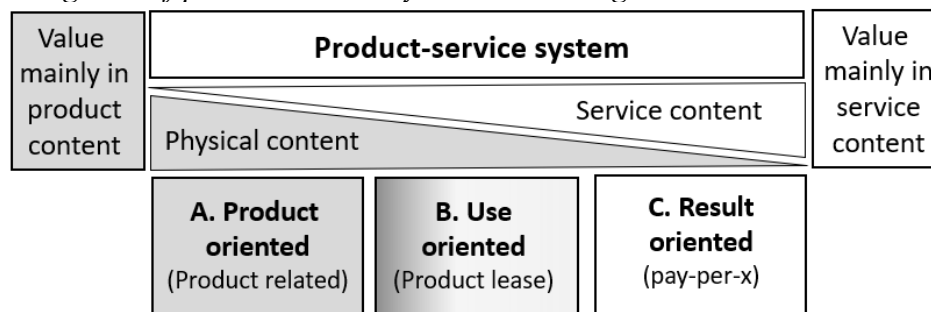
From product-related services to product-services systems

Suppliers of capital goods traditionally provide services to which they are legally obliged, e.g. maintenance. In this first maturity level of pure *product-related services* they are provided in a strong connection with capital goods and enable the user to make specific use of them. This includes not only services that have a physical connection, but also that have a close economic and organizational connection, e.g. financing or leasing of the mostly capital-intensive product. Notwithstanding the main basis of all services is still his physical product, whose assets are usually transferred to the customers at the beginning of the lifecycle. The service for industrial products has a significant impact on companies' profitability. A study of 30 companies in the DACH region carried out 2014 by Roland Berger Strategy Consultants determined, that the traditionally high-margin service with spare parts and maintenance still accounted for a large proportion of sales volume and profit (Roland Berger, 2014, p. 3 f.).

The next, more advanced stage is then the evolution to *Product-Service Systems (PSS)*, which combine physical products and services. With these bundles, it is hardly possible to differentiate between goods and services. Instead, the focus is more on customer-specific problem solving, where customers do not request goods but solutions for their specific problems. For this purpose, a PSS is made up of a specially combination of tangible goods and intangible services

and is designed towards the individual needs. It is characterized by an integrated systematic planning, development, provision and use of material and service components in early stages of its lifecycle. PSS thus establishes a new product understanding, in which the customer also plays a stronger role as external factor in the service development and its production. A large number of methodical classifications of product-service systems can be found in the literature, which categorize PSS according to different criteria. *Salwin and Kraslawski* present a current overview of ten classifications (Salwin & Kraslawski, 2020, p. 187 ff.). A detailed evaluation of all these classifications will not be presented here. *Salwin and Kraslawski*, among others, concluded that only little emphasis was placed on sustainability issues. None of the PSS classifications examined explicitly consider environmental, economic/financial as well as social performance. Also omitted are the mechanisms concerning the company's revenues and customer costs (Salwin & Kraslawski 2020, p. 197 ff.). Only *Tukker's* approach includes economic and ecological aspects, which are both of interest here.

Figure 3: Categories of product-service systems according to Tukker



Source: Own illustration based on Tukker (2004, p. 248)

Tukker distinguishes between three main categories of PSS, which are illustrated in figure 3 and assigns specific business models to them. The first category consists of the *product-related* services described above, which are based on the traditional business model. Physical products are sold and services are added to them. In the second level, the *use-oriented* approach, the transfer of ownership must no longer take place. Although the physical product still plays a central role, it remains the property of the provider or its financing partner and is sometimes shared by a number of users. The last level distinguished by *Tukker* is the *results-oriented* category. In this category, which includes, for example, pay-per-use approaches, the user and provider eventually only agree on the result without a pre-determined capital good (Tukker, 2004, p. 248). This result-oriented category refers to the corresponding basic service definition. The result-oriented perspective focus on the concretization of the service process as an intangible good and not on a possible underlying physical platform (Bruhn, 2023, p. 24). *Tukker* also examines the economic and ecological effects of the various PSS. He recommends for evaluating the economic impact using value management concepts such as EVA (Economic Value Added) (Tukker, 2004, p. 250).

The next evolution step: Servitization as the current transformation megatrend

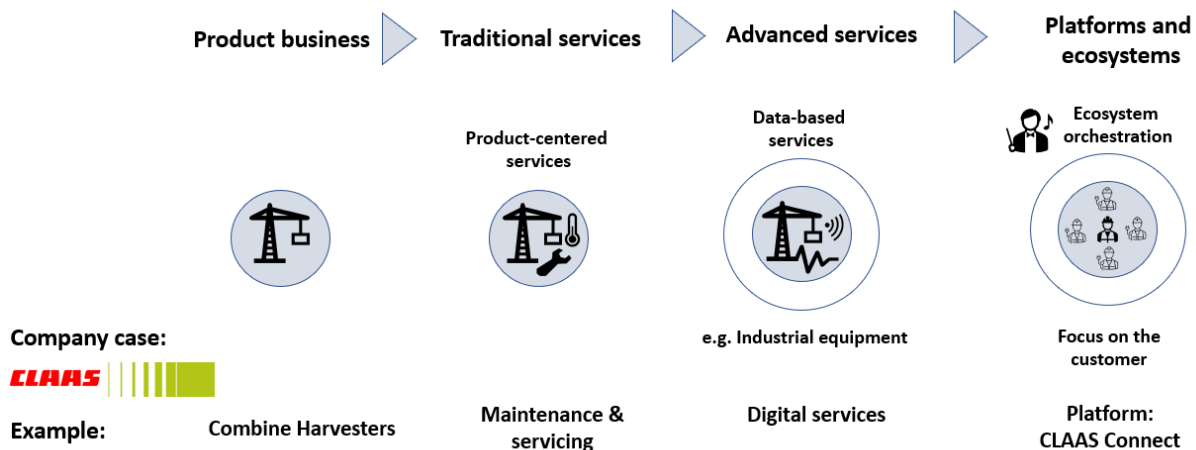
Since the beginning of this century, an even more far-reaching transformation process has been taking place. In several stages, a manufacturer is transforming into a provider of integrated solutions, in which service enables completely new business models. This transformation process represents the current megatrend and is subsumed under the term servitization:

„ ... **servitization** has been defined as the process of creating value by adding services to products. It involves offering ... combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings.” (Dinges, et al. 2015, p. 6)

The transformation process takes place in four phases partly corresponding to the evolution of PSS. In phase 1, the manufacturer is still a product manufacturer, only offering essential services, which cannot necessarily be regarded as PSS. In the second phase, the product-oriented PSS are increasingly offered. In phase 3, the manufacturer develops itself into a full-service provider with more use-oriented PSS before new result-oriented business models such as pay-per-use or pay-per-performance become possible in the final phase. This transformation process of companies is not strongly linked 1:1 with the development of PSS (for example, a full-service provider also offers product-oriented PSS) and is uniformly understood in the literature. As a full-service or provider of integrated solutions in the last stages of transformation, the service approach enables completely new business models (Gleich et. al., 2022, p. 11).

Case study: Transformation steps in the agricultural machinery industry

Figure 4: Transformation steps of servitization using the example of CLAAS



Source: Own illustration according to Kress & Schaeperkoetter (2024:105) based on Ziegler, et. al. (2021: 8)

Figure 4 shows this transformation process using the example of an agricultural machinery manufacturer. CLAAS is the world's fifth-largest manufacturer of agricultural machinery. With around 11.900 employees, the family-owned company generated sales of 5 billion Euro in the 2024 financial year with its products and services for grain and forage harvesting as well as tractors (CLAAS, 2024). The CLAAS Group is divided into product and sales companies, with the service business anchored in a subsidiary. CLAAS understands service as a clear competitive differentiator and has formulated a service strategy that includes digitalization (CLAAS, 2022, p. 20). Traditional maintenance and repair services for harvesting technology products such as combine harvesters or self-propelled foragers are supplemented by digital services for smart farming. These digital services are components of the CLAAS Connect platform, which offer services such as soil, crop and yield analysis. The final stage of servitization is orchestrating the ecosystem which includes tasks such as the value proposition, target customer addressing and revenue mechanics along the service-based value chain of the

network (Kress & Schaeperkoetter, 2024, p. 106). Further cases of other industrial companies are additionally listed in table 1.

The barriers of servitization are also often treated in the literature. For example, *Hou and Neely* conducted a comprehensive literature review in 2013 and distinguished seven barrier categories: 1. competitors, suppliers & partners, 2. society & environment, 3. customers, 4. finance, 5. knowledge & information, 6. products & activities and 7. organizational structure & culture (Hou & Neely, 2013 p. 191 f.). These barriers cannot be examined in detail here, but the methodical evaluation approach presented in the following is aimed at overcoming hurdles in the environment & finance areas.

Table1: Further company examples of servitization / literature and internet survey

Company	Company description	Servitization approaches
Rolls-Royce plc.	Listed manufacturer of engines and components for civil and military aviation as well as in the marine and energy technology sectors.	Pay-per-use model with maintenance, repair and overhaul services based on engine utilization with IoT connectivity, data analytics and remote monitoring.
John Deere Corporation	Listed manufacturer of agricultural machinery. Product range: full-liner product portfolio.	Per-per-use model with integration of an agricultural machinery, agronomic expertise and precision farming technologies.
Schindler AG	Listed manufacturer of elevators and escalators.	Platform concept with predictive maintenance, performance monitoring and personalized service. Pay-per-use model on the basis of uptime, improving energy efficiency and passenger experience.
Caterpillar Inc.	Listed manufacturer of construction and mining equipment.	Pay-per-use model based on machine usage and performance and different services such as maintenance, remote monitoring, performance guarantees.
Dürr AG	Listed machinery and equipment manufacturer. Product range: Painting and assembly systems, coating systems.	From traditional repair services, maintenance to digital platform technologies and operator models, self-understanding as a full-service provider.
Drägerwerk AG & Co. KGaA	Listed company for systems in the fields of medical and safety technology.	In the field of safety technology, the company offers maintenance, training and a complete on-site safety concept during the shutdown phase of chemical plants.
SEW-Eurodrive GmbH & Co. KG	Family-owned manufacturer of drive technology, electric motors and gearboxes for production lines, industrial gearboxes.	Numerous service modules, e.g. repair service, inspection and maintenance service, condition monitoring, which enable a full-service along the customer's life cycle. New business models are possible on this basis.

Source: Own illustration according *Gleich et al. (2023:70)*, *Gleich et al. (2022:94)*, *Moorthy & Rapaccini (2023:4)*.

Research: Application domain and methodical approach

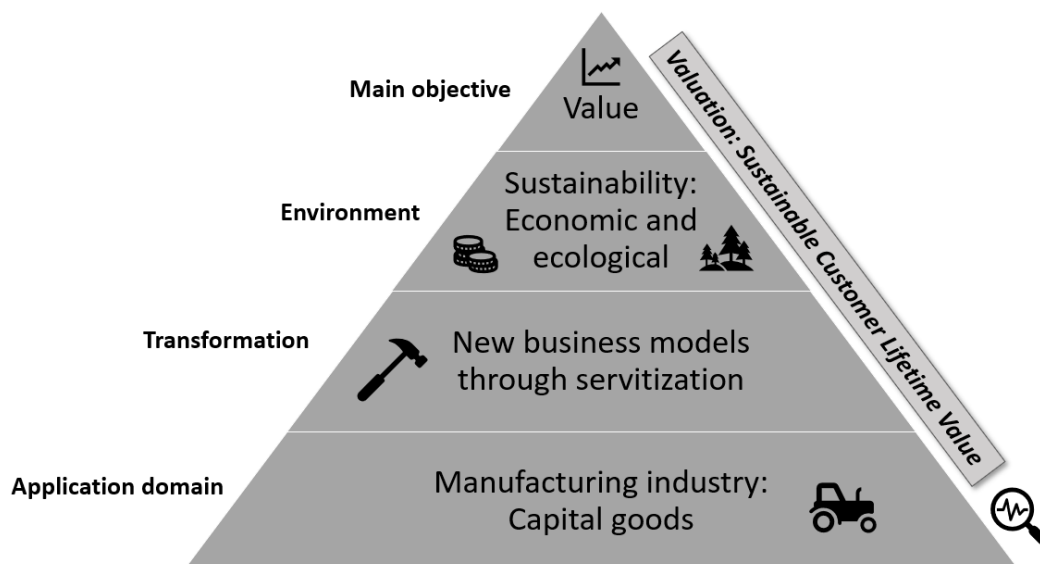
Following the transformation of the capital goods industry the intended research approach will now be presented. As shown in figure 5, the manufacturing industry is the *application domain*. The megatrend servitization is enabling new business models in this sector. These business models must also be considered in terms of sustainability in the two dimensions of a) economic and increasingly important b) ecological sustainability. The ecological dimension should include the CSR targeted goals of recycling, material savings resp. circular economy and energy savings, which are made also possible by the servitization. However, the goal of every company, profit or value creation, is still the main objective and forms the top of the pyramid.

Tukker already recommends evaluating the economic impact of PSS using value management concepts (Tukker, 2004, p. 250).

Performance-based contracted business models enabled by servitization

In the course of this *transformation* the so-called performance-based contracting approach enables completely new business models for the delivery of innovative product-service systems (Glas et. al., 2018, p. 2062). The focus of these approaches is no longer on the physical product, but rather on availability and performance guarantees. This transformation is flanked with different variants of service contracts. Contract-based forms range from pure inspection contracts in the first to full-service contracts in the later stages. At the full-service level, the manufacturer guarantees comprehensive availability of service technicians up to minimum availability levels. Finally, performance-based operator models only guarantee availability and not a specific physical product. Here, the boundary between the capital product and the services becomes completely blurred, as the customer no longer demands a specific physical good.

Figure 5: Overview of the research approach: From application domain to valuation



Source: Own illustration

Performance-based contracted business models enabled by servitization

In these operator models, the capital goods manufacturer can then take over the entire operating including the assets, according to the principles of “pay-per-use” or “pay-per-performance”. Such business models therefore deviate significantly from traditional cash flows in the capital goods industry. Four main servitization business models can be distinguished today (Gleich et. al., 2022, p. 43 f.):

No. 1: The function-oriented business model

The customer is guaranteed functionality through the integration of product-related services. Necessary services are already developed during the planning phase of the physical product. However, a transfer of ownership still takes place at the beginning of the operating phase. Services are usually billed individually via a maintenance contract. Cash in- and outflows therefore differ only a little from the traditional capital goods business with product-related services.

No. 2: The availability-oriented business model

The provider guarantees availability. For this he takes over further business operations of the customer, such as preventive maintenance or ongoing optimization. Systems can remain the property of the provider or be transferred to the customer. Depending on this, the right revenue model must be selected, which can be based on time or production volume. Service billing is usually based on key figures for system effectiveness or production use. This leads to the fact that cash flows of the provider differ significantly from his traditional capital goods business.

No. 3: The result-oriented business model

This model turns away completely from traditional payment flows by focusing now on the production volume. Its cash flows are no longer based on the transfer of ownership, as the system remains the property of the provider, but on the quantity manufactured.

No. 4: The subscription model

In this business model, also known as *abonnement*, the customer receives production output at regular intervals in return for continuous payments. Thereby not only the output is guaranteed by the provider, but the customer furthermore participates in performance increases of the equipment during the subscription period. The cash flows are comparable to those of the results-oriented business model with additional expenditure for efforts to improve the performance.

The selected business model therefore has a significant influence on the cash flows of the manufacturer on the one hand, while at the same time the valuation requires an extension to all periods of the product lifecycle, which leads to the necessity of a dynamic capital expenditure budgeting. The focus is no longer on the product as such, but now on the customer. Because of this the question is no longer: “Does the product pay off” but “Does the concrete operator model add value to us?” This reflects the increased need for a valuation as already stated by *Tukker*. The invested capital should be subject to an appropriate return in accordance with the requirements of shareholders (Tukker, 2004, p. 250). This is gaining even more importance as there is no transfer of ownership and therefore increasing capital tied to the manufacturer.

Sustainability as an additional perspective on the servitization concept

Sustainability can be viewed from several perspectives, such as the social and economic perspective (Alhaddi, 2015, p. 7). The approach that has received the most attention since the late 1990s is probably the triple bottom line. This approach basically distinguishes between three perspectives, namely the economic, social and environmental line. The triple bottom line provides a framework for measuring the performance of the business and success of an organization. The economic line treated the capability of a subsystem to survive and evolve in the future. The social line refers to measures to labor, human capital and to the community e.g. employee relations or fair wages. The third, the environmental line refers to engaging in practices that do not compromise the environmental resources of future generations (intergenerational justice) (Alhaddi, 2015, p. 8). As outlined above servitization and its business models can now impact the economic and ecological line of sustainability.

Impact on economic sustainability

Numerous company surveys have confirmed for over a decade that servitization - sometimes examined in combination with digitalization - can lead to an improvement in profitability. This is essentially due to two effects:

- a) Internal optimizations through the use of service and
- b) an improved competitive position through a closer customer relationship and thus advantages in terms of margins.

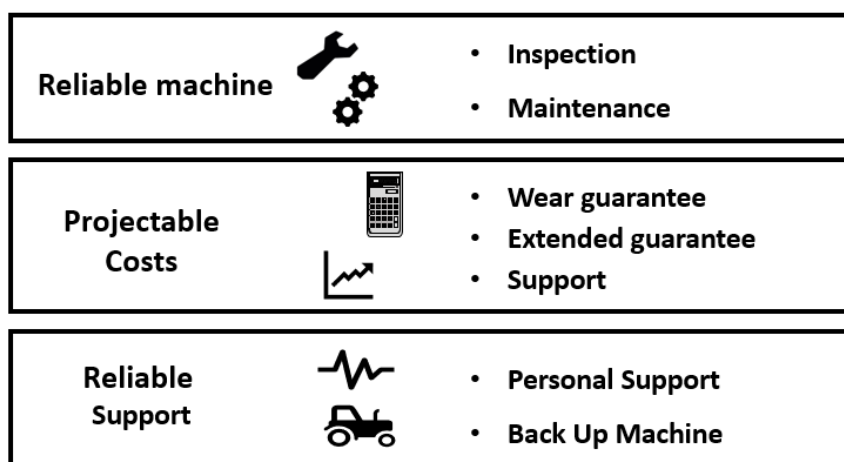
From the internal perspective the integration of service elements can reduce the accumulation of redundant resources, improve resource utilization and allocation. This could lead to a better conversion of internal resources into profit. *Miao, Shi and Jing* examined this hypothesis among others in a comprehensive study of annual reports in China and came to the result that servitization of manufacturing companies can contribute to improving business performance (*Miao, et. al.* 2023). In service-oriented business, the focus is not on the product, but on the customer's problem, e.g. instead the acquisition of a specific pump the transportation of a certain amount of fluids from a position A to another position B. Individually developed customer solutions with high-quality service reduce the interchangeability and can thus lead to the avoidance of a price war and ultimately increased profit margins. This can help to increase a sustainable revenue over the entire lifecycle and EBIT margins on service 3 to 7 times higher than the traditional product sale (*Marks*, 2017, p. 4). Nevertheless, spare parts and standardized product-related services still contribute the most to the revenues, but margins here are under increasing pressure. Therefore, *Roland Berger* already stated in 2014, to focus on more promising areas, such as remote monitoring, performance updates or refits as well as additional consulting services (*Roland Berger Strategy Consultants*, 2014, p. 3 f.). The new servitization business models take this fact into account and even go beyond this product-related services.

Impact on ecological sustainability

Servitization promotes environmental sustainability in manufacturing companies in many ways. Its business models can support the selling functionality, efficient resource utilization, dematerialization and circular economy approaches (*Kohtamäki et. al.*, 2024, p. 3). In contrast to a pure sales approach, the manufacturer is now focusing on the entire lifecycle. At the same time, the service-based approach makes it possible to increase the lifecycle via refit or update concepts and taking care of dispose or reuse them. Therefore, the link with the circular economy is obvious. Their approach to extract maximum use from the products, repurpose and recycle them relates ideal to servitization (*Dohrmann et. al.*, 2018, p. 5). Energy and material saving are two main advantages of recycling. Reusing and remanufacturing products can be part of the circular economy. *Han, Heshmati, & Rahsidghalam* stated that many studies came to the result that, if as well reliability as quality is good, service availability is guaranteed and recycled products are price competitive, that these products are evaluated favourably by consumers (*Han et. al.*, 2020). Servitization has the advantage of pooling of consumer demand on few products rather than satisfying each demand with a separate product (*Kanath & Karaer*, 2022, p. 547).

Case study: Servitization as basis of sustainability in the agricultural machinery industry

Figure 6: Service goals and service portfolio at CLAAS MAXI CARE



Source: Own illustration

As shown in figure 6, CLAAS service products ensure the availability of the machine, which is particularly important in the harvesting sector, and also contribute to the predictability of (repair) costs for the customer. Warranty contracts and, increasingly, full maintenance contracts are the first choice of customers. For this CLAAS combines its service products in the MAXI CARE product family. The majority of machines are already equipped with telemetry. So digital systems for analyzing service make it possible to analyze customer needs and support the planning of internal resources, especially during the harvesting phase.

Furthermore, the service unit practices circular economy in its REMAN exchange parts program. CLAAS applies used parts for this purpose, reconditions them industrially and offers them as a cost-effective alternative to new parts. These parts undergo the same technical development tests as new parts. REMAN parts comply with the warranty guidelines for new parts and actively protect the environment, as resources are conserved by reusing old parts. In addition to avoiding material wastage, it also offers a cost-effective alternative for older machines (CLAAS, 2025). CLAAS also offers repair services under the “Repair Service” label. The company acts here as an intermediary to specialized providers via a portal. The focus here is on electronic components, for example. In addition to this, discarded combine harvesters have also been reused for internal use as test vehicles or prototypes.

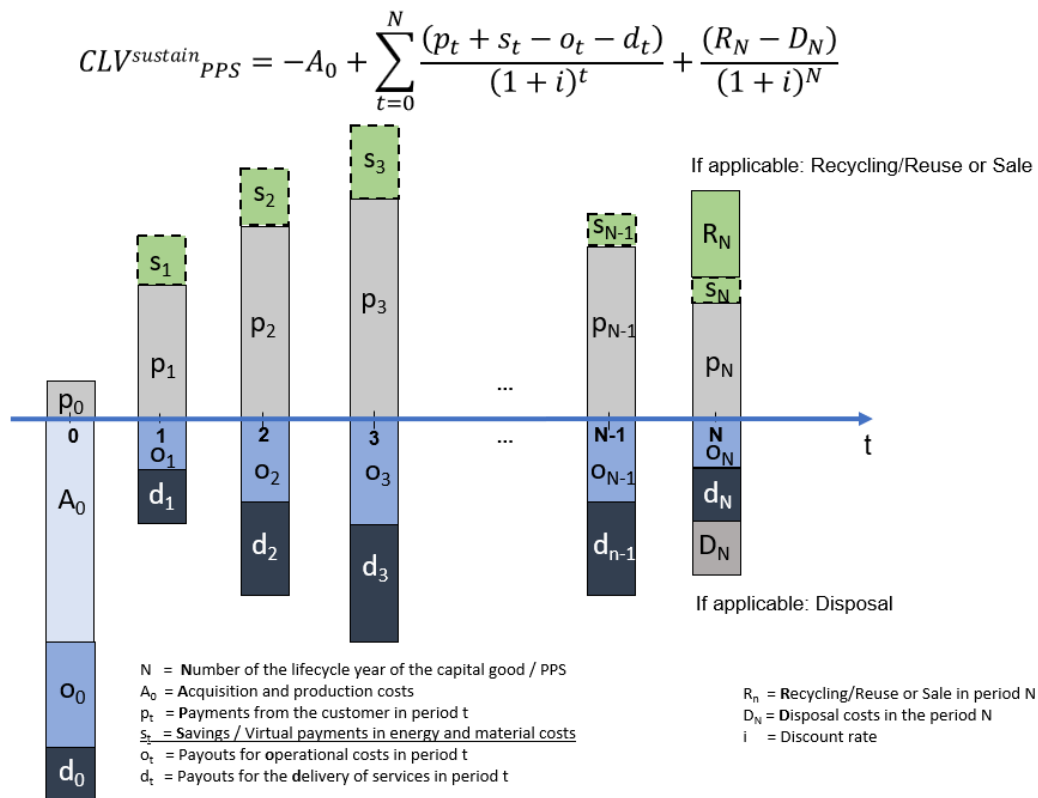
Valuation of business models: the sustainable customer-lifetime value

While the consideration in the classic product business in the stage 1 of the transformation often ended at the point in time of the sale, lifecycle-oriented servitization business models of types No. 2 to 4 now require a multi-period dynamic valuation view. Cash inflows and outflows differ significantly from those from the traditional sale of capital goods business. Furthermore, in the course of customer-relationship management marketing research has increasingly turned to customer and its value instead of focusing only on product policy (Jain & Singh, 2002, p. 34), (Berger et. al., 2006, p. 157). The requirement to evaluate the customer relationship was therefore obvious and led to the Customer-Lifetime Value concept (CLV).

Extension of the customer-lifetime value calculation

In its basic form, the CLV is a function of future revenue after deducting cost of goods sold over the duration of the relationship (Berger et. al., 2006, p. 160). By discounting with the company-specific discount rate the present value of the customer relationship is obtained. A few years later, management accounting research took up the CLV concept in the context of customer value controlling. This customer value can be viewed from the customer or provider perspective. The provider perspective, considered here, is dedicated to the contribution of one customer or the entire customer base perceived to achieving monetary and non-monetary goals.

Figure 7: Calculation of the $CLV_{PPS}^{sustain}$



Source: Own illustration

Figure 7 illustrates the extension of the calculation for a PSS where the system remains the property of the provider as usual with operator models. Key performance indicators for the availability and results-based business model, e.g. availability, operating hours or output volumes, can be used to substantiate the forecast of cash flows. Uncertainties that naturally occur can be reduced through the direct integration of sensor technology for recording and algorithms for processing and interpreting the data on the operating status (smart services). Process mining is here now an established technology. If the system is transferred to the customer at the end of the estimated lifecycle or is otherwise sold, these revenues can also be considered. Academic research already showed, that the estimates of the customer value are reasonably close to the shareholder value (Berger et. al., 2006, p. 157). Therefore, the customer-lifetime value calculation can establish a significant link to value management, which Tukker demands as the economic perspective on the sustainability of PSS (Tukker, 2004, p. 250).

This traditional CLV can now be expanded to include environmental sustainability components to the the $CLV^{sustain}$. The savings in energy and material costs can for this purpose be considered as shown as green blocks in figure 7. Although these savings from the ecological perspective do not represent direct payments to the provider, they should be counted as virtual payments that increase the total customer value. This is of particular interest if it leads to an improvement in the CO₂ footprint of the manufacturer through the pooling of systems. As a result, it is possible to avoid the purchase of additional CO₂ certificates, which can be directly attributed to the customer relationship. The total ecological effects can be assessed over the entire PSS, which could be realized in the formula by a sum over all individual customer relationships. Further the circular reuse of all or part of the PSS within the scope of recycling also leads to a (virtual) positive payment at the end of the lifecycle.

Case study: Exemplary application of the $CLV^{sustain}$

The application of the $CLV^{sustain}$ for an exemplary calculation of a fictitious tractor is shown in figure 8.

Figure 8: Exemplary Calculation of the $CLV^{sustain}$

Results		Input parameter					
$CLV^{sustain}_{PPS}$	75.210	Interest rate / WACC in %					
CLV_{PPS}	59.882	10,00%					
Year / N	0	1	2	3	4	5	6
Payouts							
Acquisition and production costs	184.000						
Payouts for operational costs in period t							
Payouts for the delivery of services in period t		780	780	780	780	780	840
Disposal costs in the period N							
Total	184.000	780	780	780	780	780	840
Payments-in							
Payments from the customer in period t	230.000	2.600	2.600	2.600	2.600	2.600	2.000
Disposal costs in the period N							
Total ^{unsustain}	230.000	2.600	2.600	2.600	2.600	2.600	2.000
Savings in energy and material costs		2.000	2.000	2.000	2.000	2.000	1.600
Recycling/Reuse or Sale in period N							
Total ^{sustain}	0	2.000	2.000	2.000	2.000	2.000	1.600
Results							
Payment surplus ^{unsustain}	46.000	1.820	1.820	1.820	1.820	1.820	1.160
Discounted Payment ^{unsustain} surplus	46.000	1.655	1.504	1.367	1.243	1.130	655
Payment surplus ^{sustain}	46.000	3.820	3.820	3.820	3.820	3.820	2.760
Discounted Payments ^{sustain} surplus	46.000	3.473	3.157	2.870	2.609	2.372	1.558

all values in T€	
24	25
1.050	1.050
1.050	1.050
2.500	2.500
2.500	2.500
1.200	1.200
5.000	
1.200	6.200
1.450	1.450
147	134
2.650	7.650
269	706

Source: Own illustration, remark: The data in the example are only sample data for reasons of confidentiality

This example still deals with the traditional business model, in which the tractor is sold at the beginning of the lifecycle to the farmer with additional product-related services during the period of use. The calculation is based on assumptions regarding the hours of use per year over a period of 25 years, which decrease from the 6th year and then again from the 11th year until the end of the lifecycle due to the advanced age. During this period, service payouts increase for both the provider and the customer. In this example, the virtual “green” payments only include costs for reduced diesel consumption through better service and optimization as well as the possibility of reusing the tractor within the circular economy. These two measures alone increase the value contribution of this PSS by over a quarter when comparing $CLV^{sustain}$ with conventional CLV. This also shows that the discounted value contributions have a much greater

impact in the first years than in the last years and that the contribution of the circular economy contributes less than 1 percent to CLV^{sustain}.

Conclusion and outlook

The discussion about sustainable management is currently omnipresent both in the corporate world and in applied business research. At the same time, the service transformation poses major challenges for companies in the manufacturing industry, as it is disrupting established business models. Taking these developments into account, a methodological approach was presented that both considers trends in the application area of the manufacturing industry and also extends methods to determine resulting value contribution. The calculation of the value contribution led to an adjusted customer-lifetime value. This concept adapted from the field of the customer-relationship management can also take sustainability actions into account to measure the value of the customer relationship. Positive effects from ecological sustainability success can be booked as virtual payments.

The estimation accuracy of the prospective part is often the reason why CLV accounting has not yet been able to establish widely in the practice business-to-business sector, despite the long-term business relationships with their high in- and outcoming payments. This problem is exacerbated in the service business with its increased uncertainties. Further applied research to develop concepts to reduce these uncertainties are therefore necessary, which, for example, underpin incoming and outgoing payment flows on the basis of special data and empirical knowledge analysis or process mining algorithm. In addition, the traditional accounting does not allocate payments from the supplier to the cost unit of the customer. In practice, however, the actual values can be assigned to corresponding settlement objects by means of projects as cost accounting instances in ERP-systems. Nevertheless, the uncertainty of the forecast over the long lifecycle of such products remains. This difficulty increases if the capital goods are subsequently sold to new customers in a second or third market. The approach must then be expanded to a product-service system customer-lifetime value across all customers and all market phases in theory and practice. In addition to improving the quality of forecasts by integrating technical methods such as the use of sensors for data acquisition or artificial intelligence for interpreting data, further conceptual research is also required. This extended evaluation approach, which has yet to be developed, should also include later market phases in order to provide a complete overview of the economic and ecological benefits.

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THE STRATEGIC INTEGRATION OF SUSTAINABILITY IN BUSINESS

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Abstract

This study explores how sustainability can be embedded into corporate strategy and structure by addressing the challenges and opportunities associated with measuring and assessing sustainability impacts. It examines the role of digitalization in transforming sustainability from a compliance-driven activity into a core strategic function. Through semi-structured interviews with industry participants, the study gathers insights into how companies strategically integrate sustainability considerations into decision-making processes. The findings reveal that a lack of standardized metrics and diverse evaluation methods hinders effective sustainability measurement, making strategic alignment difficult. However, companies increasingly leverage digitalization to standardize sustainability assessments, streamline data collection, and ensure alignment with long-term business objectives. This study contributes to the literature by emphasizing the strategic potential of sustainability and the necessity of digital platforms to facilitate its integration into corporate decision-making. It underscores the importance of defining clear sustainability parameters and establishing reliable measurement frameworks, positioning sustainability as a fundamental component of business strategy rather than an ancillary concern. Ultimately, this study highlights how strategy can empower organizations to embed sustainability at the heart of their agenda, driving meaningful economic, environmental, and social transformation.

Keywords: sustainability strategy, organizational structure, change management, corporate decision-making, standardized metrics

JEL classification: M14, Q56, O33, L21, L86

Introduction

In an era where environmental, social, and governance (ESG) considerations are increasingly shaping corporate strategy, sustainability has evolved from a peripheral concern to a fundamental business imperative. However, the integration of sustainability into corporate decision-making remains a challenge, primarily due to the lack of standardized measurement frameworks and the complexity of aligning sustainability goals with long-term business objectives (Rawhouser et al., 2019; Reeder et al., 2015). While companies recognize the need to embed sustainability into their strategic frameworks, many struggle to establish effective methodologies that ensure transparency, comparability, and accountability (Findlay & Moran, 2019).

Digitalization has emerged as a critical enabler in overcoming these challenges, offering new tools to streamline sustainability assessments, enhance data collection, and support regulatory compliance (George et al., 2020). The growing emphasis on digital sustainability solutions reflects a broader shift in corporate governance, where technology is leveraged to align business performance with environmental and social impact. Yet, the transition from compliance-driven sustainability practices to strategic integration requires not only digital innovation but also structural and cultural transformation within organizations (Lehner, 2016; Lehner et al., 2019). Based on the above this study explores how sustainability can be embedded into corporate strategy and structure.

Literature review

Despite numerous national and international initiatives, accurately measuring sustainability outcomes remains challenging (Rawhouser et al., 2019). Unlike standardized financial metrics (e.g., ROI, ROA, EBITA), no universally accepted framework exists for assessing environmental and social performance, limiting organizations' ability to integrate sustainability into corporate strategy (Bugg-Levine & Emerson, 2009; Findlay & Moran, 2019; Grewal et al., 2021; Höchstädter, 2015). Instead, governance quality assessments often rely on indirect financial indicators rather than dedicated sustainability metrics (Escrig-Olmedo et al., 2019).

A key weakness in current sustainability measurement lies in fragmented and inconsistent approaches. Organizations use varied frameworks and indicators tailored to their specific needs, undermining comparability across industries and regions (Sardy & Lewin, 2016). This inconsistency prevents meaningful aggregation of sustainability data, hindering progress toward global sustainability goals such as the Paris Agreement and the Sustainable Development Goals (SDGs) (Beske. et al., 2008; Epstein, 2008; Reeder et al., 2015). Without standardized methodologies, sustainability efforts risk being reduced to ad hoc initiatives, misaligned with long-term business objectives.

Corporate sustainability, ESG, corporate social responsibility (CSR), and socially responsible investment (SRI) are key frameworks that influence sustainability integration. ESG, in particular, has gained traction as investors demand greater transparency in corporate environmental and social impacts (Grewal et al., 2021). However, some scholars argue that ESG remains largely a compliance mechanism rather than a transformational tool for business strategy (Eccles & Serafeim, 2013). CSR, on the other hand, traditionally focused on voluntary corporate actions but has increasingly been formalized into legal and investor expectations (Carroll & Shabana, 2010). Similarly, SRI has evolved beyond exclusionary screening toward impact driven investment, aligning financial performance with sustainability outcomes (Friede et al., 2015). While these frameworks provide essential guidance, their implementation varies significantly across industries and regions, contributing to the lack of standardization in sustainability measurement (Aguinis & Glavas, 2012).

The role of digitalization in sustainability strategy remains contested within the literature. Some scholars argue that digital tools enhance transparency, efficiency, and accountability in sustainability efforts (George et al., 2020). Technologies such as artificial intelligence (AI), big data analytics, and blockchain can improve data accuracy and streamline compliance with sustainability regulations (Wang et al., 2022). However, other perspectives caution that digitalization may exacerbate sustainability challenges by reinforcing data asymmetries, increasing surveillance risks, and diverting attention from structural sustainability

transformations (Behl et al., 2023). Furthermore, there is debate over whether digital solutions serve as enablers of substantive sustainability change or merely function as mechanisms for regulatory compliance (Van Loon et al., 2021). These competing perspectives highlight the need for a nuanced discussion on the role of digitalization in sustainability integration.

To address these challenges, businesses must adopt structured methodologies and digital solutions that embed sustainability into strategic decision-making. Companies integrating digital tools into sustainability measurement enhance comparability, regulatory compliance, and long-term resilience. Historically, corporations prioritized profit over societal well-being, leaving sustainability efforts to governments and non-profits (Brandstetter & Lehner, 2014; Jackson, 2013; Rodin & Brandenburg, 2014). However, shared value creation has gained traction, aligning business success with societal benefits (Lehner, 2016; Porter & Kramer, 2011; United Nations, 2020; Weber & Feltnate, 2016). Sustainable investments increasingly balance financial returns with environmental and social impact, offering an alternative to traditional investment mechanisms (Jackson, 2013; Lehner, 2016; Lehner et al., 2019).

Integrated sustainability and strategy

Companies must embed environmental, social, and economic considerations into their strategic frameworks to integrate sustainability. This involves setting measurable goals aligned with corporate values and global standards such as the United Nations Sustainable Development Goals (SDGs), the Global Reporting Initiative (GRI), and the Sustainability Accounting Standards Board (SASB) (GRI, n.d.; SASB, n.d.; United Nations). Key focus areas include carbon reduction, waste minimization, workforce diversity, and ethical labor practices. Sustainability has evolved from a peripheral concern to a core driver of competitive advantage, shaping product innovation, procurement, and board-level decision-making (Porter & Kramer, 2011).

Stakeholder engagement is essential for a successful sustainability strategy, requiring active collaboration with shareholders, employees, customers, suppliers, local communities, and regulators (Freeman, 1984). Companies that foster transparent dialogue through advisory boards, public consultations, and sustainability reports are better positioned to align with societal expectations while mitigating risks related to regulatory compliance, operational disruptions, and consumer trends (Epstein, 2008; Freeman, 1984). Frameworks like GRI and SASB enhance credibility by ensuring transparency and accountability in sustainability disclosures (GRI, n.d.; SASB, n.d.).

Beyond internal operations, supply chain sustainability is critical, encompassing responsible sourcing, ethical labor standards, circular economy principles, and waste reduction (Beske. et al., 2008; Seuring & Müller, 2008). International guidelines such as the United Nations Global Compact (UNGC) Principles and the SDGs provide a structured approach to sustainable supply chain management. At the same time, certifications like Fair Trade and ISO 14001 reinforce environmental and ethical accountability (United Nations, n.d.). Transparent sustainability reporting, guided by GRI and SASB standards, allows companies to track, measure, and disclose their sustainability impact, ensuring consistency across industries and fostering a culture of accountability and continuous improvement (GRI, n.d.; SASB, n.d.). With increasing investor and consumer demand for climate-related financial disclosures, sustainability is now integral to corporate risk and financial management (TCFD, n.d.).

Risk management and employee engagement

Sustainability is deeply tied to risk management, as companies must address financial, operational, and reputational risks linked to climate change, social unrest, and governance failures. Integrating sustainability into risk assessment helps businesses identify, mitigate, and capitalize on emerging challenges. Investments in renewable energy, sustainable innovation, and resource efficiency reduce regulatory risks and unlock new revenue streams (Forum, n.a.; Taleb, 2007). The circular economy model, which promotes waste reduction and resource optimization, has become essential for balancing economic growth with environmental responsibility (Foundation, 2024). Companies prioritizing energy efficiency, water conservation, and sustainable sourcing benefit from lower costs and improved environmental performance, reinforcing the business case for sustainability (Häkkinen et al., 2019). Employee engagement is critical for driving sustainability efforts. Organizations that integrate sustainability into training, performance evaluations, and workplace culture foster a workforce committed to corporate social responsibility (Bocken et al., 2020; Macedo et al., 2017; Macey & Schneider, 2008). Employee-led initiatives, such as green teams and sustainability campaigns, enhance environmental performance and financial success. As investor expectations, consumer demands, and regulatory pressures evolve, businesses must adopt standardized sustainability frameworks and digital tools to improve measurement and reporting. This study examines how digitalization enhances sustainability integration, facilitating strategic decision-making and corporate resilience.

Method

This study employed a qualitative research approach, using semi-structured interviews to gain in-depth insights into how sustainability and digitalization influence corporate strategy. A total of seven face-to-face interviews were conducted, each lasting between 35 and 65 minutes, allowing for comprehensive discussions with industry professionals. To ensure that participants had relevant expertise, a purposive sampling method was used, selecting individuals who were actively involved in sustainability, digital transformation, and strategic management within their respective companies (Merriam & Tisdell, 2016). The selection process focused on professionals from six companies across four industries, ensuring diverse perspectives on the intersection of digitalization and sustainability strategy. The data collection process was carefully structured to maintain rigor and reliability. All interviews were recorded and transcribed verbatim, ensuring that no details were lost during the analysis phase. The transcriptions were systematically coded to identify recurring themes, patterns, and key insights, following established qualitative research practices (Creswell & Creswell, 2017). The study did not rely on a pre-existing theoretical framework; the theoretical insights emerged inductively from the collected data, aligning with an exploratory research approach (Esterberg, 2002; Merriam & Tisdell, 2016).

Participants and data collection

The study included six participants, each occupying a managerial role in sustainability transformation projects within their organizations. The participants were from various industries: retail, finance, production, transportation, and fisheries. Their professional experience in sustainability and digitalization ranged from 4 to 18 years, and their ages varied from 35 to 56 years. The gender distribution included four women and two men, reflecting diverse leadership perspectives.

Interviews took place between September and December 2024. To maintain confidentiality, each participant was assigned a unique numerical identifier (e.g., P1.R for Participant #1 from retail, P2.FIN for Participant #2 from finance). This anonymization ensured that sensitive business insights were protected while allowing for structured analysis of responses. The study followed strict ethical guidelines, with participants providing informed consent for recording and direct quotations while retaining the right to withdraw at any stage. Researchers had no prior affiliations with the companies involved, ensuring neutrality in data collection and interpretation.

To facilitate structured discussions, a six-section interview guide was developed. The interviews covered:

1. Participants' background.
2. Incentives for implementing digital solutions in sustainability processes.
3. How strategic decision-making might be impacted by digitalization.
4. The role of sustainability in strategy formulation and managing change.
5. Current and future challenges related to sustainability solutions.
6. The broader impact of sustainability digitalization on corporate strategy and compliance.

While most interviews were conducted using Microsoft Teams, two were face-to-face.

Data analysis

Once the interviews were transcribed, the researchers undertook systematic coding and thematic analysis to identify key themes within the data (Esterberg, 2002). Open coding was initially applied to mark significant phrases and ideas, followed by axial coding to establish relationships between different concepts. This method enabled identifying core categories that shaped the study's findings.

The analysis focused on uncovering patterns in how companies integrate sustainability into strategy through digital tools, highlighting challenges, emerging opportunities, and industry best practices. To ensure validity and reliability, a second researcher reviewed the coding, minimizing potential biases and enhancing the internal consistency of findings. Table 1 presents an overview of the participants, while Table 2 outlines the three main themes derived from the analysis.

Table 1: Interviewees

Participant	Experience in years within Sustainability	Position	Industry	Gender	Age
P1.R.	12	Manager	Retail	M	40
P2.FIN.	18	Manager	Finance	F	45
P3.FIN.	4	Manager	Finance	F	35
P4.FIN.	12	Manager	Finance	F	48
P5.T.	15	Manager	Transportation	F	41
P6.F.	15	Manager	Fishery	M	56

Table 2: Themes derived from coding of interviews.

1	Sustainability as part of strategy development
2	Digitalization for Sustainable Strategy
3	Organizational Structure and Regulatory Complexity

A key limitation of this study is the small sample size, with only six participants representing four industries. While the purposive sampling method ensured relevant expertise, the low number of interviewees may restrict the generalizability of the findings across a broader range of industries. The limited sample may not fully capture the diversity of corporate sustainability practices, especially in sectors with varying regulatory environments and digital maturity. Consequently, future research with larger and more diverse participant pools would strengthen the validity of the insights and offer a more comprehensive understanding of digitalization in sustainability strategy.

Findings

The introduction of statutory obligations for non-financial reporting, particularly Act No. 73/2016, which amended prior disclosure requirements in line with EU Directive 2014/95, marked a turning point for how companies approach sustainability strategically. The legislation requires larger corporations to disclose essential information regarding their sustainability impacts, financial scope, and long-term strategic positioning. However, the broad nature of the requirement left organizations with considerable flexibility in determining what and how to report, leading to challenges in standardization and comparability.

Sustainability as part of strategy development

Before 2016, sustainability efforts across organizations were often reactive rather than strategic. Many companies engaged in Corporate Social Responsibility (CSR) initiatives, but these efforts were philanthropic in nature rather than integrated into core business strategy. Sustainability was primarily associated with local community projects, such as sponsoring sports teams or supporting environmental awareness campaigns. The term "sustainability" was rarely used in a structured corporate sense, and there was little to no alignment with broader business objectives. A company manager of a large fishery recalled that his organization initially focused on employee behavioral changes, such as internal waste reduction programs and office recycling, rather than embedding sustainability into strategic decision-making. Similarly, a sustainability manager from a retail company reflected on early missteps: *"Not many were involved in strategically thinking of sustainability. I realized this and began to discuss sustainability with employees who truly impact the operation's value chain. That initiated some strategic thinking."* (P6.F.). For financial institutions, external pressures influenced sustainability discussions rather than internal strategy. A manager from a major bank explained that before 2016, their focus was limited to aligning with Nasdaq's ESG reporting framework rather than developing a sustainability strategy based on their own corporate objectives: *"Sustainability was viewed within the bank as an external issue or non-operational at least. Employees viewed it not as being part of the bank's operation. None saw any link to the bank's finances. Hence, sustainability initiatives were hard to sell as an integral part of the bank. We did not have the tools or synergies with the bank's strategy then."* (P2.FIN.). The shift toward strategic sustainability was largely driven by external societal and regulatory pressures rather than internal corporate foresight. Several companies only intensified their sustainability efforts when employees, investors, and international partners began demanding more precise commitments to sustainability and SDG alignment.

The structure was a critical enabler of strategic sustainability integration for a transportation firm. The company manager described how prior quality control systems resemble the

integration of sustainability into structure and how it played a key role in transitioning from ad hoc actions to structured strategic initiatives: *"Before our quality managers were located as sustainability managers are today. That is very high in the organizational structure, with a stand-alone identity next to the CEO. That is needed when presenting an important ingredient of the operation. Gradually, when quality became part of the company's DNA, the need for that position within the organization changed. We are following the same sustainability strategy. Sustainability is next to the CEO, but it has to become part of the DNA."* (P5.T.)

To make sustainability an integral part of strategy, the part of the organization that is responsible for revenue needs to be involved. A finance company manager described how change finally happened: *"When we of the sustainability team decided to host a strategy workshop only for those divisions responsible for revenue, things started to happen. Those employees had viewed sustainability only as a cost, not revenue generating. Integrating sustainability into a strategy discussion and searching for revenue opportunities that changed their mindsets."*

To summarize, before 2016, sustainability was often treated as a peripheral issue rather than a core strategic priority. Many companies engaged in corporate social responsibility (CSR) activities that were largely philanthropic, lacking alignment with business objectives. Sustainability was primarily linked to local community projects rather than integrated into decision-making processes. External pressures from investors, regulators, and employees significantly shifted corporate perspectives on sustainability. Some firms only began considering sustainability strategically when stakeholders demanded clearer commitments and alignment with the Sustainable Development Goals (SDGs). The organizational structure was critical in integrating sustainability into business strategy, with some firms positioning sustainability functions at the executive level to enhance its influence. Additionally, involving revenue-generating divisions in sustainability discussions proved to be a turning point, as it reframed sustainability from being perceived as a cost burden to a potential source of revenue. The shift towards strategic sustainability required structural changes and a cultural transformation within organizations, fostering a mindset that recognized sustainability as a business imperative rather than an external obligation.

Digitalization for sustainable strategy

The introduction of mandatory non-financial disclosure laws created an urgent need for companies to find effective digital tools to track, measure, and report sustainability performance. However, the ambiguity in regulatory requirements made it difficult to determine which data to collect and which digital tools to adopt. A retail company sustainability manager described the early approach to selecting digital solutions as highly experimental: *"There is a challenge collecting the necessary data on sustainability. New regulations put endless pressure on the availability and reliability of such data. General software solutions are something most began with (like Nasdaq's ESG framework), but now they must be more customized solutions."* (P1.R.)

Financial institutions faced similar struggles. Initially, many banks relied on basic Excel spreadsheets for non-financial reporting. In 2016, some implemented specialized data collection and processing software, but these systems often failed to meet all their sustainability reporting needs. *"We purchased a sustainability reporting tool that didn't fully align with our operational requirements. As a result, we had to develop custom in-house software to supplement what we bought from IT vendors."* (P2.FIN.) This challenge extended beyond the financial sector. A fisheries industry sustainability manager highlighted how digitalization

fundamentally changed the role of sustainability in their business: *"The flow of new regulation creates the risk that we who work with sustainability concentrate too much on finding and implementing the tools needed. Sustainability has certainly become a part of our strategy and organizational chart, but it is a challenge to balance actual work and finding out what IT to apply."* (P6.F.)

However, in some industries, tools to apply are available; at least, there is a change in just a few years. A manager of a financial company claims: *"Things have changed dramatically just over the last year or two. All financial companies within our industry now apply the same tool for data collection and sharing. This means we can now benchmark against each other. Of course, not all data required by EU regulation is available. What is challenging is that we have our own data ready, but much of the secondary data we need from other companies in other industries is not there."* (P3.FIN.).

The introduction of mandatory non-financial reporting requirements accelerated the need for digital tools to track and report sustainability performance. Initially, many organizations experimented with generic software solutions, such as Nasdaq's ESG framework, but soon recognized the need for customized tools tailored to their industry-specific needs. Financial institutions, for instance, initially relied on Excel spreadsheets before investing in specialized reporting systems, which often required in-house modifications to align with operational demands. The rapid evolution of regulatory requirements created additional challenges, as companies struggled to keep pace with compliance expectations. Some industries, such as finance, have since standardized their data collection processes, enabling benchmarking and improved firm comparability. However, the availability of secondary data from suppliers and other external sources remains a major obstacle to comprehensive sustainability reporting. As regulatory demands increase, companies increasingly turn to artificial intelligence (AI) and other advanced technologies to estimate sustainability metrics when direct data is unavailable. While digitalization has become a critical enabler of sustainability strategy, organizations face difficulties balancing compliance, operational needs, and technological advancements.

Organizational structure and regulatory complexity

The positioning of sustainability within an organization plays a crucial role in its effectiveness. While integrating sustainability into corporate strategy is widely acknowledged as necessary, interviewees emphasized that progress remains limited without a supportive organizational structure. A sustainability manager in financial services reflected on the longstanding ambiguity of sustainability's placement within her organization: *"Sustainability never had a clear identity or fixed place in the bank. With each organizational restructuring, which happened frequently, it was moved around without strategic intent. It was a secondary consideration rather than an integral function."* (P4.F.). This lack of strategic placement changed when sustainability was shifted to the HR department within the CEO's office, giving it greater influence. However, true alignment only emerged when sustainability was integrated into the Finance Division: *"Once sustainability became part of Finance, everything changed. It gained firm responsibility, deeper integration, and an actual impact on decision-making."* (P4.F.)

Another financial institution echoed this shift, where sustainability was restructured under Finance. The sustainability manager described how this realignment created synergies between sustainability and core financial activities: *"Sustainability now sits within the Financial Division, which makes perfect sense. Many of the division's conventional responsibilities, financial risk, investment, and corporate reporting now incorporate sustainability principles."*

Green financing is embedded in our funding strategies, and we collaborate closely on regulatory compliance, particularly CSRD. Finance professionals are already adept at data-driven reporting, which aligns with EU regulatory expectations. The synergies are significant." (P3.F.) Despite the advantages of aligning sustainability with Finance, not all organizations follow this model. In three of the companies interviewed, sustainability remains within the CEO's office or directly below the organizational hierarchy. Interviewees in these firms expressed confidence in this structure, emphasizing that executive leadership must take ownership of sustainability goals for them to be effectively implemented: *"Sustainability's position in the organizational chart is crucial. Senior leaders must feel responsible and lead sustainability initiatives themselves."* (P1.R.). Another sustainability manager highlighted the importance of direct executive oversight: *"The CEO must own sustainability. In our company, sustainability sits between the CEO and the Executive Team. I take directions from the CEO but implement initiatives at the executive level."* (P5.T.)

This positioning, however, does not necessarily translate to execution. A sustainability manager in the transportation sector described her role as primarily facilitative, ensuring that sustainability initiatives are actionable but not necessarily under her direct control; one interviewee explained: *"My role is to create new processes, particularly in risk assessment. I need to foresee how sustainability initiatives can be implemented at the executive level. But I don't have responsibility for their execution; that's the role of the executives. I ensure the initiatives are realistic and can be implemented effectively."* (P5.T.).

Beyond organizational positioning, interviewees expressed frustration with the increasing complexity of sustainability regulations, particularly in the EU. Keeping pace with rapidly evolving regulatory requirements has become a significant burden. A banking sector sustainability manager underscored the technological challenges in meeting compliance demands: *"Technology is advancing, but it isn't adapting fast enough to meet regulatory demands. We often have to build custom solutions because existing software lacks the necessary functionality."* (P2.FIN.). This technology gap has forced companies to invest substantial internal resources into bridging the divide between regulatory expectations and available digital tools. This challenge is compounded by regional differences in sustainability awareness and enforcement for multinational firms: *"We operate in 20 countries, and sustainability awareness varies significantly. We've had to prioritize key markets where we focus most of our sustainability efforts."* (P5.T.).

Navigating multiple EU regulations such as the EU Taxonomy, SFDR, CSRD, and NFRD—has added further complexity, with companies often struggling to access the necessary data for compliance: *"Sustainability compliance has become incredibly complex. We now have to manage multiple regulatory frameworks, each with different requirements. The problem is that the required data often doesn't even exist yet."* (P2.FIN.). To address these data limitations, some companies have turned to artificial intelligence (AI) as a solution, using machine learning to estimate environmental impacts when supplier data is unavailable. A retail sector manager described how AI is helping bridge data gaps: *"We buy tortillas from a supplier that doesn't track emissions. Now, we use AI-based estimations to calculate the product's carbon footprint."* (P1.R.)

However, data availability remains a persistent challenge, as companies are not the sole stakeholders in sustainability reporting. Government agencies and third-party regulators also influence access to sustainability data, further complicating compliance efforts. Ultimately, businesses are grappling with two simultaneous challenges: adapting their organizational

structures to embed sustainability effectively while responding to an increasingly complex regulatory landscape. The choice of where sustainability sits within an organization, whether in Finance, HR, or directly under the CEO, shapes how it is implemented, but regulatory complexity and data constraints remain key hurdles. Companies that successfully integrate sustainability within core business functions while leveraging technology and cross-functional collaboration are better positioned to navigate this evolving landscape.

The placement of sustainability within an organization significantly influences its effectiveness. Companies that embedded sustainability within financial departments experienced greater integration with core business functions, particularly in aligning sustainability with financial risk management, investment strategies, and regulatory compliance. In contrast, some firms positioned sustainability within the CEO's office or HR department, emphasizing executive ownership as a key driver of sustainability initiatives. Despite these structural adjustments, companies grapple with the growing complexity of sustainability regulations, particularly in the EU. Compliance with frameworks such as the EU Taxonomy, SFDR, CSRD, and NFRD presents substantial data challenges, as many required metrics are not readily available. Organizations increasingly invest in AI-based solutions to estimate missing data and enhance reporting accuracy. However, disparities in sustainability awareness across different markets further complicate compliance efforts, particularly for multinational firms. The evolving regulatory landscape necessitates a dual focus: adapting internal structures to embed sustainability effectively while developing technological capabilities to manage compliance complexities. Companies that successfully integrate sustainability within their financial and strategic frameworks, while leveraging technology and cross-functional collaboration, are better positioned to navigate the regulatory environment and drive long-term sustainable growth.

Discussion

This study highlights a key challenge in corporate sustainability: the absence of standardized methods for measuring environmental and social performance. Unlike financial metrics such as ROI and ROA, sustainability reporting remains fragmented, making cross-industry comparisons difficult and limiting broader learning and improvements (Bugg-Levine & Emerson, 2009; Grewal et al., 2021). A critical finding is that sustainability assessments are often tailored to individual organizations, resulting in inconsistencies. Companies develop customized methodologies based on internal priorities rather than aligning with global standards. A more structured and standardized approach is essential to enhance comparability, reliability, and transparency. Establishing global platforms for sustainability data can help businesses transition effectively toward a low-carbon and equitable economy. Digital solutions play a crucial role in embedding sustainability into corporate strategy. This study underscores how digital platforms and data analytics enable companies to move beyond isolated initiatives toward integrated, data-driven approaches. Organizations can systematically collect and analyze sustainability data by leveraging digital tools, ensuring greater transparency and alignment with business objectives. Moreover, digital transformation enhances resilience, innovation, and competitive advantage. Companies that strategically integrate sustainability into their digital infrastructure can improve operational efficiency, stakeholder trust, and regulatory compliance.

However, there is an ongoing debate regarding how digitalization facilitates genuine sustainability transformation. Some scholars argue that digital tools primarily enhance

regulatory compliance rather than driving fundamental shifts in corporate sustainability (Behl et al., 2023). Others suggest that digitalization can promote sustainability innovation by improving resource efficiency, enhancing supply chain transparency, and enabling circular economy models (George et al., 2020). Despite its potential benefits, digitalization presents risks, including data privacy concerns, algorithmic biases, and the environmental impact of digital infrastructure itself (Wang et al., 2022). This study acknowledges these competing perspectives and highlights the need for further research to critically examine how digitalization can be harnessed to facilitate substantive, rather than superficial, sustainability integration.

Looking ahead, evolving sustainability regulations and digital solutions present opportunities and challenges for businesses. As reporting requirements tighten, companies must build robust digital infrastructures to ensure data accuracy, granularity, and transparency. Integrating AI, big data, and blockchain into sustainability reporting systems can enhance data integrity and predictive capabilities (Doran et al., 2023). However, businesses must also navigate complex regulations requiring flexible and scalable digital solutions. Many managers express frustration over regulatory ambiguities, often interpreting mandates differently. Despite these challenges, digitalization remains a powerful tool for embedding sustainability into corporate strategy. Investments in sustainability analytics, real-time monitoring, and automated reporting platforms can improve stakeholder engagement, compliance, and long-term performance. Establishing standardized sustainability data platforms will support transitioning to a low-carbon, equitable economy.

While this study provides valuable insights into digitalization in sustainability strategy, it has limitations. The small sample size may limit the generalizability of findings across industries, necessitating broader research across diverse organizational structures. Additionally, qualitative research carries potential biases, even with efforts to maintain neutrality. Employing triangulation, such as combining qualitative insights with quantitative sustainability data, could enhance reliability. Furthermore, this study focused on organizational digitalization, omitting cultural, economic, and geopolitical influences on sustainability strategy. Future research should examine cross-border regulatory differences and digital adoption trends to understand global sustainability challenges comprehensively.

Despite the advantages of digital transformation in sustainability strategies, several risks and hindrances accompany its implementation. One significant concern is data security, as sustainability reporting increasingly relies on sensitive internal and external data. Companies must ensure robust cybersecurity measures to protect proprietary information and prevent data breaches, especially when using cloud-based platforms and AI tools. Additionally, the high costs of acquiring, customizing, and maintaining digital sustainability solutions pose a challenge, particularly for smaller companies with limited resources. Off-the-shelf digital tools often fail to align with specific corporate needs, requiring additional investments in in-house development. Implementation complexity is another barrier, as many organizations lack the technical expertise to integrate digital systems with existing business processes. Navigating rapidly evolving sustainability regulations further complicates the adoption of digital tools, requiring businesses to develop flexible and scalable infrastructures. Overcoming these challenges is critical to harnessing the full potential of digitalization in sustainable corporate strategy.

Conclusion

As sustainability becomes essential to corporate strategy, businesses face increasing pressure to integrate environmental, social, and governance (ESG) considerations into their decision-making processes. However, the lack of standardized sustainability metrics and the complexity of regulatory compliance continue to pose significant challenges. This study highlights how digitalization reshapes sustainability integration by providing tools that enhance data collection, streamline reporting, and support strategic alignment.

Findings from this research underscore the need for structured methodologies and digital platforms to facilitate sustainability measurement and reporting. While digital solutions improve transparency and comparability, their effectiveness depends on organizational commitment, cross-functional collaboration, and the ability to navigate evolving regulatory landscapes. Companies that successfully embed sustainability within their financial and strategic frameworks are better positioned to create long-term value while addressing environmental and social responsibilities.

Ultimately, this study contributes to understanding how businesses can transition from compliance-driven sustainability initiatives to integrated strategic functions. As digital transformation continues evolving, organizations must adopt adaptive and scalable sustainability practices that align with corporate goals and global sustainability standards. Future research should further explore the intersection of digital innovation and sustainability governance to ensure that businesses can effectively manage the challenges and opportunities of a rapidly changing ESG landscape.

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EVALUATION FRAMEWORK FOR E-SCOOTER INTEGRATION INTO CITY INFRASTRUCTURE – THE FIRST RESULTS OF HUNGARY

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Abstract

The initial enthusiasm for e-scooters as a sustainable urban mobility solution has begun to decline, largely due to their incomplete integration into existing transport systems. Despite their potential to serve as a viable first- and last-mile solution, many cities, including those in Hungary, have struggled to incorporate these vehicles effectively. We used a mixed-methods research approach, combining qualitative and quantitative methodologies and including most of the stakeholders to evaluate the current state of e-scooter integration in Hungary. Based on stakeholder insights and data collection, we developed an evaluation framework consisting of four key dimensions: regulation, infrastructure, design, and education. Our first findings indicate that when examining each of these factors individually, Hungary is still at the early stages of the integration process. The legal framework remains unclear. Infrastructure in Budapest and larger cities offers extensive cycle paths, but their quality and accessibility are not always suitable for safe scooter use. A lack of designated parking spots also poses challenges for scooter-sharing services. Although scooter design has improved with more robust frames and longer battery life, weather resistance and safer braking systems require further development. Educational initiatives, have started, but broader awareness campaigns are needed to promote safe and responsible scooter use. Our findings contribute to the broader discussion on micro-mobility adoption, emphasizing the need for data-driven policies and a more structured approach to e-scooter integration in urban mobility networks. In the following research phase, objective indicators are to be developed to refine our results.

Keywords: electric scooter, mixed method research (MMR), stakeholder, evaluation framework, micromobility

JEL classification: C83, M38, Q01, L99

Introduction

Since 2023, electric micromobility devices have faced growing restrictions in numerous major European cities, with rental versions often facing outright bans (e.g., Greaves et al., 2025). While these vehicles initially appeared to offer a sustainable alternative for urban commuters to reach their destinations and complement public transportation services (Gössling, 2020;

Kopplin et al., 2021), more recent information has surfaced questioning the sustainability of e-scooters and their positive impact on urban mobility. Several studies have demonstrated that e-scooters do not primarily replace car trips, are rarely used in adverse weather conditions, and face unresolved challenges regarding battery recyclability (Young et al., 2013; Nikiforiadis et al., 2021; Noland, 2021; Weschke et al., 2022; Szemere et al., 2024; Szemere & Surman, 2024).

Accidents related to improper usage, unresolved parking issues, lack of coordination between public transportation, park-and-ride facilities, and micromobility hubs, as well as coverage problems, clearly tilt the balance toward a negative assessment (Kostareli et al., 2021; Bozzi & Aguilera, 2021). Beyond sustainability concerns, the literature identifies additional reasons for their declining popularity, linked to vehicle design, lack of regulation, urban design, and existing urban infrastructure (Şengül & Mostofi, 2021; Zhang et al., 2024; Kazemzadeh & Sprei, 2024).

Since the emergence of the first rentable e-scooters, the academic community has shown growing interest in how these devices can be effectively integrated into existing transportation systems. Gössling (2020), based on an analysis of 173 news items identified through internet searches – including print media, television, and radio websites – already emphasized that regulatory frameworks are critical to successful integration. He argued that urban planners must adopt policies addressing maximum speed limits, mandatory use of bicycle infrastructure, designated parking areas, and restrictions on the number of licensed operators.

Several researchers have proposed aligning e-scooter services with public transportation as a solution to emerging the mentioned challenges (Hu et al., 2025). Others suggest that users' attitudes play a pivotal role in achieving smooth integration. For instance, Mavrogenidou & Polydoropoulou (2025) highlighted the substantial influence of safety concerns, transportation challenges, perceived benefits, and weather conditions on usage levels. Khan et al. (2025) further demonstrated that socio-demographic factors, the built environment, accessibility indicators, and service characteristics significantly affect adoption and frequency of use.

Based on these studies, two main conclusions can be drawn:

- First, there has been a notable surge in scholarly publications on integration-related issues, particularly since 2024.
- Second, the existing literature predominantly focuses on service-level integration, such as coordination with public transit systems, while largely neglecting a comprehensive multi-stakeholder perspective. This narrow focus may lead to biased or incomplete conclusions, underscoring the need for more holistic research approaches that account for the diverse views of all actors involved.

Our study aims to develop a comprehensive, context-sensitive framework to support decision-makers in the selection and prioritization of regulatory and infrastructural measures concerning e-scooter integration. In addition to presenting the framework itself, the paper applies it to evaluate the current state of e-scooter integration in Hungary, offering empirical insights grounded in this regional context. By employing a mixed-methods approach and incorporating the perspectives of diverse stakeholder groups – including users, non-users, pedestrians, and policymakers – the study addresses a critical gap in the existing literature, which has largely overlooked integrated, multi-perspective analyses, particularly in the underrepresented Central and Eastern European region.

We identified two research questions to explore in this paper:

1. Which key areas of integration should be assessed to evaluate the current phase of e-scooter integration, based on the perspectives of diverse stakeholder groups?
2. Based on the evaluation using the developed framework, which integration phase characterizes the current state of e-scooter use in Hungary?

The structure of the paper is as follows. The subsequent chapter outlines the methodology employed in the study. The Results chapter presents the key phases of the evaluation framework's development, along with the initial findings. The Discussion chapter pinpoints our research results related to the relevant literature. Finally, the Conclusion chapter summarizes Hungary's current state of integration.

Materials and methods

To evaluate the integration of electric scooters into urban transport, we employed a Mixed Methods Research (MMR) approach, applying both quantitative and qualitative methods (Tierney et al., 2023; Toyon, 2021). Specifically, we used the embedded design variant of MMR, enabling parallel data collection with distinct analytical procedures.

Our research began in 2022 with a bibliometric and network analysis of English-language publications (1994–2022) on Scopus, using terms such as electric scooter, e-scooter, and micromobility. Following Molontay and Nagy (2021), we cleaned the dataset to retain 1412 unique records. This research phase aimed to track thematic shifts, multidisciplinary patterns, and key contributors in the micromobility domain.

In 2023, we conducted a content analysis of Hungarian media (2019–2022) across four major news sites (Szemere et al., 2024). Articles were coded by source type, stakeholder group, sentiment, and thematic relevance. These insights informed a stakeholder mapping exercise using the Aubrey-Mendelow matrix, which guided the subsequent qualitative phase: seven mini focus groups (Table 1) involving users, experts, and researchers. Discussions explored transport habits and integration potential. Thematic analysis (Secinario et al., 2022) revealed four main areas: regulation, infrastructure, design, and education. Drawing from the focus groups, we developed a user questionnaire (Babbie, 2013; Malhotra, 2010) at the same year, which was completed by 292 respondents – mainly men, aged 20–45 from Budapest (Szemere et al., 2024; Szemere & Surman, 2024, 2025). The survey focused on usage patterns, attitudes, integration perspectives, and demographics, enabling rich cross-sectional analysis.

In early 2024, we interviewed 10 municipal stakeholders in Budapest, including mayors and urban planners (Szemere, 2025). These semi-structured interviews were thematically analyzed (Szokolszky, 2004; Secinario et al., 2022), revealing consistent concerns around regulation, mobility, and infrastructure. Concurrently, we launched an international focus group with representatives from European micromobility organizations and city councils. Meeting monthly through 2025, this group addresses shared experiences, policy challenges, safety, and future visions.

Findings prompted the design of a more refined survey, launched in December 2024 with support from EIT Urban Mobility and Hungarian academic and professional partners. The survey remains open through April 2025, with 400 valid responses collected so far. Ongoing data collection allows for iterative comparison across phases – e.g., early Hungarian focus

groups (2022) versus international discussions (2024-2025) – highlighting the adaptability of the MMR framework.

Table 1: Focus group participants

Aspect	1st	2nd	3 rd	4th	5th	6th	7th
The number of participants	5 people (5 Female)	4 people (2 Male, 2 Female)	6 people (4 Female, 2 Male)	4 people (3 Female, 1 Male)	4 people (3 Female, 1 Male)	4 people (2 Female, 1 Male)	4 people (3 Female, 1 Male)
Ages	24-45	28-37	35-45	30-35	33-45	30-45	25
City	Budapest	Budapest	Wien, Budapest, Kecskemét, Szigetszentmiklós	Budapest	Budapest, Pécs	Budapest, Gödöllő	Budapest
Platform	Ms. Teams	Personal	Ms. Teams	Personal	Personal	Personal	Personal
Duration	60 min	45 min	80 min	60 min	60 min	60 min	90 min
Date	March 4, 2022.	March 6, 2022.	March 8, 2022.	February 15, 2023.	February 21, 2023.	March 2, 2023.	March 15, 2023.

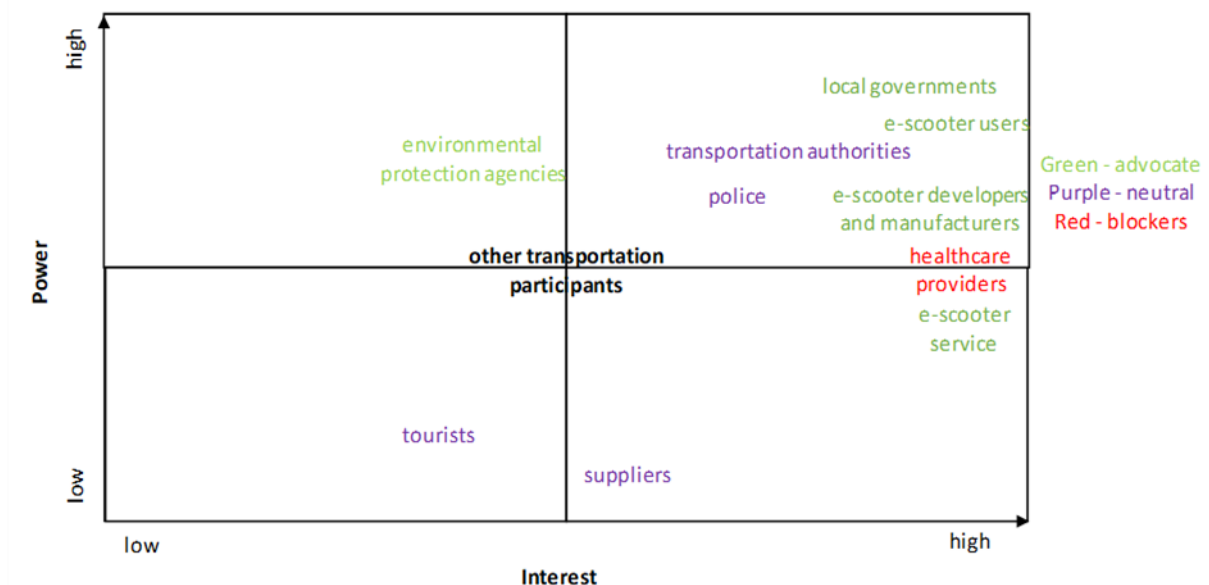
Source: Authors' own work.

Results

Determining stakeholders

In order to identify the stakeholders in our research, we mapped and categorized them using the Aubrey-Mendelow power-interest matrix (Szemere et al., 2024).

Figure 1: Stakeholder map



Source: Authors' own work.

The identified stakeholders include the followings (Figure 1):

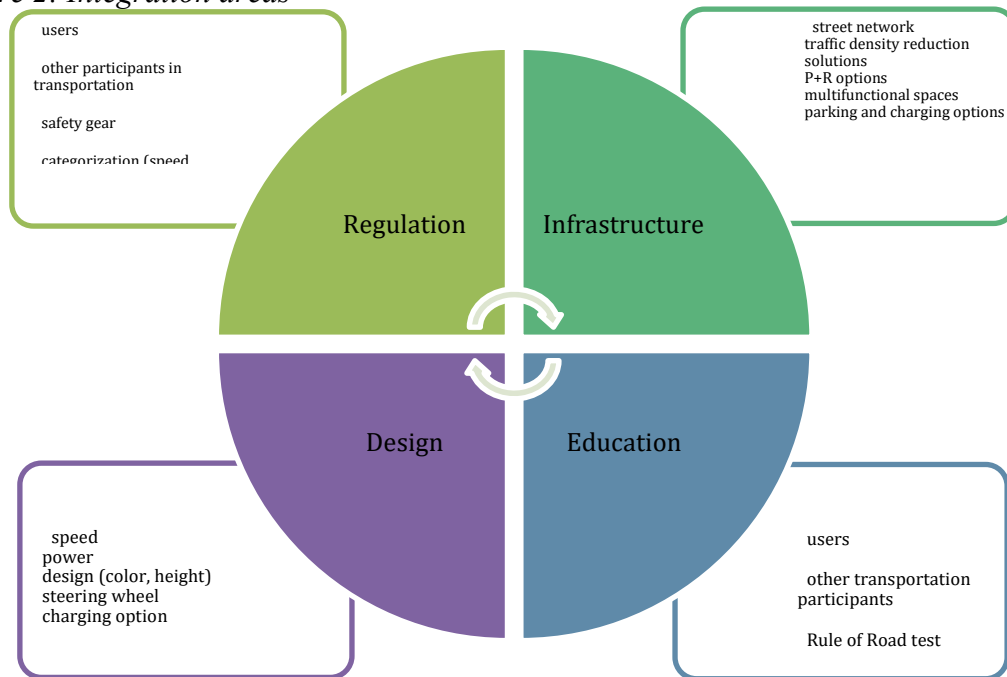
- General Transport Participants: This group includes everyday road users – pedestrians, drivers, cyclists – who make up the bulk of traffic. Their needs must be considered to prevent public resentment, though their direct impact on transport systems is limited. Their interest is generally moderate unless disruption occurs.
- Electric Scooter Users: They have high interest and influence. Without proper regulation and integration, user experience suffers, leading to a decline in usage. This shift could result in users reverting to less sustainable modes like cars or causing traffic disruptions due to unsafe scooter practices.
- Scooter Developers & Manufacturers: They actively monitor market trends and influence regulation through design (e.g., speed limits, safety features). Their role affects both product compliance and environmental impacts like noise.
- Suppliers: With only indirect ties to e-scooters and users, their interest is medium and influence low. They usually work across various product types rather than focusing solely on e-scooters.
- Service Providers: Covering maintenance, fleet management, and app operations, they have high interest in market success. While they significantly affect user experience, their influence on the broader transport system is moderate.
- Environmental Agencies: These actors have moderate interest, mainly from a sustainability perspective. While e-scooters align with green transport goals, concerns around production may limit focus. Their campaigns and funding initiatives can nonetheless accelerate adoption.
- Healthcare Providers: Rising accident rates increase their interest in integration. Although not regulatory bodies, their messaging can shape public opinion and safety expectations, influencing policy indirectly.
- Local Governments: They hold the most influence due to regulatory authority at the municipal level. Their interest lies in creating safer, more efficient transport systems, making continuous monitoring and adaptation essential.
- Tourists: Often unfamiliar with local regulations, tourists frequently use e-scooters. Their high, unregulated usage can lead to public frustration, potentially slowing integration. However, their direct influence is low.
- Police: As key enforcers of traffic law, police have high influence. Their role in implementing and refining rules through data and reporting is critical to integration success.
- Transport Authorities: These bodies help shape the broader transport framework through design and oversight. Their influence is significant but secondary to that of local governments in most practical matters like parking or infrastructure changes.

Regarding the attitude of these stakeholders towards the current integration and regulation in Hungary, the transport authorities, the police, suppliers and tourists were classified as neutral, while healthcare institutions (only they) were blockers. All other stakeholders were classified as supporters. These groupings are only hypotheses based on the literature (Dias et al., 2021; Sobrino et al., 2023; Szemere et al., 2024) and everyday effects, their real classification can be determined after evaluating the needs and experiences of the stakeholders.

The first results of the evaluation framework

The information collected can be divided into 4 categories (Figure 2): regulation, infrastructure, design, education.

Figure 2: Integration areas



Source: Authors' own work.

Regulation

The integration of e-scooters into transportation is closely related to the development of the legal environment, which determines the conditions for the use of the devices, their safety regulations and their role in the urban mobility system. We started the regulatory studies in 2022, i.e. shortly after the first e-scooters appeared on the streets of Budapest, and every year after that we re-examined the position on this issue and tried to observe how this factor has developed over the years and as a result of changes in legislation. In the case of community scooters, regulation takes place at two levels. On the one hand, local governments or the state regulate the service providers. In Budapest, the speed of rental electric scooters is capped at 25 km/h, and there are zones where the engine in them must stop or slow down. Parking is also regulated, and rentals can only be stopped at micromobility points. At one point, there is a limit on the total number of devices and the number of vehicles a service provider can have at a given point. If a service provider has more vehicles than allowed, a fine is imposed. These measures have managed to regulate the use of rental electric scooters. General traffic rules apply to these devices as well. In the case of private scooters, the above regulatory issues are not relevant, but general traffic rules also apply to those using these devices. However, these features are not regulated: vehicle classification, age, speed, maximum power, plate number, liability insurance, helmet. There is no uniform regulation for these within Europe, only a directive applies to them, which was issued in 2023. Based on this, the prescribed speed on public roads would be set at 20 km/h, the minimum age would be 16 years, e-scooters would not be allowed to transport people and animals or other vehicles, the maximum power would not exceed [0.4 kilowatt (kW)], and they would be required to be equipped with an index and a lamp (Bálint, 2023). As a result, technical and construction requirements are uniform at the European level. The devices must carry the mandatory CE mark for all products (directive 2006/42/EC). From half an hour after sunset, as well as in the case of atmospheric conditions making lighting necessary, these devices must be equipped with white front lights and red rear reflectors for visual signals. However, the maximum power is still quite variable. For example, in Sweden and Finland, the maximum limit is 1000 watts, versus 600 watts in Austria; 500 watts in Italy, Germany, and

Switzerland; and 250 watts in Spain. Hungary and Belgium do not have a maximum limit, nor is any limit defined in the remaining states examined (Kleinertz et al., 2021; Buongiorno et al., 2022; Szemere et al., 2024.).

The largest differences were found by age in the literature. Portugal, for example, has the highest threshold at 16 years of age. It is 15 years in Denmark and 14 in Germany and Switzerland (but only in possession of a moped license, whereas from the age of 16, a license is not required). In Austria and France, on the other hand, the minimum threshold is 12 years, and in the remaining countries examined, namely, Belgium, Finland, Hungary, Norway, Poland, Spain, and Sweden, no age restrictions have been established (Buongiorno et al., 2022; Szemere et al., 2024.).

Our results therefore confirm that regulation is an important issue for stakeholders and that they are not satisfied with the current situation. Based on our questionnaire research (Szemere et al., 2024), the regulatory factors in order of importance are: maximum power, speed limit, helmet obligation, vehicle classification, age restriction, registration plate, need for obligatory legal liability insurance. Based on the thematic analysis of the focus group discussions and interviews, we obtained the following key concepts: “harmonizable”; “stakeholder involvement”, “adaptive regulation”.

Optimal regulation should therefore take into account traffic safety aspects, infrastructure conditions, and compatibility with public transport and other forms of mobility. In addition, it is worth involving the affected communities and users in the rule-making process, so that the adopted provisions truly support the efficient and safe integration of e-scooters into the urban transport system. In order to achieve successful integration, it is advisable to apply a multi-level, adaptive regulatory approach, which provides the opportunity for feedback and continuous fine-tuning of legislation depending on changing usage patterns and the transport environment.

Infrastructure

The next element of the framework, infrastructure, is important for all stakeholders, but interviews with local governments also revealed that this element is the most difficult to change. On the one hand, because cities and districts in Budapest (and many other large cities around the world) were designed primarily for car travel. The width of roads, sidewalks, and the number of parking spaces are all aligned with this organizing principle, and if this is changed, the interests of two numerically large groups of stakeholders (car drivers and pedestrians) will certainly be harmed. During the interviews, one of the mayors also drew our attention to the fact that the harm to interests may not only affect car drivers or pedestrians, but if, for example, a zone is created where micromobility devices cannot be driven through or parked there, then rental devices are placed on the border of the zone, which causes inconvenience to residents and disruptions to traffic. A similar situation occurs when, for example, electric scooters are banned in one district, and they proliferate in neighboring districts. Furthermore, the transformation of the road network does not require legislative regulation, but coordinated planning and financing. Districts cannot transform it unless external resources are involved (e.g. EU tenders, real estate investment, development, etc.), and the issuance of a building permit is tied to the construction of a new road section or the renovation of an existing one. The interviews with the heads of local governments made it clear that this is not yet feasible in Hungary. Separating more lanes would either take away pavement space, which is already very narrow in some districts of the capital, or it would have to be taken from the roads, which would

lead to even more traffic jams than now. The transformation not only harms the interests of several transport participants and is costly, but also causes inconvenience to the residents. Infrastructure refers to the road surface and road network itself, on the one hand, and the necessary infrastructure related to e-scooters, i.e. the establishment of micromobility points in an appropriate manner and location. The development of multifunctional urban spaces, where micromobility devices can be stored, parked and even charged, promotes the efficient use of scooters and reduces the problem of unorganized storage in public areas, and contributes to the plannability of trips and easy accessibility of the devices. The European Union has launched several initiatives to promote sustainable urban mobility. The new Urban Mobility Framework provides guidance to cities on how to reduce emissions and improve mobility, highlighting the construction and upgrading of multimodal hubs and the introduction of new digital solutions and services (Mitropoulos et al., 2023; Aguilera-Garcia et al., 2024).

Our results underscore the necessity of integrating public and multimodal transport systems to mitigate traffic congestion. One effective strategy is the development of Park and Ride (P+R) systems, which facilitate the reduction of individual car use by enabling seamless connections between different transport modes, such as public transit and micro-mobility solutions like e-scooters. This approach has already been implemented in several European countries. In Berlin, for instance, the city's public transport provider, BVG, introduced the Jelbi mobility app, which consolidates multiple mobility options - including public transport, e-scooters, and bike-sharing - into a unified platform.

Design

Based on our research results, it can be concluded that the integration of electric scooters into the transport system is closely related to the issue of design, which can be interpreted as a multi-level concept. On the one hand, it includes aspects of product design, such as the frame structure of the vehicles, the ergonomics of the handlebars, the height of the frame or even the choice of color, which determine accessibility, comfort and safety for different user groups. On the other hand, however, we need to extend the concept of design to the application as well, since the user experience is also largely related to how intuitive and easy to use the digital side of the service is, including the functionality of the application, navigation options and the possibility of feedback. Furthermore, our research has shown that users are increasingly playing a role in shaping the design. Some studies have shown that users often complain about the stability and safety of scooters, especially on uneven road surfaces. In response to this feedback, several providers have modified the design of their scooters, strengthening the frame structure and improving the suspension for better stability.

While user feedback previously had less influence on the design of micromobility services, it is now gaining more weight and is becoming an increasingly active player in the development processes of transport systems on various platforms (e.g. social media, Google reviews) (Aman et al., 2021). For example, several providers have introduced features in their applications that allow users to report problems with the condition of the scooters in real time or make suggestions for improving the service. In this way, users can directly contribute to increasing the quality of the service.

Accordingly, design optimization is now not just an aesthetic or user experience issue, but a fundamental factor in the integration of e-scooters into a sustainable and efficient urban mobility system.

Education

The successful integration of electric scooters into the transport system depends not only on the development of infrastructure and the establishment of regulatory frameworks, but also on the education of users. Research results and European examples show that expanding transport knowledge and acquiring good usage practices significantly contribute to the spread of safe and sustainable micromobility solutions. Appropriate educational programs not only play a key role in reducing accident risks, but also help to mitigate conflicts between transport actors (Zhang et al., 2024; Dibaj et al., 2021). Accordingly, educational campaigns have been launched in several European cities. In Paris, where traffic conflicts related to the use of e-scooters have received special attention, the city government has launched mandatory educational programs for users, with particular attention to compliance with speed limits and parking rules. In Berlin and Amsterdam, service providers are working with city authorities to provide users with interactive traffic safety guides via apps before their first use. Similarly, positive educational initiatives have been launched in Hungary. The Hungarian Automobile Club and E-TWOW have launched a joint program for high school students to teach them how to use electric scooters safely. The program offers theoretical and practical training, during which students can learn correct traffic techniques and the importance of following traffic rules.

Focus group interviews revealed that educational programs are effective when they cover traffic rules, appropriate speed and route selection, and safe vehicle handling, including braking techniques and optimal cornering methods. However, it has also become obvious that in order to ensure the smooth integration of electric scooters, not only users need to be educated, but also other transport actors - drivers, pedestrians and users of public transport - need to be sensitized in order to recognize and accept the presence of new forms of mobility.

Discussion

To address our first research question, we employed the Aubrey-Mendelow power-interest matrix as the core analytical tool. This framework facilitated the systematic classification of stakeholder groups based on their level of interest (the extent to which they are affected by e-scooter integration) and degree of power (their ability to influence the process).

Our findings reinforce existing literature, particularly the notion that successful integration requires the engagement not only of e-scooter users, typically considered key actors, but also of a wider range of stakeholders whose support – though more indirect – is equally vital for long-term sustainability. (see e.g., Gössling 2021; Nikiforiadis et al., 2021; Kazemzadeh & Sprei, 2023).

The integration areas identified in our analysis can be grouped into four interrelated categories (Figure 2): regulation, infrastructure, design, and education. These domains reflect both systemic and behavioral dimensions of e-scooter use. The integration of e-scooters into urban transport depends heavily on evolving legal regulations, which vary significantly across countries and distinguish between shared and private use. Effective regulation should be adaptive, safety-focused, and involve stakeholder input to support the safe and efficient incorporation of e-scooters into public mobility systems. Infrastructural limitations remain a pressing issue, as existing roadways, bike lanes, and pedestrian paths are often ill-equipped to accommodate the increasing volume of e-scooter traffic. Simultaneously, vehicle design plays a critical role in ensuring user safety, as e-scooters – like bicycles – lack lateral stability when

stationary and require continuous balance while in motion. Education and skills training are equally important, particularly as many safety risks stem from inexperienced users, insufficient protective gear, and poor handling skills. Although these categories are distinct, they converge around a shared concern: safety, which serves as a foundational requirement across all stakeholder expectations. Regulators worldwide consistently cite safety as the principal goal of micromobility policy. Key issues include helmet usage, speed limits, alcohol consumption, and driving experience (Kazemzadeh & Sprei, 2024).

By combining stakeholder perspectives with these four integration domains, our analysis offers a comprehensive framework for evaluating the current state of e-scooter integration and identifying areas for policy and infrastructural improvement.

In relation to our second research question, we found that the integration of e-scooters into urban mobility systems remains only partially addressed throughout Europe. Although Western and Northern European countries have made notable progress, challenges persist even in these more advanced contexts. In Hungary, integration efforts are still at an early stage. The regulatory environment, infrastructural foundations, and educational initiatives remain underdeveloped. For example, as of this writing, e-scooters have yet to be officially categorized within the national legal framework. The only available guidance is a 2019 position statement from the Ministry of Transport, which states that in the absence of specific regulation, e-scooters should be treated as mopeds. However, this statement holds no binding legal authority and cannot serve as a formal source of law.

Our findings reinforce the conclusions of Bozzi & Aquilera (2021), and Zhang et al. (2024), suggesting that without clear and coherent policies, local infrastructure investment, and targeted public engagement, micromobility integration is likely to remain fragmented and insufficiently effective. The Hungarian case thus offers a representative and timely example of the systemic barriers facing Central and Eastern European cities in the adoption of new forms of sustainable urban mobility.

Conclusion

Through the application of both qualitative and quantitative methods, we have developed a comprehensive evaluation framework that identifies the necessary conditions for successful e-scooter integration and assesses the current stage of the process in Hungary. Using the developed evaluation framework, we found that the integration of electric scooters in Hungary is still in its initial, starting phase. Currently, the legal environment is unclear, the Road Traffic Act does not precisely define the status of e-scooters, which causes uncertainty for both road users and authorities. According to the position of the Ministry of the Transport, electric scooters are classified as motorized bicycles, which means that they should be used on the road, but practical experience shows that users often prefer the sidewalk or cycle paths, which results in traffic conflicts. In terms of infrastructure, Budapest and some larger cities have an extensive network of cycle paths, but their quality and accessibility are not always adequate for the safe use of scooters. In addition, there is a lack of designated parking spots, which is a problem for community scooter-sharing services, as the devices are often abandoned illegally. Progress has been made in the design of scooters and education, but significant improvements are still needed. Compared to early models, current community scooters have more robust frames and longer battery life, but the development of weather resistance and safer braking systems remains a key issue. Positive initiatives have been launched in terms of education, such as programs that

offer training on safe scooter use to high school students. However, broader awareness-raising campaigns and targeted educational programs would be needed to ensure that users are aware of traffic rules and the principles of responsible scooter use.

Overall, the research demonstrates that the integration of e-scooters – both in Hungary and globally – is a complex, resource-intensive, and time-consuming process. It requires coordinated regulatory frameworks, targeted infrastructure development, and public education efforts, not only at the national level but also across regional and local governance scales. Beyond its academic relevance, the findings also hold practical implications. The framework and results provide actionable insights for policymakers, particularly in relation to the regulation and spatial positioning of shared e-scooter systems; for urban planners, by informing data-driven infrastructure design; and for service providers, in optimizing fleet density and designing location-specific marketing strategies.

However, one of the limitations of our study is that it does not discuss rental and private electric scooters separately. This is primarily because we believe that the same applies to them in terms of regulation, although they are aware that they are not used in a similar way and for different purposes. In the case of private scooters, the issue of storage and charging does not arise, these devices have already been integrated into their transportation by their owners, they wear protective equipment during use and education is also carried out in various forums (they exchange experiences in Facebook groups, learn about changes in legislation, etc.). Another limitation of the article is that it does not use objective metrics to evaluate and identify integration progress, but rather evaluates directions determined during information collection based on research. The next step in developing the research framework is to define objective metrics for the determined evaluation directions and continue the evaluation according to them.

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MANAGEMENT

TRACK 4: Employees, Work, And Organizational Well-Being

PREFACE

MANAGEMENT – TRACK 4: EMPLOYEES, WORK, AND ORGANIZATIONAL WELL-BEING

This track focuses on the evolving human dimension of work, exploring how organizational climates, leadership approaches, and workplace practices impact employee identity, competence, and overall well-being. As work environments transform through factors like digital skill requirements and hybrid models, understanding these changes is critical for fostering sustainable employee engagement and productivity. The papers here investigate various aspects of the employee experience, from adapting to career transitions and enhancing digital competencies to fostering innovation through leadership and optimizing flexible work arrangements. Collectively, these contributions provide a holistic view of how organizations can effectively support their workforce's identity, skills, and well-being amidst ongoing transformations.

Bartol, Grah, and Peljhan explore work-related identity loss during retirement, emphasizing how organizational climate and social life can moderate this transition and help preserve identity continuity. Baziuk, Hanák, Černý and Romanová review existing assessment scales for digital competence in the workplace, identifying commonly evaluated skills and discussing the validity of self-report versus performance-based tools. Ďurišová and Blštáková examine the HR-related enablers of hybrid work regimes, using CRANET data to empirically validate organizational factors that facilitate effective remote and flexible work arrangements. Hruška, Szarucki, and Marić propose playful leadership as a transformative force, demonstrating how it fosters identity, creativity, and innovation by cultivating psychologically safe workplaces conducive to exploration. Melkić, Dragičević Rogge and Marić test individual-level paradoxes (such as individual ambidexterity and job demands-resources fit) to determine their sufficiency and necessity conditions for employee performance outcomes across Croatian organizations. Stanković and Slavec Gomezel provide a bibliometric review of workplace physical activity, mapping its research landscape and highlighting its impact on both job performance and overall employee well-being.

NAVIGATING WORK-RELATED IDENTITY LOSS IN RETIREMENT: THE ROLE OF ORGANIZATIONAL CLIMATE AND SOCIAL LIFE

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Abstract

This paper explores the transition to retirement, emphasizing work-related identity loss and factors that moderate this challenging adjustment. Building on a qualitative pilot study, it examines how organizational climate and social life outside of work act as key moderators in shaping retirees' ability to preserve identity continuity and meaning. Additionally, the study identifies other critical factors, including health, self-awareness, and gradual disengagement from work-related identity (WRI), which influence the transition. This study draws on data from a qualitative pilot study involving in-depth semi structured interview with 2 participants before retirement and 2 after retirement. The participants had different professional backgrounds and educational backgrounds. To get a better understanding on topic and the results, we conducted semi-structured interview with 2 experts from the field of ageing and age management. The findings suggest that fostering supportive workplace environments, encouraging vibrant social networks, and addressing individual factors like health and self-awareness can significantly ease the work-related identity loss due to retirement. The study contributes to the literature by offering a holistic understanding of the factors influencing retirement transitions, emphasizing the interplay of organizational, social, and individual dimensions. It highlights actionable strategies for organizations to support retirees and underscores the importance of addressing personal factors in mitigating WRI loss. These findings provide practical guidance for policymakers, organizations, and individuals in facilitating smoother retirement transitions.

Keywords: work-related identity loss, retirement, organizational climate, social life

JEL classification: J24, J26, J28

Introduction

Retirement is one of life's major transitions, marking a significant change in daily routines, roles, and identity. Despite its importance—especially in developed countries with aging populations (Eurostat, 2022; OECD, 2021)—the effects of retirement on individual health and well-being remain relatively under-researched. Work is a central part of life for many

individuals, closely tied to personal identity (Eagers et al., 2018; Silver & Williams, 2018). The loss of meaningful work-related activities and social connections in retirement can disrupt stability and a sense of positive identity, posing challenges for mental health and overall well-being (Jolles et al., 2022). With automatic adjustment mechanisms in some EU Member States expected to raise the retirement age to 71 by 2060 (OECD, 2021), work will occupy an even larger part of our lives. As such, understanding the psychological, social, and organizational factors influencing the retirement transition is becoming increasingly critical. Although many workers look forward to retirement and its associated benefits, such as greater leisure and freedom (van der Mark-Reeuwijk et al., 2019), for others, this transition brings work-related identity loss (WRI) and mental health challenges (Chiesa & Sarchielli, 2009; Conroy & O'Leary-Kelly, 2014; Kragt, 2019; Wang, 2007). These challenges may increase demand for healthcare services and contribute to rising health expenditures (Breyer et al., 2010; Fasbender et al., 2016).

This article is a part of a larger study on the relationship between the meaning of work and the WRI loss in the retirement dynamics. Current research aims to provide a deeper understanding of the challenges faced by older workers approaching and entering retirement, focusing specifically on WRI loss. We aim to identify factors that influence this process, with a particular emphasis on the roles of organizational climate and social life outside of work. By investigating these factors, we hope to offer insights that help organizations and individuals navigate this pivotal life transition more effectively. The use of a qualitative research method enables us to explore the personal experiences of individuals navigating retirement and work-related identity (WRI) loss. This approach helps identify the key psychological and social factors that influence retirees' well-being. Ultimately, our work contributes to addressing the broader implications of population ageing and labor shortages while promoting the stability and well-being of older adults as they enter this new phase of life.

Literature review

Work-related identity and the transition to retirement

Our understanding of who we are and who we want to become is importantly shaped by our work, and this "identity work" is central to our professional and personal lives (Brown, 2015). Work identity includes different aspects of how individuals perceive themselves in relation to their work, including their roles, responsibilities, group membership and unique characteristics within their work environment (B. E. Ashforth, 2001). Work identity is affected by the dynamic interaction between individuals and their work environment, which shapes their self-concept and behavior at work (Miscenko & Day, 2016). Dutton et al. (2010) define work-related identity as the "aspects of identity and self-definition that are tied to participation in the activities of work or a membership in work-related groups, organizations, occupations or professions". Conroy and O'Leary-Kelly (2014) use Dutton's (2010) definition of WRI and further define WRI loss, as the loss of aspects of identity and self-definition that are closely linked to participation in work-related activities or membership of work-related groups, organizations, professions or occupations. Such a loss involves significant disturbances in self-concept and identity balance, necessitating the abandonment of the previous self-concept and the adoption of a new identity.

In an aging society, addressing the shift away from WRI and ensuring a smooth adjustment to retirement has become a critical concern for both individuals and organizations (Froidevaux et

al., 2018). Work serves as a cornerstone of personal identity (B. Ashforth & Mael, 1989; Skorikov & Vondracek, 1998; Walsh & Gordon, 2008), and retirement—a significant life transition—reshapes how individuals construct their identities as they enter a new phase of life (Manor & Holland, 2022). This transition prompts substantial changes in personal and social dynamics, as work for many people is not just a means to fill time or earn income, but a fundamental source of identity and purpose in life (Bogaard et al., 2014; Bullock et al., 2020). When the benefits of work after retirement disappear, individuals are compelled to seek alternatives to compensate for this loss (Bogaard et al., 2014). Coping strategies during this phase often include reimagining and reassessing aspects of the self by engaging in new activities and reprioritizing existing ones (Onyura et al., 2015).

Organizational climate

Organizational climate has been widely studied, with varied definitions across the literature, with Schneider & Reichers (1990) characterizing it as the shared perceptions of policies, behaviors, and expectations within a specific organizational context. In the realm of successful aging Zacher & Yang (2016) explored the role of organizational climate as a moderating factor. Their findings revealed that emphasizing opportunities within the organizational environment positively influences job satisfaction, organizational commitment, and motivation to continue working beyond the official retirement age. Working beyond retirement age has been recognized as an important coping mechanism for retirement adjustment, helping to mitigate the WRI loss in retirement. It enables individuals to retain their professional identity alongside their retirement identity, smoothing the transition into retirement. Different studies showed, that working beyond the retirement age is strongly connected to the professional identity and occupational commitment. For instance, Manor & Holland (2022) found that doctors often struggle to let go their professional identity, as their sense of self remains deeply tied to the medical profession. Rather than viewing retirement as a desirable transition, they often experience it as a forced event. By continuing to work beyond retirement, they maintain their role as doctors, fostering a sense of purpose and improving their self-image. Extending their careers allows them to avoid defining themselves solely as retirees, maintain a hybrid identity, and sustain their professional status identity. Similarly, Cahill et al. (2021) studied the experiences of eleven retired women academics. The study revealed that women with long, continuous careers and notable research accomplishments often felt dissatisfied with compulsory retirement. However, many continued to pursue research activities post-retirement, thereby maintaining their sense of professional fulfillment and identity. End-of-career experiences also influence how individuals adjust to retirement. For example, Tougas et al. (2004) found that older workers who perceived themselves as personally disadvantaged compared to younger colleagues experienced diminished self-esteem and life satisfaction. This shows that workplace dynamics can have an impact on individuals approaching retirement and, on the retirement, process itself.

Studies suggest that organizational climate plays a significant role in shaping the transition to retirement. For employees with strong professional identities, organizational commitment, or significant social ties to the workplace, supportive measures can ease the shift. Initiatives such as pre-retirement workshops, mentoring programs, flexible job opportunities, recognition of contributions, and alumni networks help retirees maintain a sense of belonging and continuity. Conversely, a lack of transitional support, such as abruptly severing ties with retirees, failing to acknowledge their contributions, or neglecting to check on their well-being, can worsen feelings of abandonment and disconnection (Bullock et al., 2020). Effective management of late-career transitions can mitigate WRI loss, enhance self-esteem, and promote life satisfaction during

retirement. Institutions that prioritize supportive organizational climates and invest in transitional programs empower retirees to navigate this critical life stage successfully (Onyura et al., 2015).

Social life outside of work

An additional thread of research on adjusting to retirement highlights the significance of cultivating a vibrant social life outside of work. Social interaction is essential for older adults, and many experience concerns about losing workplace social connections upon retirement (Carter & Cook, 1995; Fletcher & Hansson, 1991). Mariappanadar (2013) showed that fear of losing work-related friendships often motivates pre-retirees to explore casual or contract employment opportunities, such as bridge employment. This underscores the integral role work plays in shaping personal identity, with the loss of daily contact with colleagues post-retirement often contributing to feelings of social exclusion (Price, 2000).

Social life, defined as a dynamic interaction between individuals and society, plays a crucial role in the well-being of older adults (Stets & Serpe, 2013). Maintaining social connections, whether through family, friends, or community activities, is therefore vital during the transition to retirement. Lazarus et al. (1980) highlighted the beneficial effects of engaging in enjoyable activities, especially during periods of stress and recovery. Pressman et al. (2009) defined enjoyable leisure activities broadly as the pleasurable activities that individuals engage in voluntarily when they are free from the demands of work or other responsibilities, for example, hobbies, sports, socializing, or spending time in nature.

The process of joining new social groups can have profound benefits during life transitions like retirement. Haslam et al. (2018) emphasized the significance of acquiring new social identities and groups in adapting to retirement, particularly in fostering a positive self-concept as a retiree. The Social Identity Model of Identity Change (SIMIC), as outlined by Haslam et al. (2019) demonstrates that successful adjustment to retirement is facilitated when retirees (1) maintain access to multiple group memberships and their psychological resources, (2) sustain positive and valued existing group memberships, (3) form meaningful new group connections, and (4) ensure compatibility among these groups. These findings reinforce the role of group memberships and social networks in promoting well-being during the retirement phase.

Volunteering has been identified as a particularly effective means of fostering these connections. A study by van Ingen & Wilson (2017) on volunteers aged above 50 demonstrated that the volunteer role became a key part of their identity. Retirement often provides the additional time needed to invest in such roles, offering a way to compensate for the loss of WRI through meaningful social engagement. Beyond formal volunteering, retirees often rediscover or expand their involvement in informal civic activities, such as supporting family and friends or participating in community organizations (Bogaard et al., 2014). These activities help retirees maintain an active social network, offering a sense of belonging and purpose. Similarly, Cook (2015) found that retirees who engaged in volunteer work developed a new sense of self and discovered renewed meaning in their lives.

Research consistently highlights that building and nurturing social connections—whether through volunteering, community involvement, or informal support networks—can be an effective way to manage the transition to retirement. These activities help retirees sustain a sense of identity and continuity, while also enriching their social lives, ultimately promoting greater overall satisfaction and well-being. For example, Taylor et al. (2008) indicate that

emotional support is beneficial during a stressful transition to retirement and Crego et al (2008) claim that transition to retirement is not uniformed for all, as it varies based on individual circumstances, pointing out the aspect of social support.

Methodology

This study draws on data from a qualitative pilot study involving in-depth semi structured interview with 4 participants (Table 1). The participants had different professional backgrounds (strategic program manager, communication specialist, translator, company secretary) and educational backgrounds (PhD in pharmaceutical sciences, economic technician, professor of English and French, university graduate in administrative organization) to capture varied experiences of WRI loss and retirement adjustment. The sample was selected purposively, using a snowball approach, including recommendations from first participants. The interviewees were contacted by e-mail or telephone.

Table 1: Demographic data

Interviewee	Status	Education	Age	Last Position/*Current Position	Tenure (in years)
I1	Pre-retirement	PhD in Pharmaceutical Sciences	63	Strategic Programme Manager	43
I2	Pre-retirement	Economic Technician	59	Communication Specialist	40
I3	Post-retirement	Professor of English and French	66	Translator	38
I5	Post-retirement	Company Secretary	62	University Graduate in Administrative Organization	40,5
I4	Expert	PhD in Pedagogy	-	*Researcher and Professor in Department of Educational Science	-
I6	Expert	PhD in social gerontology	-	*Researcher in Department of Occupational Therapy	-

Source: Authors' work

The interviews provided an in-depth insight into retirement transition and WRI loss, and enabled the identification of potential facilitators, focused on participants' perceptions of organizational and social factors influencing their retirement adjustment. All interviews started with a question about the interviewee's personal identity: "If I ask you who you are, how would you describe yourself, how do you identify yourself?". All interviews were conducted in person and lasted on average 40 min. A semi-structured interview was also conducted with 2 experts in the field of aging and age management. The interviews with the experts contributed to the understanding of the retirement transitions, challenges and potential facilitators for adjustment to the retirement.

Given the inductive nature of the research, data analysis employed thematic coding to identify patterns and relationships between organizational climate, social life, and WRI in the transition to retirement (Table 2) at the first level and defining themes and categories with added quotes (Flick, 2022; Mesec & Žibera, 2023) in Figure 1. We then returned to the raw data to identify similarities and differences between the narratives in terms of thinking about retirement, feelings in transition and retirement adjustment.

Table 2: Important Factors in Retirement Adjustment

Construct	Codes	
Social Life Outside of Work	• Third Age University • New social networks • Morning walks in company • Workout	• Seeking new interests • Grandchildren • Partnership • Support of your Generation
Organizational Climate	• Annual meetings for pensioners • Teamwork	• Involvement in the organization • Invitations to events
Health	• Poor health	• Energy recovery
Construct	Codes	
Self-awareness	• Raising your own awareness • Self-reflection	• Reading literature
Gradual Disengagement from WRI	• Abandoning a WRI with before retirement	• Slowly dropping out of contact colleagues
Keeping Contacts	• Keeping in touch with colleagues organization	• Embeddedness in the • Annual meetings of pensioners

Source: Authors' work

Results

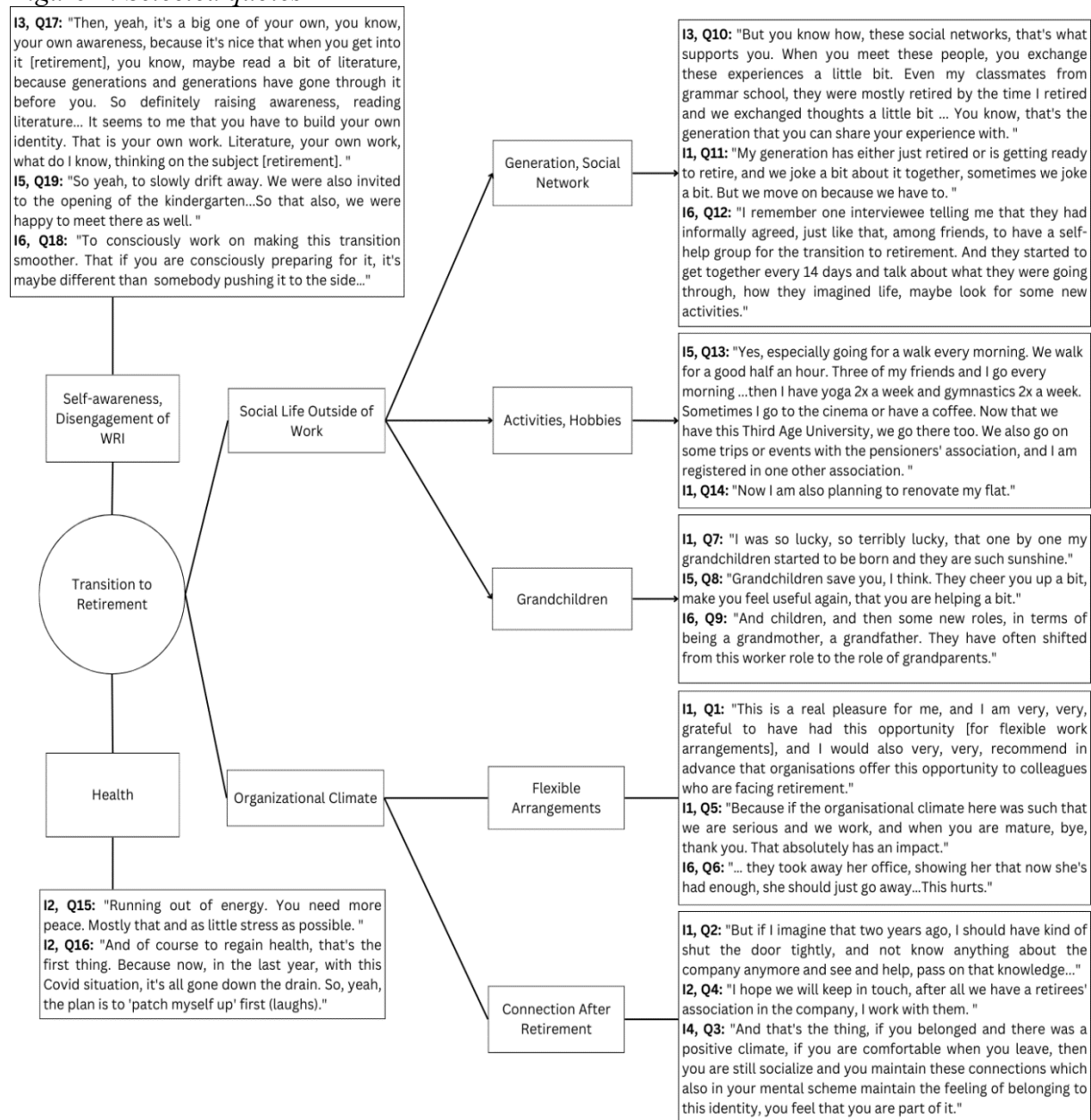
The pilot study provided insights into the challenges faced by employees approaching retirement and individuals who have already retired, with a focus on the WRI loss. The results show that the most important factors that can influence the mitigation of work-related identity loss are the organizational climate of the company, social life outside of work, health, self-awareness and the gradual disengagement from the WRI.

Organizational climate

The results show that organizational climate has an important role in experiencing WRI loss, during the transition to retirement. A supportive organizational environment significantly facilitates this transition, as it fosters a sense of value and belonging among employees approaching the end of their careers. In particular, strong interpersonal relationships and managerial support are key determinants of a smoother adjustment. The presence of an understanding and empathetic manager who provides tailored support and guidance during this period can substantially reduce the impact of WRI loss (see Figure 1, Q1 and Q2). Moreover, maintaining a WRI post-retirement, such as through opportunities for collaboration, knowledge-sharing initiatives, and staying in contact with former colleagues, allows retired employees to continue contributing their expertise and experience. Positive and enduring relationships with former colleagues provide retirees with a sense of connection to their professional community, reinforcing their identity and fostering emotional well-being. The study highlights the importance of offering retirees avenues to pass on their knowledge and maintain professional relationships, as this provides them with affirmation of their value, utility, and significance. Organizations that encourage such involvement and facilitate opportunities for ongoing connection help preserve retirees' sense of purpose, reducing the adverse effects of retirement on their psychological well-being (see Figure Q3 and Q4).

Conversely, an impersonal or unsupportive organizational climate makes retirement more challenging and increases the WRI loss. Employees in such environments often feel undervalued and unsupported, leading to heightened distress both pre- and post-retirement. For instance, organizations that fail to invest in the training and development of older employees, or that neglect to acknowledge their contributions, risk alienating these workers. This lack of recognition fosters feelings of obsolescence and diminished worth, further amplifying the sense of WRI loss (see Figure 1, Q5). In some cases, retirees may even experience abrupt and insensitive transitions, such as the sudden loss of office space or resources, which can serve as a symbolic dismissal of their work-related identity and contributions (see Figure 1, Q6). Such actions can be deeply hurtful, reinforcing feelings of obsolescence and diminished worth. Post-retirement, the absence of acknowledgment or appreciation for decades of service can reinforce feelings of unworthiness and render employees' professional achievements seemingly insignificant. This highlights the critical need for organizations to foster a climate that actively supports employees nearing retirement and appropriately honors their contributions after their departure.

Figure 1: Selected quotes



Note. I_x refers to the interview number, and Q_y refers to the quote number.

Source: Authors' work

Social life outside of work

Social life plays a pivotal role in mitigating the challenges associated with WRI loss, providing emotional support, opportunities for connection, and alternative sources of meaning after retirement. Among these social factors, the involvement with grandchildren emerges as a particularly significant contributor. Grandchildren bring joy, purpose, and a sense of continuity to the retiree's daily life, fostering a renewed sense of responsibility and belonging, significantly enriching their daily lives (see Figure 1, Q7 and Q8). In addition to providing emotional fulfilment, grandchildren help shift the retiree's focus from the challenges of aging to meaningful social interactions, strengthening their sense of connection and engagement. Moreover, by taking on caregiving roles and supporting their family, retirees regain a sense of being needed and useful, which reinforces their self-worth and purpose (see Figure 1, Q8).

Engaging in caregiving and participating actively in the lives of grandchildren often serves as a substitute for the responsibilities and sense of being needed that work once provided, as reported by participants (see Figure 1, Q9).

Beyond familial ties, an active and diverse social life further alleviates the potential void left by retirement. Activities such as attending cultural events, traveling, and socializing with peers provide essential social support and opportunities for engagement. Friendships, particularly those formed with individuals from the same generation, contribute significantly to creating a strong social network that facilitates the transition to retirement. These peers, sharing similar life experiences, often provide deeper empathy and understanding than younger family members, helping retirees navigate this life stage with greater ease (see Figure 1, Q10 – Q12).

Additionally, hobbies and leisure pursuits represent another critical component in establishing a fulfilling post-retirement life. Activities such as engaging in creative events, learning new skills, or participating in group-based hobbies not only fill the increased availability of time but also contribute to a renewed sense of self-worth and personal identity (see Figure 1, Q13 and Q14). These pursuits offer retirees an opportunity to redefine themselves beyond their former professional roles and cultivate new, meaningful identities. This is particularly evident in individuals who were highly active prior to retirement and anticipated dedicating more time to their hobbies, as well as those who had to proactively seek new interests and social connections to navigate this life transition.

Therefore, the interplay of family involvement, active social engagement, and meaningful leisure activities provides a multifaceted framework for retirees to navigate the challenges of WRI loss. These elements collectively offer emotional support, foster a sense of community, and promote the development of a fulfilling and purposeful post-retirement life.

Self-awareness, health and gradual disengagement from WRI

Analysis of the interviews revealed that health, self-awareness, and the gradual disengagement from WRI, along with maintaining connections to former colleagues and the organization, are important factors influencing the transition to retirement and mitigating WRI loss.

Health plays a critical role in shaping how individuals experience and manage the shift from a work-related identity to retirement. Poor health can exacerbate the sense of WRI loss by limiting a person's ability to stay engaged with the work environment, whether through physical presence or ongoing collaboration. Conversely, maintaining or improving health can support retirees in preserving a sense of self-worth, independence, and vitality, thereby reducing or slowing the impact of WRI loss (see Figure 1, Q15 and Q16). This highlights the importance of physical and mental well-being as a foundation for a smoother transition into retirement.

Self-awareness also emerges as a key factor in mitigating the effects of WRI loss. Through practices such as self-reflection and engaging with literature on retirement challenges, individuals can better understand their evolving identity and navigate the complexities of this life stage. Enhanced self-awareness fosters a deeper appreciation of personal interests, values, and goals that extend beyond the professional domain, enabling retirees to form a new identity that is more independent of their previous work-related roles (see Figure 1, Q17).

The process of gradually relinquishing a WRI offers another valuable approach to mitigating the psychological impact of WRI loss. A phased reduction in work-related responsibilities,

combined with a conscious effort to prepare for the transition, can help individuals adjust to their new circumstances in a more controlled manner (see Figure 1, Q18). Rather than avoiding or suppressing thoughts about retirement, actively engaging with the transition process allows individuals to navigate it with greater ease and clarity. This intentional preparation can make the shift feel less abrupt and reduce the likelihood of a sudden identity crisis. In addition, maintaining connections with former colleagues and the organization can also act as a buffering factor against the sense of WRI loss. For instance, being invited to significant workplace events, such as the opening of a new facility at a former workplace, can reinforce a sense of belonging and continued recognition (see Figure 1, Q19). Even after retiring, involvement in organizational activities—such as attending annual retirement meetings or informal gatherings—can preserve a sense of belonging and offer opportunities for continued social interaction. These connections help retirees retain aspects of their former identity, providing continuity during a time of significant change. However, such opportunities are highly dependent on the organizational climate and the extent to which the workplace fosters ongoing engagement with retired employees.

In summary, health, self-awareness, gradual disengagement from professional roles, and maintaining ties to former colleagues and the organization collectively play a pivotal role in easing the transition to retirement. These factors help individuals navigate the challenges of WRI loss while fostering a sense of continuity, independence, and purpose in their post-retirement lives.

Discussion

The findings underscore the pivotal roles of organizational climate and social life in mitigating WRI loss. A supportive organizational climate not only facilitates a smoother transition but also fosters a sense of continued value and connection (see Figure 1, Q1 and Q3) which is in line with the study of Onyura et al. (2015). An additional theme identified in the pilot study was the potential role of working beyond retirement age in mitigating WRI loss. Participants who had a chance to pursue part-time work, consulting, or other professional engagements before and after formal retirement reported a smoother transition (see Figure 1, Q1, Q2, Q5) which was previously observed by Zacher & Yang (2016), and Manor & Holland (2022). This gradual disengagement from WRI allowed them to maintain elements of their professional roles while progressively adapting to retirement. By sustaining a connection to their WRI, retirees felt a sense of purpose and relevance, which helped to ease the psychological shift into full retirement. These findings highlight the importance of worker's acknowledgment and possibility of flexible retirement policies and opportunities that enable retirees to phase out their professional commitments at their own pace.

Similarly, rich social networks provide opportunities for identity continuity by offering alternative sources of meaning and purpose (e.g., Haslam et al., 2018, Bogaard et al., 2014). Individuals who maintained an active social life before retirement often experienced a smoother transition to retirement. Those who were less socially active initially found retirement challenging. However, with support from peers of the same generation, many discovered new interests and, in some cases, a renewed sense of purpose (see Figure 1, Q10, Q11, Q13). Additionally, individuals with grandchildren often expressed that their relationships with them brought joy and a sense of usefulness (see Figure 1, Q7 – Q9).

The study identified additional factors that might mitigate WRI loss during retirement, including health, self-awareness, gradual disengagement, and maintaining connections with colleagues and organizations. The analysis revealed that poor health can amplify feelings of disconnection and diminish opportunities for engagement with work-related environments, making the transition more challenging (see Figure 1, Q15 and Q16). On the other hand, good physical and mental health supports a sense of vitality, independence, and self-worth, which are crucial for managing the psychological impact of WRI loss. Self-awareness through reflection and exploring new interests enables retirees to redefine their identity beyond work (see Figure 1, Q17 and Q18). A gradual transition, reducing responsibilities over time, minimizes abrupt identity crises. Maintaining social connections with former colleagues' fosters belonging and continuity, though organizational climate plays a crucial role (see Figure 1, Q4 and Q19). Promoting wellness, phased transitions, and ongoing engagement are essential strategies for easing the retirement process and addressing WRI loss.

Conclusion

This pilot study highlights the interplay of personal and organizational factors in shaping the retirement experience, with emphasizes on organizational climate and social life outside of work. Supportive environments that prioritize interpersonal relationships, managerial empathy, and opportunities for ongoing connection help retirees transition smoothly and maintain a sense of purpose. Conversely, impersonal or unsupportive workplaces amplify feelings of unworthiness and distress. Organizations can mitigate these challenges by fostering positive relationships, offering knowledge-sharing opportunities, and recognizing retirees' contributions, thereby reducing the psychological impact of retirement and preserving their sense of value and identity.

While this study provides valuable insights, it is a pilot investigation with a limited sample size, which restricts the generalizability of the findings. Future research with larger and more diverse samples is needed to validate these results and further explore the nuances of retirement adaptation. The interplay of familial relationships, peer-based social networks, and meaningful hobbies demonstrates the multifaceted nature of adapting to retirement. Together, these factors create a framework for maintaining psychological well-being and social integration, ultimately easing the process of redefining one's identity and purpose during this life stage. In addition, health, self-awareness, gradual disengagement, and maintaining connections with colleagues and organizations were identified as important factors in mitigating the WRI loss in retirement dynamics. Future research should further explore the interplay of these factors to develop comprehensive strategies for retirement adjustment.

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During the preparation of this work the authors used Grammarly and Microsoft Copilot in order to check for grammatical errors and language improvements. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the paper.

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DIGITAL COMPETENCE IN THE WORKPLACE: REVIEW OF ASSESSMENT SCALES

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Abstract

The rapid development of technology significantly influences workplace processes and the labor market as a whole. The demand for basic digital skills is increasingly essential in modern workplaces and continues to grow annually. The aim of this paper is to review scales and tools for measuring employee digital skills and identify commonly assessed skills. Using literature review approach, keywords like "digital skills" and "digital competence scale" were searched in databases such as EBSCO, Scopus, Web of Science, and Google Scholar. The results revealed that most tools for assessing digital skills rely on a self-report approach, which may affect the validity of results due to respondents' subjectivity. Additionally, we identified performance-based assessment tools, which provide more accurate results but are used far less frequently. Furthermore, most of the identified scales were developed between 2018 and 2021, indicating a need for their improvement to account for the integration of emerging technologies, including the rapid advancement of AI, into workplace processes.

Keywords: digital skills assessment, technology adoption, digital competence.

JEL classification: O33, M53, C83.

Introduction

The development of information technologies significantly impacts organizations worldwide, bringing not only opportunities but also demands for changes in business processes and the adoption of new technologies. This evolution also affects the labor market: some professions

have disappeared due to automation, while new jobs related to technology maintenance have emerged (Curtarelli et al., 2016). Moreover, existing roles are undergoing transformations, with employees increasingly required to acquire digital skills — a requirement that expands each year.

In this context, enhancing employees' digital skills brings several key benefits to organizations (Patriak, 2023). Firstly, it boosts productivity and efficiency in business processes (Borowiecki et al., 2021). Employees proficient in modern technologies can perform their tasks more quickly and accurately, leading to optimized workflows and cost reductions (Sartika et al., 2023). Secondly, investing in employees' digital education is not just a competitive edge — it is an essential step to ensuring the sustainability in the global digital economy (Du, 2023). Furthermore, the ability of enterprises to adapt to digitalization has a broader impact on national and regional economies (Hallová et al., 2024).

However, the level of digital skills among the working-age population in many countries remains low and does not meet employers' needs. For example, over 90% of jobs in Europe now require basic digital knowledge alongside traditional skills (European Data, 2023). However, according to the Digital Economy and Society Index (European Commission, 2022a), four in ten adults in the European Union lack fundamental IT competencies, and as a result, more than three-quarters of businesses in the EU report difficulties in finding qualified workers (European Commission, 2022b). This underscores the urgent need to bridge the digital skills gap, fostering sustainable economic growth in Europe.

Theoretical background

Digital skills encompass a broad set of abilities required in the workplace, varying across industries and professions. Typically, these skills include not only technical competencies but also dimensions such as critical thinking and problem-solving (Audrin & Audrin, 2022). Ferrari (2012, p. 30) defines digital competence as "the set of knowledge, skills, attitudes, abilities, strategies, and awareness that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, and socializing." A more detailed description of digital skills is provided in the Digital Competence Framework for Citizens (DigComp 2.2), developed by the European Commission. This framework identifies 21 specific key competences organized into five areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving (Vuorikari et al., 2022). Similarly, the UK Department for Education's framework outlines six categories of digital skills: digital foundation skills, communication, handling information and content, transacting, problem-solving, and being safe and legal online (Department for Education, 2019). These frameworks emphasize foundational digital skills applicable across a wide range of professions and roles.

Additionally, specialized tools have been developed to assess advanced digital competencies required by specific professions. For instance, programmers (Zamfir & Prikop, 2022), data scientists and analysts (Malallah et al., 2024), workers in creative industries (Van Laar et al., 2020), and nurses (Qin et al., 2024) require unique sets of advanced skills tailored to their respective fields.

A variety of methods are used to evaluate the level of digital skills. The most commonly employed approach is self-reported measures, where participants respond to questions about their perceived competence levels or evaluate their ability to perform specific tasks (Litt, 2013). However, self-reports have been criticized for their validity due to the subjective nature of these evaluations (Kaarakainen et al., 2017).

A less commonly used but higher-quality method is task-based assessments, where participants are required to complete specific tasks in a virtual test environment. These performance-based measurements provide more objective data but are time-consuming and costly (van Deursen et al., 2014). As a result, some studies combine self-reported and task-based assessments to balance validity and practicality.

As discussed above, digital skills are crucial for today's work performance and even more crucial in the future. European employees have low levels of digital skills, but if we want to improve them, it is necessary to measure them first. Many measurement tools are available, but they differ in terms of scientific quality. Therefore, in this article, we will explore in greater detail some scales and tools used to measure employees' digital skills and provide a comparative analysis of their scientific quality (validity, reliability, objectivity, etc.) and practical effectiveness and applications.

Aim and methodology

The primary objective of this study is to systematically search for existing measurement tools (scales, inventories, questionnaires) and review them as tools designed to measure employee digital skills, providing insights into their scientific quality, development, validation, limitations, and practical application in the workplace setting. The study addresses the following research questions:

RQ1: What measurement tools currently exist for measuring digital skills and which are most frequently used?

RQ2: What specific skills are typically considered in these measurement tools?

To achieve this, we conducted a literature review search using a structured approach. After defining the research goals, we established a set of criteria to evaluate the quality of papers to be included in our analysis. Firstly, only tools and scales published within the last ten years were considered, reflecting the rapid evolution of digital technologies and the need to focus on recent advancements. Additionally, we evaluated the size of the sample used in each study, as well as the methods used to assess reliability, such as Cronbach's Alpha and McDonald's Omega. The second step involved conducting a comprehensive search across academic databases, including ScienceDirect, Web of Science, Scopus, and Google Scholar. Keywords and their combinations were carefully chosen to capture a wide range of tools and frameworks relevant to digital skills assessment. These included: "digital skills", "employee digital skills measurement tool", "digital competence questionnaire", "digital skills inventory", "digital competence scale", and "measuring digital skills". The final search query was: (digital OR computer OR ICT) AND (skills OR competences) AND (measurement OR scale OR questionnaire). In total, N = 1,447 open-access articles were identified. At the initial stage, we removed duplicate works or those that were irrelevant (N = 657). At the next stages, only studies meeting the following criteria were included for consideration:

- The full text of the article was available in English.
- The study included a measurement instrument for digital skills.

- The assessed skills were related to the use of digital technologies.
- The quality of the questionnaire or assessment tool was based on theory and had sufficient internal quality.
- The questionnaire or assessment tool was empirically tested on young people or employees.

Ultimately, for further analysis, we selected $N = 10$ articles, while the others were excluded for various reasons. The most common reasons for exclusion were that the studies relied on previously developed scales with only minor modifications or lacked sufficient information about the scale development and validation process. Or were in the process of development.

In addition to database searches, a manual review of relevant articles and cross-referencing of cited sources was performed to ensure a thorough and comprehensive analysis. As a result, we identified one additional relevant study, bringing the final sample for the literature review to $N = 11$ sources. Once the identified studies were screened against the established requirements, we conducted an in-depth analysis and comparison based on the criteria mentioned above. This approach allowed us to systematically evaluate the development, validation, and practical application of digital skills measurement tools, as well as identify trends and challenges in the field.

Results

In our study, we identified a variety of methods used to assess the level of digital skills, with surveys and self-reports being the most utilized due to their simplicity and ability to include a large number of participants. However, for a more comprehensive analysis and comparison, we focused on tools that are grounded in a solid theoretical framework and have undergone rigorous validation processes. Based on these criteria, we selected the most suitable tools and summarized them in Table 1. This table provides an overview of how each assessment tool meets these criteria, offering valuable insights into their effectiveness in measuring digital skills. To examine the specific skills typically included in these measurement tools, Table 2 summarizes the skills covered, the number of questions or tasks in each framework, and the scale used for respondents' answers. Table 3 provides details on the validity assessment of the scales.

Table 1: Measurement tools investigating digital skills

Scales (Authors)	Type	Target population	Factor analysis	Reliability test	Validation sample
Audrin et al., 2024	Self-report	Adults in USA	EFA	$\alpha = 0.77 - 0.93$	$N = 923$
BITS (Weigold & Weigold, 2021)	Self-report	Adult workers	EFA, CFA	$\alpha = 0.86 - 0.90$	$N = 355$
DigCompSAT (Clifford et al., 2020)	Self-report	Adult EU citizens	ICLUST	$\alpha = 0.987$;	$N = 460$
Kaarakainen et al., 2018	Performance-based	Youth and teachers	EFA	$\alpha = 0.66 - 0.81$	$N = 3159$ (youth) $N =$

Scales (Authors)	Type	Target population	Factor analysis	Reliability test	Validation sample
					626 (teachers)
Na-Nan et al., 2019	Self-report	Employees of SMEs in Thailand	EFA, CFA	$\alpha = 0.888$ Each variable: $\alpha = 0.679 - 0.897$	N = 409
NDASS (Qin et al., 2024)	Self-report	Registered nurses	EFA, CFA	$\alpha = 0.964$, Test-retest reliability = 0.740, Split-half coefficient = 0.935.	N = 429 nurses
Rodríguez-de-Dios et al., 2016	Self-report	Secondary school students (12-18 years old) in Spain	EFA	$\alpha = 0.63- 0.75$	N = 715
Rubach & Lazarides, 2021	Self-report	Teachers in Germany	EFA, CFA	$\omega = 0.63-0.95$	N= 372
Son & Ha, 2024	Self-report	Middle and high school	Rasch analysis (Item Response Theory)	Pearson reliability (PR > 0.83), Item reliability (IR > 0.91), Cronbach's alpha (CA > 0.86)	N = 1,194 students (651 middle school, 543 high school)
Van Laar et al., 2018	Self-report	Professionals in creative industries in Netherlands	EFA	$\alpha = 0.72 - 0.94$	N = 907
yDSI (Helsper et al., 2020)	Self-report + Performance-based	Youth (12-17 years old) in Europe	EFA, CFA	$\alpha = 0.77-0.88$	N = 2,438

Source: Authors, 2024

Audrin, Audrin & Saurin, 2024

The development of this questionnaire involved several stages, including a literature review, interviews with experts, two pilot surveys, and a full validation survey conducted among workers in the USA. As the theoretical foundation for their framework, the authors used DigComp 2.2 and the tool developed by Van Laar et al. (2018) as a basis. The large sample on which the research was conducted, along with its strong validity and reliability indicators, supports the quality of the instrument. However, it is important to note that for its use in research in European countries, additional confirmatory factor analysis would be necessary to account for the influence of cultural context.

Brief Inventory of Technology Self-Efficacy (BITS), (Weigold & Weigold, 2021)

The Brief Inventory of Technology Self-Efficacy is a tool consisting of 18 items related to basic computer skills, that was tested on a large group of people aged 18 and older. The results from factor analysis and reliability testing showed that it is valid and appropriate for use in further

research. However, its limitation lies in its narrow focus, assessing only computer self-efficacy rather than providing a comprehensive evaluation of digital skills. The authors also developed a shorter version of the questionnaire (BITS-SF), which includes only six items.

DigCompSAT, (Clifford et al., 2020)

One of the dominant frameworks cited by researchers in studies of digital skills in the adult population is DigComp, a tool developed by (Vuorikari et al., 2022) and officially adopted by the European Commission. It has undergone several phases, beginning with the identification of areas of digital competence (Ferrari & Punie, 2013), and progressing to more specific and developed scales, such as DigComp 2.2 (Vuorikari et al., 2022). It is designed to methodologically measure digital knowledge, skills, and attitudes towards ICT within five categories, which encompass a total of 21 digital competencies. To practically assess the level of these skills, a self-reflection tool, DigCompSAT, was developed. The study that validated this instrument was conducted in 2020 with a target population of individuals aged 16-65 from Latvia, Spain, and Ireland (Clifford et al., 2020). Given that the study was based on a solid theoretical foundation, with two pilot studies were conducted in different cultural contexts, and high reliability, validity, and internal consistency among the questions were confirmed, we can classify it as one of the most rigorous digital skills measurement tools.

Kaarakainen, Kivinen & Vainio, 2017

This instrument is grounded in a strong theoretical foundation and employs a performance-based approach to assess three groups of digital skills: 1) Basic digital skills (word processing, spreadsheet usage, social networking, information seeking, presentation, basic computer use, image processing, and web content creation); 2) Advanced technical skills (operating system installation and initialization, maintenance and updating, software installation and initialization, information security, and information networks); 3) Professional ICT skills (server environments, database operations, digital technology, and programming). Testing of this instrument was conducted on a large sample of youth and teachers in Finland in 2017, confirming its validity. However, low (yet acceptable) Cronbach's alpha values indicate room for improvement, particularly in items assessing professional ICT skills, which recorded the lowest reliability scores within the instrument.

Na-Nan, Roopleam & Wongsuwan, 2019

This study developed a scale that includes eight dimensions, including skills rarely assessed in similar questionnaires, such as digital emotional intelligence. The validity of this tool was statistically confirmed, allowing managers to use it for assessing digital intelligence based on both work and lifestyle parameters. However, since the study was conducted solely on a sample of Thai respondents, the scale requires further refinement and validation using additional sampling contexts.

Nursing Digital Application Skill Scale (NDASS) (Qin et al., 2024)

The development and validation of this scale went through several stages, based on previous researches, expert assessment of content validity, a focus group interview, and a final study in which nurses answered 12 questions. The final version of the questionnaire demonstrated high internal consistency and reliability; however, since the questions were specifically designed to assess digital skills in the medical field, this tool cannot be used in a broader context.

Rodríguez-de-Dios, Igartua & González-Vázquez, 2016

The aim of this study was to develop a scale to assess digital literacy among teenagers, and its validation was conducted on a sample of Spanish students aged 12 to 20 years. To ensure the high quality of the questionnaire, a pilot study was initially conducted, after which the number of items was reduced from 47 to 29. These items can be grouped into six main categories: technological skills, personal security, critical thinking, device security, informational skills, and communication skills. However, it is important to note that the study was conducted in 2016, so for further use, this scale should be reviewed and, if necessary, supplemented with new questions that reflect current needs.

Table 2: Overview of the competencies being tested in the analyzed models

Scales (Authors)	Number of items /tasks	Number of competences tested	Competences description	Scale Tasks description	Available languages
Audrin et al., 2024	52	8	Technology use, cybersecurity, content management, communication and collaboration, critical inquiry, responsibility, well-being, and identity and development.	7-point Likert scale	English,
BITS (Weigold & Weigold, 2021)	18	1	Basic computer skills	6-point Likert scale	English, Chinese
DigCompSAT (Clifford et al., 2020)	82	21	Information and data literacy, communication and collaboration, digital content creation, safety, problem solving	4-point Likert scale	English, Spanish, Latvian
Kaarakainen et al., 2017	42	12	Information management, content creation and social networking, software installation, programming, information security etc.	Multiple-choice and open-ended questions	English
Na-Nan et al., 2019	33	8	Digital identity, digital use, digital safety, digital security, digital emotional intelligence, digital communication, digital literacy, digital rights	5-point Likert scale	Thai
NDASS (Qin et al., 2024)	12	Not specified	Digital content, decision making, collaboration, continuous learning, communication etc.	5-point Likert scale	English, Chinese
Rodríguez-de-Dios et al., 2016	29	6	Technological, personal security, critical, devices security, informational and communication skill.	5-point Likert scale	English, Spanish

Scales (Authors)	Number of items /tasks	Number of competences tested	Competences description	Scale / Tasks description	Available languages
Rubach & Lazarides, 2021	32	6	Information and data literacy, communication, collaboration, digital content creation, safety and security, problem solving, analyzing and reflecting.	5-point Likert scale	English, German
Son & Ha, 2024	38	5	Data collection and recording, Analysis and interpretation 1 (statistics), Analysis and interpretation 2 (analytical tools), Conclusion generation, Sharing and presentation.	Specific number of points not mentioned	English
Van Laar et al., 2018	60	6	Information management, communication, collaboration, critical thinking, creativity, problem solving	5-point Likert scale	English, Dutch
yDSI (Helsper et al., 2020)	25	4	Technical and operational skills, information navigation and processing skills, communication and interaction, Content creation and production	7-point Likert scale	English

Source: Authors, 2024

Son & Ha, 2024

This scale is one of the most recent and has been tested on a large sample of middle and high school students. It assesses various aspects of digital literacy, including information competence, technical skills, and ethical aspects of digital technology use. The authors conducted a statistical validation and reliability analysis, including Rasch analysis, confirming its suitability for assessing students' digital skills. However, since the questions were not specifically designed for an educational setting, with additional testing, this questionnaire could be adapted for other professional domains as well.

Van Laar, Van Deursen, Van Dijk & De Haan, 2018

This instrument was developed to evaluate skills within a broader context, with a specific focus on assessing 21st-century skills in the domain of information technologies. The final instrument consists of 60 questions, to which respondents provide answers ranging from 1 (never) to 5 (always). By formulating the questions this way, the authors aimed to minimize the influence of respondents' subjective self-assessments, as prior scales often required individuals to directly evaluate their own skills. The pilot and final testing phases were conducted among employees in creative industries, addressing the limitations of previous research that primarily focused on students or citizens. The quality of the questionnaire was confirmed through strong exploratory factor analysis (EFA) results and reliability indicators.

The Youth Digital Skills Indicator (yDSI) (Helsper, Schneider, van Deursen & van Laar, 2020)

This scale was developed as part of the Youth Skills (ySKILLS) project, funded by the European Commission, to assess the level of digital skills among youth, particularly in preparation for digital careers. Its development involved several stages, including expert consultations, cognitive interviews, pilot surveys (construct validity testing), and performance tests conducted in multiple European countries. The final questionnaire consists of 31 items, which the authors categorize into two main groups: digital skills (25 items) and digital knowledge (6 items). In our study, we focused specifically on the first group of questions, although knowledge remains an essential component of digital skills.

Table 3: Scales' validity (quality) assessment

Scales (Authors)	Convergent validity	Discriminant validity	Cross-cultural validity	Construct validity
Audrin, Audrin & Saurin, 2024	++	?	?	+++
BITS (Weigold & Weigold, 2021)	+++	+++	++	+++
DigCompSAT (Clifford et al., 2020)	++	++	+++	++
Kaarakainen et al., 2017	?	?	?	+++
Na-Nan et al, 2019	++	?	?	+++
NDASS (Qin et al., 2024)	+++	?	?	+++
Rodriguez-de-Dios et al., 2016	?	?	?	+
Rubach & Lazarides, 2021	?	?	+	+++
Son & Ha, 2024	?	?	?	+++
Van Laar et al., 2018	+++	+++	+++	+++
yDSI (Helsper et al, 2020)	+	+	?	+++

Source: Authors, 2024;

Note that “+” means that the measurement tool has that specific quality characteristic; more pluses indicate a higher level. Sign for “?” means that we did not identify that specific quality characteristic at sufficient level.

In Table 3, we report validity information about the specific scales. As can be seen from the table, three scales have higher levels of validity compared to others, where some of them completely miss specific types of validity.

Conclusion

The primary goal of our research was to identify and analyze the tools used to measure digital skills. Among the most robust tools with the best psychometric characteristics, we identified the DigComSat scale by the European Commission and the tools developed by Van Laar et al. (2018), as well as Audrin et al., (2024). These tools were tested on substantial respondent samples and demonstrated strong validity and reliability. DigComSat, in its initial paper, provided limited information about its quality (Clifford et al., 2020), but later it was tested and verified by many different authors with good results. The BITs scale was designed to measure computer self-efficacy, but the questions overlap with digital skills.

The results of our study reveal that most scales designed to assess digital skills levels rely on a self-report approach, where participants based on a group of questions evaluate their own skills. While this method has several advantages, it is essential to consider its subjectivity, which may

affect the validity of the results (Kaarakainen et al., 2018). In contrast, the performance-based approach provides more accurate results but is used far less frequently due to the significant time and resource requirements for its implementation (Van Deursen et al., 2014). Among the eleven tools analyzed in our study, only two employed a performance-based approach, highlighting the need for further exploration and development in this area.

Despite the rapid development in digitalization, most of the tools we identified were developed during the 2020–2021 period. This may indicate increased interest in digital skills assessment driven by the COVID-19 pandemic. However, given the ongoing technological evolution and the integration of new tools such as artificial intelligence into workplace processes, these scales must be updated, or new tools developed to reflect these advancements.

As part of our research, we also aimed to answer research questions regarding the specific skills typically included in the scope of digital skills assessments. Our analysis found that such tools commonly focus on skills such as information search and analysis, problem-solving, digital content creation, communication and collaboration, and safety and security. However, the list of essential skills continues to grow as technologies evolve. For example, the European Commission has been continuously improving its Digital Competence Framework (DigComp), with the latest version including skills like identifying disinformation on social media and understanding AI and IoT concepts (Vuorikari et al., 2022).

Our research has certain limitations, as we analyzed a limited number of studies, each focused on different samples. This might make it harder to apply our findings globally. Future studies should overcome these issues by analyzing more tools and including a wider variety of samples and industries.

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EXPLORING THE LINK BETWEEN PURPOSE-DRIVEN LEADERSHIP AND EXTRA-ROLE BEHAVIOR: THE MEDIATING ROLES OF ENGAGEMENT AND JUSTICE

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Abstract

In today's dynamic business environment, managers face increasing challenges in fostering employees' positive attitudes and behaviors. Leadership style plays a critical role in shaping these attitudes, influencing workplace behavior and overall organizational performance. This study examines the relationship between purpose-driven leadership and extra-role behavior, focusing on the mediating effects of employee engagement and organizational justice. A delayed-response field survey was conducted among 447 employees from 21 Croatian organizations. Mediation analysis revealed that purpose-driven leadership indirectly influences extra-role behavior, fully mediated by employee engagement and organizational justice. These findings underscore that employee engagement and organizational justice are essential psychological mechanisms linking leadership and employees' discretionary behaviors. This study is the first to introduce purpose-driven leadership into the Croatian organizational context, offering new insights into leadership's role in fostering employees' positive attitudes and behaviors. The results provide practical implications for managers, highlighting the importance of aligning leadership strategies with engagement and justice to enhance extra-role behavior. However, limitations arise from data collection from a single source and the involvement of both private and public sector organizations, suggesting avenues for further research.

Keywords: purpose-driven leadership, employee engagement, organizational justice, extra-role behavior, Croatian organizations

JEL classification: D23, M12, J24, J28

Introduction

In modern business environments, managers face various challenges in developing employees' positive attitudes and behaviors. Leadership style plays a pivotal role in fostering these attitudes, influencing employees' behavior and overall organizational effectiveness (Dartey-Baah et al., 2019; Kadar Khan et al., 2018; Kim, 2014; Niehoff et al., 1990; Organ et al., 2006;

Paulisić & Gonan Božac, 2013). Previous research indicates a significant relationship between various employee attitudes, with particular attention given to the relationships between employee engagement (EE) and organizational justice (OJ) (Alvi & Abbasi, 2012; Ghosh et al., 2014; Mubashar et al., 2022; Saks, 2006), EE and organizational citizenship behavior (OCB) (Ahmed et al., 2012; Babcock-Roberson & Strickland, 2010; Kataria et al., 2013; Marić et al., 2019; Rurkkhum & Bartlett, 2012; Wahyu Ariani, 2013), as well as between OJ and OCB (Chegini, 2009; Jafari & Bidarian, 2012; Moorman et al., 1993; Sani, 2013; Zeinabadi & Salehi, 2011). These studies contribute to a better understanding of how the perception of justice within an organization and the level of employee engagement can influence their willingness to make additional contributions beyond their formal job responsibilities. However, the influence of purpose-driven leadership on these specific employee attitudes remains unexplored, highlighting a significant research gap and underscoring the necessity of this study. Therefore, given the growing recognition of purpose-driven leadership (PDL) and its role in shaping workplace dynamics, this study investigates how PDL relates to extra-role behavior (ERB) through the mediating effects of EE and OJ. The study thus addresses the following *research question*: *Do EE and OJ mediate the relationship between PDL and ERB?*

Theoretical framework

PDL as a new leadership perspective

Organizations increasingly recognize the significance of purpose as a key driver of long-term success. Purpose-driven organizations align their mission, values, and strategic goals to create meaningful impact beyond financial performance, fostering a sense of shared commitment among employees and stakeholders (Quinn & Thankor, 2018). By embedding purpose at the core of their operations, such organizations enhance employees' motivation, organizational resilience, and sustainable performance. Despite its evident importance, creating purpose-driven organizations is challenging because it requires a deep integration of purpose, vision, and values with business strategies, often necessitating the overcoming of entrenched neoliberal beliefs that separate social impact from business objectives (Kempster & Jackson, 2023). In this context, PDL, also called purposeful leadership, emerges as a critical enabler, guiding organizations toward aligning strategic decisions with a broader societal mission while cultivating EE and ethical work cultures.

PDL represents a contemporary leadership approach centered on the idea of shared purpose. It is built upon three fundamental principles: discovering a leader's personal purpose, helping others find their personal purpose, and connecting personal purpose with the broader organizational purpose (Cardona et al., 2019). Leaders who embrace PDL cultivate a strong organizational sense of purpose, directly influencing leadership engagement practices and contributing to positive outcomes, such as increased stakeholder commitment, enhanced organizational performance, and greater societal impact (Hong et al., 2021). By conducting a bibliometric analysis of research on purposeful leadership, Zaharuddin et al. (2024) defined it as "leading by prioritizing living example over communication, leading with deep purpose, or leading with an exponential purpose to overcome disruptive business challenges", emphasizing that the core aim of PDL is to address commercial and social challenges in a way that generates sustainable value for stakeholders.

Expanding on these principles, Joly (2021) presents PDL as a leadership model structured around five key dimensions: (1) being clear about one's own purpose, the purpose of those

around them, and how it aligns with the company's purpose; (2) understanding one's role as a leader; (3) recognizing whom they serve; (4) being driven by values; and (5) leading with authenticity. Building on this model, PDL fosters deeper connections within organizations by integrating personal and organizational purpose, thereby creating a values-driven culture that strengthens trust, engagement, and long-term success. This shift toward PDL reveals the limitations of traditional top-down leadership models, where purpose is defined at the top and cascaded downward; instead, modern organizations must recognize that purpose already exists within their workforce and must be actively uncovered, nurtured, and aligned at all levels (Cardona et al., 2019). Consequently, purpose-driven leaders must be authentic individuals with integrity, who are deeply committed to building sustainable organizations, staying true to their core values, and courageously shaping their companies in ways that meet the needs of all stakeholders while recognizing their broader responsibility to society (Zu, 2019).

As leaders embrace this paradigm shift, they transcend conventional mindsets and recognize opportunities for organizational excellence by fostering networks of people united by a higher purpose, cultivating resilience, continuous learning, and collaboration (Nader & Maheshwari, 2023). Willingness to prioritize a collective purpose over personal gain reinforces a leadership model that is deeply rooted in authenticity and long-term impact. Building on this idea, Wilson (2017) conceptualized purpose as a guiding principle and a multidimensional force that operates on five interconnected levels—psychological, organizational, biological, energetic, and mathematical. This perspective broadens the understanding of PDL by suggesting that leadership shaped by purpose extends beyond individual and organizational levels, influencing broader systemic dynamics. Through this holistic influence, PDL creates inspiring organizations that engage all stakeholders and ensure sustainable success.

Beyond its impact on organizations, PDL aligns closely with global sustainability efforts, particularly the Sustainable Development Goals (SDGs). Ferreira Ribeiro et al. (2024) noted several positive outcomes of PDL, including increased EE, enhanced organizational commitment, and improved overall performance. More specifically, PDL fosters sustainable business practices by promoting decent work and economic growth (SDG 8), supporting innovation (SDG 9), encouraging responsible consumption and production (SDG 12), strengthening ethical decision-making, and institutional integrity (SDG 16), and by cultivating strong stakeholder relationships, and aligning business objectives with societal well-being, it contributes to long-term sustainable success (Zaharuddin et al., 2024).

The importance of employees' attitudes in organizational behavior

Organizational behavior literature has highlighted several key employees' attitudes. When these attitudes are positive, they contribute to higher employee productivity and better organizational results. Robbins & Judge (2019) emphasized the importance of *job satisfaction*, *job involvement*, *organizational commitment*, *perceived organizational support*, and *EE* as fundamental employees' attitudes. Contrarily, Pološki Vokić (2018) stated that the most well-known employees' attitudes are *job satisfaction*, *EE*, *organizational commitment*, *OJ*, and *OCB*. A literature search on employees' attitudes led to the conclusion that there is another employee's attitude toward the organization: *employee loyalty*. This paper investigated EE, OJ, and ERB closely related to OCB as fundamental employees' attitudes.

One of the first challenges in conceptualizing EE is the lack of a universal definition of this employee's attitude. Kahn (1990) defined EE as the connection of employees with their work roles, where employees physically, cognitively, and emotionally employ and express

themselves while performing their roles. The cognitive aspect of EE concerns employees' beliefs about the organization, the emotional aspect concerns employees' feelings about their roles, and the physical aspect concerns employees' physical energies to accomplish their work. Most often, EE has been defined as a positive and fulfilled state of mind associated with work, characterized by energy, dedication, and absorption (González-Romá et al., 2006; Schaufeli et al., 2002a).

To explain the concept of OJ, it is crucial to mention that it consists of three dimensions: *procedural*, *distributive*, and *interactional* justice. Although these three types of justice are defined based on different managerial decisions, without them, it won't be easy to develop effective OJ (Ambrose & Schminke, 2007). Distributive justice is the fairness of the distribution of resources within an organization (Colquitt, 2001). Therefore, distributive justice refers to the allocation of resources. Procedural justice pertains to the fairness of the management policies and procedures that regulate a process leading to organizational outcomes (Colquitt, 2001). Procedural justice focuses on managers' steps to reach a just decision. Interactional justice is an employee's treatment resulting from managerial decisions (Colquitt, 2001). Specifically, interactional justice pertains to employees' interpersonal transactions with workplace authority figures (Cropanzano et al., 2007). Considering all three dimensions of OJ, Cropanzano et al. (2007) believed that OJ relates to how employees feel about the moral correctness of their treatment. In other words, OJ is employees' subjective assessment of managers' ethical and moral behavior.

OCB has been defined as individual ERB that helps organizational effectiveness but is not a requirement of the individual's job that is directly rewarded by the formal system (Organ, 1988). Organ's claim that OCB is ERB was criticized because some researchers included in-role behaviors in measuring OCB (Organ, 1994). However, Morrison's (1994) findings suggested that many items of OCB may be tapping behaviors that employees and supervisors considered in-role. Organ (1997) responded by changing the definition of OCB and proposing that no reference to ERB should be made when describing or defining OCB. By contrast, Motowidlo (2000) explained that one major problem with Organ's redefinition of OCB is that not all researchers using previously developed scales to measure OCB knew about this redefinition. Motowidlo (2000) suggested that two distinct definitions of OCB now exist in the literature: one with and one without an extra-role requirement.

Van Dyne et al. (1995) positioned OCB within a larger framework of ERB. More precisely, constructs related to OCB include contextual performance, prosocial behavior, and ERB (Van Dyne et al., 1995). ERB, which is similar to OCB, refers to actions that aim to benefit the organization and extend beyond formal job responsibilities or predefined role expectations. However, this framework excludes much of the OCB compliance dimension because it generally involves adherence to expectations that are either explicitly named or implied in the job definition. However, Van Dyne et al. (1995) placed the helping dimension within ERB, characterizing it as an affiliative form of ERB. In other words, OCB is a type of ERB that strengthens emotional connections among employees, fosters positive feelings, and encourages unity and agreement rather than disagreement or discord within the organization.

Previous research and hypotheses

One of the forms of ERB is OCB (Hall & Ferris, 2011; Organ et al., 2006). Researchers have established a mediating effect of EE on the relationship between predictor variables of EE (e.g., job characteristics, using strengths at work, perceived organizational and supervisor support,

distributive and procedural justice) and OCB (Lavy & Littman-Ovadia, 2017; Marić et al., 2019; Saks, 2006). More precisely, Lavy-Littman-Ovadia (2017) examined associations between employees' use of character strengths at work and their productivity, OCB, and job satisfaction in a sample of 1095 employees. Marić et al. (2019) collected data from 255 employee-supervisor dyads to illustrate how formal job resources and job challenges are indirectly (via EE) related to OCB that benefits organizations (OCB-O). In his research on 102 employees working in various jobs and organizations, Saks (2006) distinguished between job and organization engagement and measured various antecedents and consequences of job and organization engagement.

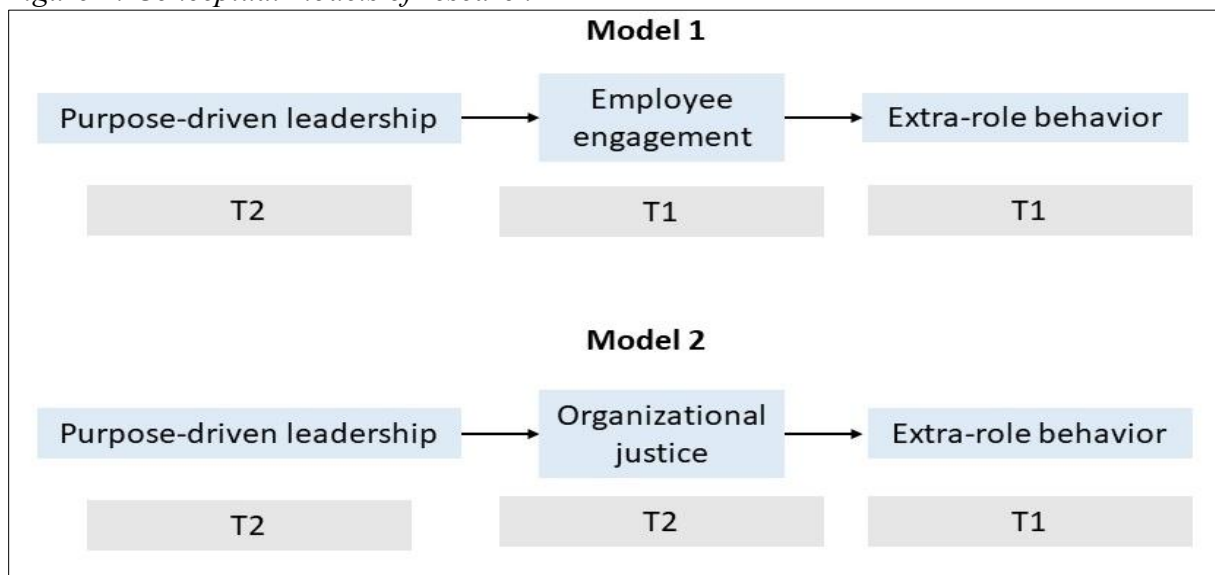
Previous research has also found that OJ has a mediating effect between different variables (e.g., perceived organizational support, role efficacy, and servant leadership) and OCB (Devasagayam, 2013; Zehir et al., 2013). More precisely, Devasagayam (2013) examined the relationships among perceptions of organizational support, role efficacy, and OCB by examining the mediating effects of OJ from 276 people selected through a convenience sample across globally located software organizations. By contrast, Zehir et al. (2013) used 300 respondents from private education institutes in Turkey to investigate servant leadership's effects on OCB and job performance by impacting OJ (Zehir et al., 2013). Therefore, the following two hypotheses were formulated:

H1. EE mediates the relationship between PDL and ERB.

H2. OJ mediates the relationship between PDL and ERB.

This research examined the mediating effect of EE and OJ on the relationship between PDL as an independent variable and ERB as a dependent variable. The study also sought to contribute to the theoretical understanding of PDL within the Croatian context. Based on the above research hypotheses, two conceptual models were formulated to test the mediating effects of EE and OJ on the relationship between PDL and ERB over two distinct time periods: T1 (April 2024) and T2 (October 2024), as illustrated in Figure 1.

Figure 1: Conceptual models of research



Source: Authors' creation

Methodology

Measurement instruments

The study employed the following well-established measurement instruments: the Purpose-Driven Leadership Scale (4 items) developed by Marimon et al. (2016) for assessing PDL; the Utrecht Work Engagement Scale (9 items) developed by Schaufeli et al. (2002b) for assessing EE; the Organizational Justice Scale (8 items) developed by Elovainio et al. (2010) for assessing OJ; the and Organizational Citizenship Behavior Scale (3 items) for assessing ERB (Motowidlo, 2000). These instruments were selected because of their established reliability and validity in prior research. All measurement instruments used a 5-point Likert scale from 1 = strongly disagree to 5 = strongly agree. The internal consistency, measured through Cronbach's alpha coefficient, was more than satisfactory ($> .70$) for all scales, as shown in Table 1.

Table 1: Cronbach's alpha coefficients for measurement instruments

Variables	Number of items	Cronbach's alpha
PDL	4	.964
EE	9	.930
OJ	8	.921
ERB	3	.864

Source: Authors' calculations

Table 2 shows all items' descriptive statistics, including total mean scores and standard deviations. The lowest mean value is 3.1521 (SD=1.00409) for one item related to measuring OJ, and the highest mean value is 4.2215 (SD=.82434) for the item related to measuring ERB. All mean values are at sufficiently high and satisfactory levels.

Table 2: Descriptive statistics of items

Items	N	Mean	Std. Deviation
PDL1	447	3.5839	1.06367
PDL2	447	3.6063	1.06167
PDL3	447	3.5011	1.07952
PDL4	447	3.5638	1.09824
EE1	447	3.3714	1.09662
EE2	447	3.3579	1.11324
EE3	447	3.3535	1.03974
EE4	447	3.1544	1.01154
EE5	447	3.4720	1.03460
EE6	447	3.8501	1.02978
EE7	447	3.8322	1.02263
EE8	447	3.8277	.99069
EE9	447	4.0940	.92068
OJ1	447	3.3669	1.02855
OJ2	447	3.1857	1.06260
OJ3	447	3.1521	1.00409
OJ4	447	3.9262	.99839
OJ5	447	3.9553	1.03645
OJ6	447	3.6421	1.04251
OJ7	447	3.6644	1.07318
OJ8	447	3.7025	1.04755
ERB1	447	3.9799	.93610
ERB2	447	4.2215	.82434
ERB3	447	4.1655	.84406

Source: Authors' calculations

Sample and procedure

The study aimed to test the mediating effect of EE and OJ on the relationship between PDL and ERB. A quantitative online survey questionnaire was used, and primary data were collected via a delayed-response field survey. In other words, retrospective measures were used to avoid subjectivity when assessing the dependent variable (Cox & Hassard, 2007; Miller et al., 1997). Respondents completed a questionnaire assessing EE and ERB at T1 (April 2024). Respondents also completed a questionnaire assessing PDL and OJ at T2 (October 2024). The time points were separated by 6 months.

The data were collected from 21 Croatian organizations from the private and public sectors with a minimum of 20 employees. Most organizations were private (14), but seven were public. The largest number of private organizations came from the manufacturing industry sector (9), and the rest came from the information and communication sector (3) and the financial and insurance sector (1). Public organizations that participated in the study are education institutions (2), hospitals (2), local and regional self-government units (2), and a non-profit public organization (1).

The final sample consisted of 447 respondents who participated in the survey. Regarding demographic characteristics, most respondents were between 30 and 44 years old (43.40%). Also, 282 respondents were female (63.09%), and 165 were male (36.91%). Most respondents had faculty (graduate), academy, or postgraduate study (43.85%) and 10 or fewer years of service in their current organization (57.05%). Most respondents worked as executive or operations workers (44.30%). Table 3 provides a detailed breakdown of the respondents' demographic characteristics.

Table 3: Demographic characteristics of the respondents

Variables	Categories	N	%
Age	29 years or less	78	17.45%
	30 to 44 years	194	43.40%
	45 years and above	175	39.15%
	Sum	447	100.00%
Sex	Females	282	63.09%
	Males	165	36.91%
	Sum	447	100.00%
Educational level	Primary school or lower	8	1.79%
	Vocational secondary school up to 3 years	42	9.40%
	Vocational secondary school for 4 years or more, and high schools	111	24.83%
	First university degree and college	72	16.11%
	Faculty (graduate), academy and/or postgraduate study	196	43.85%
	Scientific master (MSc. Sc.) and/or doctoral degree (Ph.D.)	18	4.03%
	Sum	447	100.00%
Length of service in the organization	10 years or less	255	57.05%
	11 to 20 years	114	25.50%
	21 to 30 years	60	13.42%
	31 years and above	18	4.03%
	Sum	447	100.00%
Position in firm	Executive/operations workers	198	44.30%
	Professional/administrative workers	132	29.53%
	Lower/middle management	97	21.70%
	Top management	20	4.47%
	Sum	447	100.00%

Source: Authors' calculations

Research results and discussion

Conditional process mediation analysis was used to test the hypotheses using the PROCESS macro for SPSS (Hayes, 2018). This methodological approach allows for a robust examination of mediating relationships and provides detailed insights into leadership's direct and indirect effects on ERB. Two conditional process mediation analyses were performed to test two different models. The results of these analyses are presented in Table 4. Considering that the direct effect of PDL on ERB is not significant, and the indirect effect is significant for both mediating variables, EE and OJ fully mediate the relationship between PDL and ERB. These findings support H1 and H2, underscoring the roles that EE and OJ play in connecting PDL with ERB.

Table 4: Results of conditional process mediation analyses

Model	Direct effect			Indirect effect	Total effect
	(X → Y)	(X → M)	(M → Y)	(X → M → Y)	
	c'	a	B	a x b**	c
PDL → EE → ERB	-.0146	.4548	.4543	.2066*	.1920
PDL → OJ → ERB	.0271	.5979	.2758	.1649*	.1920
					* p < .05 ** 95% bootstrap confidence interval

Source: Authors' calculations

Although earlier research has confirmed the mediating role of EE (Marić et al., 2019; Saks, 2006) and OJ (Devasagayam, 2013; Zehir et al., 2013) in the relationships among different variables, this study is the first of its kind to examine the mediating role of EE and OJ in the relationship between PDL and ERB. Therefore, this study strongly contributes to the literature on organizational behavior, leadership, and employees' attitudes. Additionally, the research findings strongly support the thesis that leadership style influences employee behavior and workplace attitudes, as established in previous studies (Dartey-Baah et al., 2019; Kadar Khan et al., 2018; Kim, 2014; Niehoff et al., 1990; Organ et al., 2006; Paulisić & Gonan Božac, 2013). Furthermore, this study creates opportunities for future research on the relationship between PDL and other employee attitudes, such as organizational commitment, perceived organizational support, and job involvement.

In addition to the significant scientific contribution, the results of this study confirmed the existence of PDL in Croatian organizations. They confirmed that employees are aware of the importance of this leadership perspective. The results may encourage managers to lead according to PDL principles because such a leadership perspective enables the achievement of numerous advantages and benefits. These benefits include positive employees' attitudes toward work and the organization and improving organizational performance. When employees and managers are aware of their personal purpose and the purpose of their work, they directly contribute to the achievement of organizational goals.

Conclusions

Scientists and practitioners are aware of the evident benefits of creating purpose-driven organizations, which include increased EE, OJ, and ERB. This study is the first to examine the mediating effect of EE and OJ on the relationship between PDL and ERB worldwide and in Croatia. It also introduces PDL into the Croatian organizational context, adding a novel

dimension to the existing body of leadership literature. The research results may guide managers in adopting PDL to form positive employees' attitudes and behaviors in modern workplaces, with the ultimate goal of influencing employees' work performance and overall organizational performance. Managers are encouraged to align individual and organizational purposes and foster an environment of justice and engagement to maximize employee contributions.

This study has several limitations. The first limitation is that only employees assessed all variables; data were collected from a single source, contrary to the recommendation in the literature (Cox & Hassard, 2007; Miller et al., 1997). Since employees assessed all variables, future researchers should consider including additional variables that managers and supervisors could evaluate in the model, such as work performance. Furthermore, the study involved different organizations from the private and public sectors, so future researchers could investigate whether there is a difference in variables and research results between the private and public organizations and whether differences in variables and relationships according to demographic characteristics can be observed.

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HR-RELATED ENABLERS OF HYBRID WORK REGIMES: CRANET DATA-BASED EVIDENCE

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Abstract

The purpose of this study is to shed light on hybrid work regimes, by empirical validation of the significance of organizational enablers in facilitating hybrid work arrangements. The aim of our study is to empirically validate the significance of organizational enablers in facilitating hybrid work arrangements. This study aims to contribute to understanding hybrid work regimes by examining the relationship between remote work arrangements and the prevalence of key HR-related enablers of hybrid work regimes. The research utilizes data from 5,800 enterprises across 38 countries, collected through the CRANET Scientific Network's international research initiative (2021–2022). Employing correlation analysis and linear regression techniques, the study empirically investigates the relationship between remote work arrangements and company performance outcomes, as well as the role of HR-related determinants in sustaining hybrid work models. The findings indicate that remote work arrangements exhibit weak to moderate positive associations with key performance outcomes, including innovation, stock market performance, and profitability. These results suggest that while organizations adopting remote work may experience incremental benefits, the impact on productivity, service quality, and environmental performance remains limited, potentially contingent on additional organizational initiatives. Furthermore, the study identifies HR digitalization, structured performance appraisal systems, communication and empowerment as critical enablers of hybrid work effectiveness. Among these factors, formal employee evaluation frameworks exert the strongest influence, followed by employee self-service HR tools, consultation through line managers, and well-integrated HR information systems. These findings underscore the necessity for organizations seeking to optimize hybrid work arrangements to invest in HR technology, establish robust performance appraisal mechanisms, and empower managerial communication and decision-making. By empirically validating the significance of HR-related enablers in facilitating remote work, this study advances HR management theory and provides practical insights into the structural and technological determinants necessary for developing and sustaining effective hybrid work regimes.

Keywords: remote work, hybrid work regime, human resources management, empowerment of line managers, Cranet

JEL classification: M55, M14, M54

Introduction

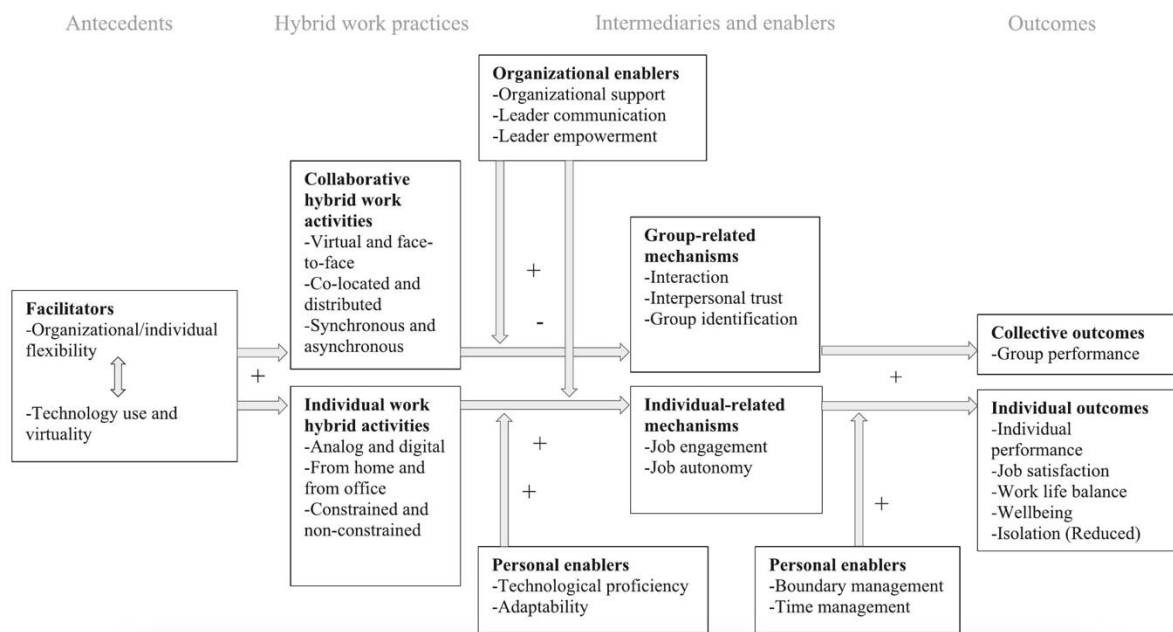
Hybrid work is a combination of online and offline work environments that are increasingly converging and merging to create a new work environment (Chamakiotis et al., 2024). While some authors differentiate switching as one of the important characteristics of the new work arrangement, not only in the online/offline environment but also in the face-to-face versus digital technology environment (Lauring & Jonasson, 2025; Pink et al., 2022), others characterize the hybrid work environment as a blended one, where the emphasis on online and offline elements is no longer relevant (Šimůnková, 2019).

Hybrid work is seen as a third way of working, where physical presence and synchronization are combined with further rearranging office spaces for communal work, cooperation, and socialization, while home office places for thinking, working productively, and focusing on tasks (Zamani et al., 2025). Managing people in hybrid work arrangements opens new challenges and requirements for managers, organizations, and employees. Work in hybrid work arrangements is often organized and experienced along the continuum of time, and how the temporalities are shared, multiplied, and conflicting influences the relationship between workers and the organization (de Vaujany et al., 2021). Organizations and managers need to identify relevant measures of performance management and workers' productivity in hybrid workspaces. Research must prioritize reframing employee performance management and identifying supportive infrastructure that enhances productivity in hybrid workspaces. Organizations and managers must go beyond traditional metrics to develop comprehensive, adaptive measures that align with the evolving nature of work.

Our research builds on the systematic literature review paper by Lauring et al. (2025), who, through a rigorous systematic study of the available literature, defined the following organizational enablers for hybrid work modes: Organizational support, Leader communication, and Leader empowerment. Following his model, the goal of the hybrid work arrangements is to reach collective and individual outcomes of hybrid work: Group performance, Individual performance, Job satisfaction, Work-life balance, Well-being, and Reduced isolation of employees (Lauring & Jonasson, 2025), Figure 1. The author has encouraged the need for quantitative research of his model's literature findings.

While this framework provides a strong theoretical foundation, a significant research gap remains in empirically validating these relationships through quantitative analysis. Specifically, the impact of organizational enablers on hybrid work outcomes has not been systematically tested across diverse organizational settings. Additionally, the model does not explicitly account for the role of performance management systems and supportive infrastructure in optimizing hybrid work effectiveness. Given the increasing shift towards hybrid and remote work structures, there is a need to reframe employee performance metrics and investigate how technological and managerial infrastructures support collective and individual outcomes in hybrid environments.

Figure 1: The model of hybrid work arrangements by Lauring et al (2025)



Source: Lauring et al. (2025)

Understanding the organizational enablers of hybrid work regimes is essential for advancing theory of HRM and implications for practice. Lauring et al. (2025) finds organizational support, leader communication, and leader empowerment as organizational enablers of hybrid work arrangements and calls for further empirical research to provide evidence on how these enablers function in practice. Existing studies suggest that HR digitalization is a crucial element, equipping leaders with tools for efficient employee management in hybrid settings (Detjen & Webber, 2023). Additionally, performance appraisal mechanisms facilitate hybrid work by reducing misunderstandings, preventing workload imbalances, and ensuring regular feedback between managers and employees (Lamovšek et al., 2025). Furthermore, managerial communication strengthens the role of line managers, empowering them to make impactful decisions and actively contribute to organizational direction (Ishak et al., 2025; Staniulienė & Zaveckis, 2022). By integrating these elements, this research aims to strengthen and refine the existing model, contributing to a more accurate and empirically grounded understanding of the structural and technological determinants that underpin the effective management of sustainable hybrid work environments.

Theoretical background

The possibility to work from home, for those who can, became a substantial in-kind benefit similar to a company car or workplace childcare (De Fraja et al., 2024), and by the latest research it looks like it will stay in the workplace practice for long and even increase in its usage (Barrero et al., 2023). Strong management of hybrid work arrangements remains challenging because it can create disparities between employees regarding performance management, reward, and promotion (Barrero et al., 2023). The rise of hybrid work arrangements is driven not only by employee preferences but also by organizations' capacity to adapt and cultivate a dynamic work environment. Recent research has increasingly focused on how strategic work organization and the integration of digital technologies facilitate the effective implementation of hybrid work models.

Organizational determinants affecting hybrid work arrangements

Lauring (2025) defined the organizational enabler of effective hybrid work arrangements as Organizational support, Leader communication, and Leader empowerment (Lauring & Jonasson, 2025). Working in a hybrid work arrangement requires more individualized leadership toward employees. The organizations must have established the conditions and environment for line managers in the form of digitized self-service in HR tools (Detjen & Webber, 2023), supporting the management of work performance and transparent employee appraisal (Lamovšek et al., 2025), as well as empowerment for the possibility of increased independent decision-making and autonomy (Kumari et al., 2024; Staniulienė & Zaveckis, 2022).

A) Performance management and transparent formal appraisal system

Recent studies have shown that clearly defined performance expectations are crucial in hybrid and remote settings (Mabaso, 2024; Eng, 2024; Mujtaba & Lawrence, 2024). The study by Mabaso & Manuel (2024) highlighted key elements in managing performance in hybrid regimes, like continuous communication, clarity in expectations, and trust-building. Authors find successful performance management in hybrid and remote work settings is contingent on effectively communicating between managers and employees. Several experts agree that hybrid work modes bring increased employee productivity due to an increase in flexibility and autonomy (Khatimah, 2022), as well as an increase in work happiness and job engagement (Wesarat et al., 2025). By promoting work-life balance, employee satisfaction with the workplace increases, affecting work engagement and employee performance. However, due to the partial remote work, it is necessary to be able to transparently evaluate the performance of employees and save and manage the results for further HR work.

B) Empowerment and communication

Studies on the role of leadership in hybrid regimes implementation have engaged many perspectives. Van Gelder (2022) finds that hybrid working implies that work will take place more independently of time and place and this may be at odds with line managers' preferences as to work-life segmentation. Employees' engagement through support and empowerment has already been found as enhancing organizational goal fulfilment (Boamah & Laschinger, 2015). Eng (2024) implies that the support of managers and employers in a hybrid work environment should be given to create strategies tailored to individual needs rather than to control how and where employees work. Study by Hopkins & Figaro (2021) finds, that when employees are experiencing face-to-face and remote work environments, the leadership competencies and attributes increase. For example, in terms of communication, the upward communication and derived support to address employees' targeted needs enabled a better home-office experience (Couto et. al., 2024). This suggests the relevance to further investigations of empowerment of managers and employees, and areas of organizational infrastructure development for its support.

C) Digitalized HRM

The study by Couto (2024) highlights that effective implementation of remote work environments has significantly contributed to the digitalization of human resource (HR) processes, enhancing overall people management. The findings suggest that in the context of remote work, the increasing complexity of people management necessitates greater organizational digitalization, particularly through digital HRM practices, employee support and monitoring, e-leadership development, and targeted coaching for team managers. Study by

Capone (2024) highlights the need for interventions to support employees in remote working environments by leveraging employees' self-efficacy as a key factor in reducing stress related to new technologies as well as enhancing well-being, job satisfaction, and, in turn, their performance.

From a strategic perspective, the relationship between HR digitalization and strategic human resource management (SHRM) orientation has been further examined. Rimac-Bilušić and Pološki-Vokić (2024) investigated the role of digital tools in enhancing both individual and organizational efficiency and effectiveness. Their findings indicate that the adoption of manager self-service, algorithm-driven HRM, HR analytics, telework, digital learning, and social media-based recruitment and selection significantly increases the likelihood of an organization adopting a SHRM orientation. Among these, digital learning emerged as the most influential digital HRM practice in shaping SHRM strategies, as demonstrated through dominance analysis.

Measurement of organizational HR enablers of hybrid work arrangements

To contribute to the theoretical understanding of organizational enablers in hybrid work regimes, we found the need to provide empirical insights into key facilitating factors, including the existence of a formal appraisal system, organizational structures that support employee self-service and manager self-service, the developed HR information system, and the role of effective communication through line managers. We found several calls for further research in this trajectory. The study by Williams & Shaw (2024) state that while hybrid working offers notable benefits such as improved work-life balance and productivity, it also presents significant challenges that organizations must address to ensure effective performance management and employee well-being. The systematic literature review by (Vanitha & T, 2024) finds that organizations transitioning to hybrid work models aim to enhance employee engagement through reinvented appraisal systems, indicating a focus on adapting performance evaluations in this context. Authors Katsenos & Pierrakeas (2022) highlight innovation and knowledge as key appraisal criteria, while personal relations are less emphasized in digital collaborative environments. Consequently, organizations transitioning to hybrid models must reinvent appraisal systems to maintain fair evaluations and ensure employee engagement. However, there is still a lack of understanding of how hybrid work affects all aspects of performance appraisal, including feedback mechanisms, goal setting, and competency evaluations. Therefore, we address the research inquiry by hypothesizing that formal employee appraisal is one of the enablers of remote work.

The concept of managers' self-service and employees' self-service are increasingly relevant, where hybrid work models and self-managing organizational structures are gaining traction. Self-managing modes offer potential for democratic participation and decision-making, although they require continuous negotiation and communication to manage inherent tensions (Stöber, 2024). Research on hybrid workplace ecosystems (Gannabathula, 2024) finds autonomy enhanced through self-service tools, enablers of access to information, self-management of tasks, and communication with teams without needing constant oversight, further boosting employees' engagement levels. Tailored approaches to hybrid work, considering departmental roles and collaboration needs, are crucial for effective implementation (Tsipursky, 2023). Self-managing structures can empower employees and improve performance, but maintaining culture and communication in hybrid settings remains a complex management challenge. Ongoing research and adaptation are essential to maximize their potential in different organizational contexts. Therefore, we address the research inquiry

by hypothesizing that self-service models and organizational infrastructure for sharing information and communication are enablers of remote work.

Measurement of companies' performance in conjunction with hybrid work arrangements

Recent studies consistently show that hybrid and remote work arrangements enhance productivity, engagement, and overall organizational performance. Lopez (2023) found that remote workers are more productive than on-site employees, with hybrid models positively influencing employee engagement and satisfaction. Nwankpa & Roumani (2024) confirmed a positive link between remote work and productivity, emphasizing that innovation benefits are amplified when knowledge-sharing mechanisms are in place. Paudel & Sherm (2024) synthesized literature and empirical data, concluding that remote work improves both individual well-being and organizational performance. As flexibility is one of the attributes of work in hybrid work regimes, we found extensive evidence of the positive impact of flexible work arrangements on organizational performance. Flexible working arrangements have been shown to positively influence productivity by allowing employees greater control over their work schedules, which can lead to increased motivation and efficiency (Lisnawati, 2024). Flexibility in work regimes was found positively related to performance and major contributor to enhance productivity (Hariyanto et al., 2024; Çivilidağ & Durmaz, 2024). To measure company performance in hybrid models, businesses should prioritize output-based productivity metrics, employee engagement surveys, and innovation tracking. Research highlights that hybrid work models, when properly structured, contribute to both employee success and long-term company performance.

We found research on hybrid work regimes has primarily focused on employee-related effects, while company-level impacts remain underexplored. HRM theory requires empirical data on organizational outcomes to fully assess hybrid work models. Therefore, we address the research inquiry by hypothesizing that remote work is related to company performance outcomes measured in a complex qualitative perspective. By employing ratings of service quality, productivity, profitability, innovation, stock market performance, and environmental matters, this study shifts the focus to company-related effects. These metrics provide a comprehensive evaluation of hybrid work's impact on business success, addressing gaps in HRM research and offering a framework for future corporate strategy.

Research methods and methodology

Research objectives and questions

To address the research gap, and shed light on hybrid work regimes we focused on remote work arrangements. Halford (2005) states in a hybrid work arrangement, employees work from different locations (i.e., remotely) but also onsite at the conventional office. Our research was guided by two key research questions.

RQ1: What are the HR-related organizational enablers of remote work?

RQ2: How is remote work related to company performance outcomes?

The aim of our study is to empirically validate the significance of organizational enablers in facilitating hybrid work arrangements, as identified in the literature review specifically, HR digitalization, formal appraisal systems, and line manager empowerment. Through a

quantitative research approach, this study aimed to contribute to hybrid work regimes by examination the relationship between remote work arrangements and the prevalence of key HR-related organizational determinants that support hybrid work effectiveness.

H1: There is a significant positive association between remote work arrangements and organizational enablers.

H2: Organizational enablers have significant positive effect on remote work arrangements.

H3: There is significant positive association between remote work arrangements and company performance outcomes.

Measurement

To empirically validate the hypothesized associations, we have employed variables leaning on CRANET questionnaire survey methodology. Involving the focus group, consisting of experts including representatives from business practice, seniors in HR specialization, and experienced scholars, we have identified relevant items for measurements.

We used the implementation of **remote work arrangement** to verify the use of hybrid work arrangements in the sample. We measured the use of remote work before, during and after the Covid 19 pandemic. For hypothesis testing we work with the data on remote work after Covid 19 pandemic. The scale was used to quantify the approximate proportion of employees working in remote work arrangement (0-not used, 1-up to 5%, 2- up to 20%, 3-up to 50%, 4-more than 50%).

We used self-reported company data to measure **the companies' performance** – HR managers were asked to rate the company's performance in comparison to other companies in the same sector (1-poor or at the low end of the industry, 2-below average, 3-average or equal to the competition, 4 – better than average, 5-superior). The companies' performance measurement was in areas of Service quality, Level of productivity, Profitability, Rate of innovation, Stock market performance, and Environmental matters.

To deliver empirical evidence on the **organizational enablers**, we included items for measuring organizational support (developed formal appraisal system, HR information systems), leader communication (communication through line managers) and leader empowerment (manager self-service, employee self-service).

To measure **organizational support**, we measured the extent of use of digital organizational infrastructure to measure digitalization of HRM (0-not at all, 3- to a very great extent), and formal appraisal system. We measured the use of Manager self-service (System giving managers access to information and ability to handle HR tasks rather than relying on HR department), Employee self-service (System giving employees access to information and ability to handle HR tasks themselves), and HR information systems. These systems provide managers or employees access to information and the ability to handle HR tasks rather than relying on the HR department. The digitalization of HRM is contributing to organizational support of hybrid regimes. Formal appraisal system is considered organizational support and was measured as confirmatory question (yes/no). We measured the **leader empowerment** by the organisational support in form of the extent of the use of self-service systems, as well as by internal **leader communication** through immediate supervisors (line managers) bottom-up measured as confirmatory question (yes/no).

Sampling

This study utilizes data from the CRANET survey conducted in the 2021-2022 period, which encompassed responses from 5,899 human resource management (HRM) professionals employed in organizations with a minimum of 150 employees across 38 countries. The findings of this research are derived from the largest and most comprehensive dataset on HRM, encompassing critical HRM practices such as recruitment, selection, compensation and benefits, career management, and performance evaluations, as well as the organizational structuring of the HRM function, including outsourcing, delegation to line management, and the application of technology in HRM delivery. This survey is administered regularly, yielding large-scale, multi-time-point, cross-national data. For a comprehensive account of the questionnaire survey methodology, refer to Brewster (2004) (Brewster et al., 2004).

Data collection

For each round of the survey, questions are constructed by network members to ensure consistency in data comparisons between periods, but at the same time capture emerging trends in the field. Each question is based on a literature review, the researchers' expert perspective, and discussions with HR professionals. Data collection is cross-country, concerning sectors and firm sizes to ensure the representativeness of the samples. The return rate of the questionnaires is approximately 25%. The research data are widely accepted for publishing research outputs internationally (Einarsdóttir et al., 2018; Christensen et al., 2019; Peretz et al., 2018; Prince et al., 2020; Szierbowski-Seibel et al., 2019).

Results and discussion

From the research sample of responding companies, we excluded companies that did not answer questions about the implementation of remote work ($n=392$) and further developed the research questions on a group of 5503 companies. We have cleaned the database from missing values. Of the sample, 42.5% of businesses responded that remote work is used by less than 6% of the proportion of the workforce. From 6-20% of the workforce, up to 24% of companies use remote work after the Covid-19 pandemic. Utilization above 20% of the proportion of workforce had 32.5% of enterprises in the research sample, of which 15% of enterprises provided remote work arrangements for more than 50% of employees.

The use of remote work arrangements was highly sector-specific, with sector-specific use being very similar across regions. Remote work arrangements for more than 6% of the workforce proportion were mostly used in the Telecommunications and IT services, Financial and insurance, Accounting, architecture, and administrative services sectors. We can see remote work arrangements for some proportion of the workforce used also in manufacturing, mainly in Chemical, pharmaceutical, and medicinal chemical products and Manufacture of computers, electronic products, and electronic equipment.

H1: There is a significant positive association between remote work arrangements and organizational enablers.

Results show significant, strong and positive association between remote work regimes and Employee self-service HR ($r = 0.2841$, $p < .001$), HR information system ($r = 0.2419$, $p < .001$), Managerial self-service HR ($r = 0.2369$, $p < .001$), and significant, moderate and positive

association of remote work regimes and formal appraisal system ($r = 0.1613$, $p < .001$), and consultation bottom-up through line managers ($r = 0.1160$, $p < .001$), were found. The results are detailed in Table 1.

Table 1: Correlations between remote work and organizational enablers

	Pearson's r	p-value	Result
H1a: Existence of formal appraisal system	0,16	< 0,001	Accepted
H1b: Manager self-service	0,24	< 0,001	Accepted
H1c: Employee self-service	0,28	< 0,001	Accepted
H1d: Information system	0,24	< 0,001	Accepted
H1e: Consultancy through line managers	0,12	< 0,001	Accepted

These findings suggest that digitalization in HR is fundamental enabler of remote work, as it provides employees and managers with streamlined access to HR functions, reduces administrative bottlenecks, and enhances interaction in a hybrid work environment. Structured performance evaluation mechanisms and managerial communication practices were found related to sustaining hybrid work environments. The role of line managers in facilitating bottom-up consultation suggests that empowerment in leadership and communication structures are necessary for the successful development of hybrid work regimes. Our research contributes to the control or commitment research. Our findings are complementary to research results by McPhail (2023), stating that traditional performance reviews, were largely suspended or modified, and it remains to be seen if this will continue or, in their place, more fit-for-purpose ways of measuring and encouraging performance and development will emerge.

H2: Organizational enablers have significant positive effect on remote work arrangements.

To explore accurate understanding of our findings, we also employed linear regression analysis, where we sought support from a group of companies for hybrid work arrangements through organizational determinants. Based on the analysis, we can confirm that in the presence of organizational determinants, hybrid work arrangements are more strongly enabled, i.e. the given organizational determinants affect the stronger and more frequent use of hybrid work arrangements. For a given model, the result is $R=0.3389$, $R^2=0.1149$, RMSE 1.2628, p -value<0.001 (Table 2). For each determinant, the results are in Table 3.

Table 2: Linear regression analyses of organizational enablers as predictors of remote work

Model Fit Measures				Overall Model Test			
Model	R	R ²	RMSE	F	df1	df2	p
1	0.3389	0.1149	1.2628	128.8799	5	4965	<.001

Table 3: Organizational determinants affecting hybrid work arrangements

Model Coefficients - RemoteAfterCOVID

Predictor	Estimate	SE	t	p
Intercept	0.9794	0.0430	22.7594	<.001
HRManagerSelfService	0.0482	0.0226	2.1314	0.033
HREmployeeSelfService	0.2413	0.0220	10.9769	<.001
HRInfSystem	0.1318	0.0187	7.0412	<.001
FormalAppraisalSystem	0.2782	0.0409	6.8065	<.001
ConsThroughLineMan	0.1947	0.0360	5.4054	<.001

The results show that remote work after COVID even without the listed factors, is highly prevalent (Intercept 0.9794, p-value<0.001). A structured performance appraisal system significantly increases remote work adoption ($\beta = 0.2782$, $p < .001$), it has the highest impact among measured predictors, also employee self-service was found to have high impact ($\beta = 0.2413$, $p < .001$). Effective consultation through line managers ($\beta = 0.1947$, $p < .001$) and well-integrated HR information system ($\beta = 0.1318$, $p < .001$) support hybrid work. When HR managers have self-service tools, remote work is slightly more likely ($\beta = 0.0482$, $p = 0.033$).

H3: There is a significant positive association between remote work arrangements and company performance outcomes.

To answer the research question, we used a correlation matrix. A significant and positive correlation between the use of remote work arrangements and company performance was shown in the sample. All five areas of company performance measured have been associated with involvement of remote work arrangements. Results are shown on Table 4.

Table 4: Correlations between remote work and company performance outcomes

	Pearson's r	p-value	Result
H3a: Service quality	0,03	0,047	Accepted
H3b: Productivity	0,05	< 0,001	Accepted
H3c: Profitability	0,08	< 0,001	Accepted
H3d: Innovation	0,13	< 0,001	Accepted
H3e: Stock market performance	0,15	< 0,001	Accepted
H3f: Environmental matters	0,04	0,003	Accepted

The results show weak to moderate, positive and significant associations of remote work arrangements and measured variables. The strongest relationship was found between Remote Work and Innovation ($r = 0.1253$), Stock Market Performance ($r = 0.1538$), and Profitability ($r = 0.0823$). While these are still relatively weak correlations, they indicate that companies supporting hybrid work might benefit in these areas. Productivity ($r = 0.0515$) and Service Quality ($r = 0.0284$) association to remote work was found weak, suggesting that remote work may not dramatically improve or hinder these aspects. Surprisingly, the positive correlation with environmental performance ($r = 0.0431$) is weak, although it supports the idea that remote work contributes to sustainability.

To verify the authenticity of the correlation matrix, we searched for a correlation between company size or industry of companies to avoid the mis explanation of positive correlation and searched for other factors affecting both parameters positively. In the given correlation relationship, the parameter. Number of employees or Industry did not prove to be below the p-value of <0.05 . The size of the company or the business industry does not affect the positive results of the company.

The research found a positive association of remote work to all measured categories of company performance. This is complementary to the study by Theres & Strohmeier (2023), who conducted a meta-analysis, finding that digital HRM significantly improves the performance of individual users, the operational, relational, and transformational performance of HRM, and corporate performance. With the focus on performance categories our findings suggest that remote work may foster innovation by enabling greater flexibility, autonomy, and knowledge-sharing in hybrid environments. Our finding supports the results by Nwankpa & Roumani (2024), who revealed that the positive link between remote work and innovation was stronger in the presence of knowledge sharing. Similarly, the positive association with stock market performance may reflect investor confidence in companies that successfully integrate hybrid work regimes. The correlation with profitability, though weak, suggests that cost savings from remote work (e.g., reduced office space expenses) could contribute to financial performance. This finding aligns with the research by Pokojski (2022) reporting that companies with a positive attitude toward remote work experienced greater efficiency and provided more support for remote employees. Based on the results we are indicating that productivity and service quality may be more dependent on other organizational factors rather than the mere adoption of remote work. Interestingly, the correlation between remote work and environmental performance was weaker than expected. This finding is complementary to research by McPhail (2023) finding changes in workforce management, virtual communication and collaboration, reduced carbon emissions, and increased plastic consumption, due to technological infrastructure development. This finding suggests that while hybrid work may contribute to sustainability efforts, its impact may be less pronounced or contingent on additional sustainability initiatives implemented by organizations.

Conclusions and recommendations

The aim of our study was to shed light on hybrid work regimes by empirical validation of the significance of organizational enablers in facilitating hybrid work arrangements. The results indicate that the remote work has a modest relationship to various company performance outcomes. We imply that companies embracing hybrid work models may experience some degree of improvement in innovation, market performance, and financial outcomes. Also we found the effect of hybrid regimes may be less pronounced or contingent on additional sustainability initiatives implemented by organizations.

Empowerment in interactions, formal evaluation and digitalization in HR has shown to be highly influential enabler of hybrid regimes. These findings suggest that organizations aiming to sustain and enhance remote work arrangements must prioritize investments in HR technology, developed performance appraisal strategies, and engagement of leaders. Our study provides empirical support for understanding of HR-related enablers of remote work. It suggests considerable insights into mechanisms for the development of hybrid work regimes.

This study contributes to HRM theory by providing empirical validation of the organizational

enablers necessary for the development of hybrid work regimes. While previous research has largely focused on the conceptual foundations of hybrid work regimes, our findings offer quantitative empirical evidence supporting the role of HR digitalization, structured appraisal mechanisms, and managerial engagement in shaping effective remote work regimes.

From perspective of practical HRM, this study highlights the necessity for companies to invest in HR technology, enhance performance management systems, and empower leadership structures to foster sustainable hybrid work models.

Limitations and future recommendations

While this study provides empirical insights into the organizational enablers of hybrid work and their relationship with company performance outcomes, several limitations must be acknowledged. As with most survey-based research, the generalizability of findings is a concern, as self-reported organizational data may introduce response bias and inconsistencies in how companies define and measure performance outcomes. Additionally, the study is constrained by the scope of the CRANET questionnaire, limiting the inclusion of additional items that could have provided a more comprehensive assessment of hybrid work enablers. The reliance on perceptual measures rather than objective performance indicators, such as financial reports or productivity metrics, further restricts the validity of the findings. Future research should incorporate multi-source data collection to strengthen the robustness of empirical evidence.

Although the research draws from a large international dataset, variations in regulatory frameworks, workplace cultures, and industry-specific factors may influence hybrid work effectiveness. Comparative studies across regions and countries could provide deeper contextual insights. The study employs correlation analysis and linear regression, which allow for association testing but do not establish causal relationships. Employing experimental methods or longitudinal panel studies would help determine the causal impact of HR enablers on remote work effectiveness and organizational performance. Another limitation is that hybrid work is not synonymous with remote work but rather encompasses a combination of in-office and remote arrangements. While remote work is a key component of hybrid work, the interplay between on-site collaboration and digital work remains underexplored. The study does not fully capture the complexities of workplace dynamics, such as how organizations balance flexibility with physical presence or how much remote in hybrid structures affects employee interactions and engagement.

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PLAY AS A TRANSFORMATIVE FORCE: HOW PLAYFUL LEADERSHIP FOSTERS IDENTITY, CREATIVITY, AND INNOVATION

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Abstract

Play, traditionally perceived as a leisure activity, is increasingly recognized as a fundamental mechanism for leadership development, identity formation, and organizational learning. Recent research highlights its crucial role in fostering cognitive flexibility, creativity, and adaptability, suggesting that play can be a strategic tool for leadership and innovation in modern organizations. This study employs a narrative literature review as part of a qualitative, theory-building approach to examine the role of play in leadership practices. By synthesizing insights from organizational behavior, psychology, and leadership theory, this research develops a conceptual model that connects playful leadership, identity work, and innovation. The findings highlight that playful leadership fosters an environment conducive to risk-taking, open communication, and collaborative problem-solving. Through mechanisms such as role-playing, gamification, humor, and storytelling, leaders can create psychologically safe workplaces that encourage exploration and experimentation. This study also explores the play-based leadership identity model, emphasizing the iterative nature of leadership identity formation through playful interactions between leaders and followers. By embedding play into leadership development, organizations can cultivate more resilient, innovative, and purpose-driven teams. Ultimately, this study positions play as a strategic tool for leadership and innovation, rather than a mere workplace distraction. Organizations that integrate play into leadership practices will be better equipped to foster creativity, adaptability, and sustainable innovation, ensuring their ability to navigate an increasingly complex and dynamic business landscape.

Keywords: Playful leadership, identity formation, innovation, leadership development, gamification, organizational learning.

JEL classification: M12, M14, O31, D23, L21

Introduction

In contemporary organizations, play is increasingly recognized as more than mere entertainment; it serves as a fundamental mechanism for learning, identity formation, and leadership development. While traditional organizational structures often separate work from play, recent research underscores the value of playful activities in fostering creativity, engagement, and professional development (Kark, 2011). Play provides a psychologically safe environment where individuals can explore new roles, test ideas, and engage in experiential learning without fear of failure (Kolb & Kolb, 2010). This ability to explore and experiment has important implications for leadership, as it enables employees to refine their self-concept, develop adaptive skills, and align their professional identities with organizational goals (Ibarra & Petriglieri, 2010, Ryan et al., 2024).

Play is a fundamental human experience that transcends cultures, generations, and professional settings. Traditionally associated with childhood, play is now understood as an essential factor in adult cognitive flexibility, problem-solving, and social connection. The work of Vygotsky (1978) highlights the transformative power of play, stating that "a child in play acts as though he were a head taller than himself." This perspective extends to organizational settings, where leaders who foster a playful work environment enable employees to push their creative and intellectual boundaries, ultimately leading to greater innovation and resilience.

Play is not merely a leisure activity; rather, it is a vital human need that shapes culture, behavior, and creativity (Huizinga, 1955). In *The Ambiguity of Play*, Sutton-Smith (1997) explores the paradoxical nature of play, emphasizing that its oscillation between productivity and leisure makes it a powerful driver of cognitive and creative growth. Similarly, Brown (2009) describes play as a catalyst for engagement, productivity, and happiness, reinforcing the idea that even small doses of play can have a profound impact on professional performance and organizational culture.

For many years, the domains of work and play were considered separate and unrelated in both academic research and business practice. The workplace was historically viewed as a domain of seriousness, discipline, and responsibility, while play was confined to recreation and leisure. However, recent research has challenged this rigid division, demonstrating that integrating play into business processes, particularly through leadership, enhances creativity, fosters innovation, and improves organizational performance (Bilderback 2025, Petelczyc et al., 2018, Schrier et al., 2023).

This study employs a narrative literature review as part of a qualitative, theory-building approach to critically examine the role of play in leadership development, organizational learning, and identity formation. By synthesizing relevant theoretical frameworks and empirical insights, we construct a conceptual discussion that explores how play shapes leadership behaviors, fosters innovation, and influences team dynamics. By integrating those perspectives, we develop a theoretical model that connects playful leadership, identity work, and innovation. Through this qualitative and integrative approach, the study identifies gaps in the literature and proposes new directions for empirical research and practical applications.

Through this theory-building exploration, we argue that playful leadership fosters a climate conducive to experimentation, learning, and strategic risk-taking, ultimately shaping an organization's capacity for sustained innovation. By integrating our model into leadership

research, we contribute to a deeper understanding of how play can be leveraged as a strategic tool for organizational growth, adaptability, and competitive advantage.

The role of playful leadership in fostering creativity and innovation in organizations

Play is a fundamental aspect of human experience, often defined as an activity driven by enjoyment, exploration, or learning (Van Vleet & Feeney, 2015; Kark, 2011). While traditionally associated with childhood, play holds a crucial role in adulthood, particularly in organizational settings. Wittgenstein (1958) noted that play cannot be easily defined due to its diverse forms and applications, ranging from structured games with rules to spontaneous, imaginative interactions. Anić (1991) further categorizes play into various dimensions, such as intellectual or physical engagement, competition, role-playing, or even strategic maneuvering. These broad conceptualizations highlight the versatility of play as a mechanism for cognitive, social, and professional development.

Incorporating play into leadership practices can serve as a powerful catalyst for creativity and innovation. Leaders who cultivate a playful work environment encourage divergent thinking, allowing teams to break away from rigid problem-solving approaches and explore unconventional solutions. Playful activities stimulate cognitive flexibility, enabling individuals to establish novel connections between seemingly unrelated concepts, thereby fostering innovative ideas (Mainemelis & Ronson, 2006; Petelczyc et al., 2018). This flexibility is particularly valuable in dynamic business environments where rapid adaptation and original thinking provide a competitive advantage.

Research confirms a strong link between play and workplace creativity. Petelczyc et al. (2018) argue that play, both as an activity and as a trait (playfulness), creates a positive work atmosphere by fostering emotions that enhance problem-solving capabilities and reduce stress. Playful leadership encourages employees to take risks and explore new ideas without fear of failure. Such an environment not only boosts productivity but also strengthens interpersonal relationships by fostering teamwork and shared experiences.

Several mechanisms explain how play facilitates innovation and collaboration within organizations. Playful leadership fosters intrinsic motivation, as employees engaged in play-driven work are often motivated by the activity itself rather than by external rewards, leading to deeper engagement and greater investment in creative problem-solving (Mainemelis et al., 2015; Dishon-Berkovits et al., 2024). Additionally, play enhances cognitive flexibility, enabling employees to experiment with ideas and develop novel solutions, which is particularly beneficial in brainstorming sessions and high-stakes decision-making scenarios. Play also strengthens social bonds and communication, fostering collaboration across hierarchical structures (Petelczyc et al., 2018). In a playful work environment, employees feel more comfortable expressing ideas, providing feedback, and participating in knowledge-sharing activities. Consequently, teams become more cohesive and better equipped to co-create innovative solutions. Furthermore, play serves as a stress-relief mechanism, reducing workplace pressure and creating a positive emotional climate conducive to creativity. Research indicates that stress often inhibits innovation, whereas relaxed and engaged employees are more likely to generate fresh ideas.

Beyond leadership, play holds broad significance across disciplines, including philosophy, psychology, pedagogy, informatics, and sports (Croatian Encyclopedia, 2025). Philosophically, play has ontological and epistemological dimensions, while in psychology, it is linked to emotional well-being and developmental learning (Sutton-Smith, 1997; Brown & Vaughan, 2009). Pedagogically, play is regarded as a fundamental component of education, fostering creativity, socialization, and skill development. Wittgenstein (1958) argued that play does not have a fixed definition but can be understood through overlapping characteristics rather than a single essential feature. These elements manifest in various organizational activities, from gamified training programs to team-building exercises. Perry (1998) describes play as pressure-free, intrinsically motivated, and non-serious, emphasizing its voluntary nature and its role in stimulating imagination. However, Burman (1994) cautions against idealizing play, highlighting that it can sometimes involve coercive or exclusionary dynamics.

A simplified view of play in leadership often focuses on gamification, storytelling, and humor. However, an increasing body of research suggests that organizational humor, fun at work, and a playfulness climate contribute directly to leadership effectiveness, innovation, and employee engagement. Leaders who cultivate a playful work culture encourage risk-taking, open communication, and collaboration, all of which are essential for fostering innovation. Humor, in particular, is recognized as a potent leadership tool that fosters positive emotions, strengthens workplace relationships, and stimulates creative thinking. Robert & Wilbanks (2012) define organizational humor as a distinct communication style designed to elicit amusement and generate a positive affective response. Research suggests that humor facilitates creativity by highlighting inconsistencies in logic and encouraging cognitive flexibility (Duncan, 1982; Martin & Lefcourt, 1983). Lang & Lee (2010) further argue that humor's impact on creativity depends on how it is used: liberating humor fosters innovation, whereas controlling humor can stifle creative expression.

Additionally, humor enhances workplace relationships (Cooper, 2008) and strengthens group dynamics (Romero & Pescosolido, 2008). Leaders who effectively integrate humor into their management style are often perceived as more approachable, engaging, and influential (Holmes & Marra, 2002; Hughes & Avey, 2009). These elements collectively create an organizational culture that is more resilient, adaptable, and open to innovation.

Fun at work, which includes social, interpersonal, or task-based activities of a playful or humorous nature, contributes to higher employee engagement and satisfaction (Fluegge, 2008). Fun in the workplace fosters positive emotional states that, in turn, stimulate higher-order thinking, problem-solving, and creative ideation. Fluegge-Woof (2014) examines the relationship between workplace fun and performance, identifying its direct and indirect effects on task execution, organizational citizenship behaviors, and creative performance. Employees who experience enjoyment at work are more likely to be innovative, proactive, and invested in their tasks.

Leadership in modern organizations, particularly in fast-changing, competitive environments, must prioritize creativity and adaptability. A playfulness climate fosters trust, psychological safety, and open idea exchange, making it fertile ground for innovation and breakthrough thinking. Research by Liu et al. (2024) highlights that a playfulness climate enhances employee performance and innovation by promoting a sense of self-efficacy and psychological safety. Their findings indicate that when employees feel empowered in a playful work environment, they are more likely to contribute novel ideas and engage in meaningful experimentation—a key driver of innovation.

Yu et al. (2003) propose a framework for measuring playfulness climate, emphasizing leadership support, pleasure in leisure, cooperation and intimacy, and humor and happiness. Leadership support refers to the extent to which leaders actively encourage play and creative thinking. Pleasure in leisure describes a culture where enjoyment and work coexist harmoniously, allowing employees to balance productivity with engagement. Cooperation and intimacy highlight the importance of strengthening social bonds through playful interactions, fostering collaboration and trust among team members. Lastly, humor and happiness contribute to a positive emotional climate where laughter and lightheartedness facilitate idea generation and open communication.

Ultimately, leaders who integrate play into their management approach create an environment that promotes risk-taking, creative exploration, and continuous learning. By embedding play in decision-making processes, they encourage adaptive thinking and resilience—qualities essential in today's rapidly evolving business landscape. Furthermore, play-based leadership extends beyond internal team dynamics, influencing product and service design by inspiring teams to create more engaging and user-friendly solutions.

Play serves as a bridge between structured work processes and creative freedom, allowing organizations to strike a balance between efficiency and innovation. Leaders who embrace play as a strategic tool unlock new levels of team performance, drive sustainable innovation, and cultivate a dynamic, forward-thinking corporate culture. By fostering a playfulness climate, organizations ensure that employees remain engaged, motivated, and prepared to tackle the complexities of the modern business world with creativity and enthusiasm.

Theoretical perspectives on play and its impact on leadership identity formation

In organizational settings, play serves as a pivotal mechanism for identity development among employees. Engaging in playful activities allows individuals to experiment with different roles and behaviors, facilitating personal and professional growth.

Play provides a safe environment for individuals to explore various aspects of their identities without the fear of real-world consequences. This exploratory process enables employees to test new behaviors and roles, contributing to their identity formation within the organization. According to social identity theory, individuals derive a sense of self from their membership in social groups, and play can facilitate the exploration of these group identities (Ashforth & Mael, 1989). By engaging in play, employees can navigate and negotiate their identities, leading to enhanced self-awareness and adaptability.

Understanding the distinction between leader development and leadership development is crucial in the context of identity formation. Leader development focuses on enhancing an individual's capabilities, skills, and self-efficacy, emphasizing personal growth. In contrast, leadership development centers on building interpersonal competencies, social influence processes, and the capacity to foster collective goals within a group (Day, 2000). Recognizing this distinction highlights the importance of both individual and collective aspects of identity development in organizational settings.

The concepts of identity play and identity work are integral to understanding how individuals construct and reconstruct their identities. Identity play involves a provisional and exploratory engagement with various possible selves, allowing individuals to experiment with different roles and behaviors in a low-risk environment (Ibarra & Petriglieri, 2010). Conversely, identity work refers to the ongoing process of forming, repairing, maintaining, or revising one's identity to align with personal and social expectations (Sveningsson & Alvesson, 2003). Both processes are essential for employees to adapt and thrive in dynamic organizational contexts.

Leaders play a pivotal role in shaping their team members' identities, particularly using play and feedback. By creating environments that encourage playful experimentation, leaders enable employees to engage in identity play, facilitating personal and professional growth (Kark, 2011). Constructive feedback during these activities serves as a mirror, reflecting back to individuals how their behaviors align with organizational values and expectations. This process not only aids in identity work but also strengthens the alignment between individual identities and organizational objectives, fostering a cohesive and adaptive workforce.

Mechanisms of leadership identity development through play

Play serves as a powerful mechanism for identity formation in organizational settings by providing individuals with a psychologically safe space, enabling feedback-driven self-reflection, facilitating identity experimentation, and fostering creativity and adaptability. This section explores these mechanisms in detail, illustrating how play allows employees to shape their professional identities dynamically.

A crucial aspect of identity formation through play is the establishment of psychologically safe environments where individuals feel free to experiment without fear of negative consequences. Psychological safety refers to the perception that one can express ideas, take risks, and explore new roles without fear of embarrassment or punishment (Edmondson, 1999). In this context, play serves as a transitional space where individuals can navigate between their current and potential selves (Winnicott, 1975).

Kolb & Kolb (2010) emphasize that ludic learning spaces—environments designed for playful exploration—facilitate deeper learning and identity construction. These spaces function as laboratories for professional identity experimentation, where employees can engage in trial-and-error processes without immediate professional stakes. Leaders who cultivate such environments foster employees' ability to navigate career transitions, build resilience, and internalize organizational values in a way that aligns with their evolving self-concept.

The role of feedback in identity formation cannot be overstated. Leaders act as key facilitators of identity development by providing feedback that helps individuals interpret and refine their professional selves. Feedback during play-based activities allows employees to assess how their behaviors align with organizational expectations and adjust accordingly (Ashforth & Schinoff, 2016).

Constructive feedback in playful settings fosters adaptive identity work by enabling individuals to test different behaviors, receive responses from peers and leaders, and recalibrate their self-concept accordingly (Dutton et al., 2010). When leaders frame feedback as a learning opportunity rather than a performance evaluation, they encourage employees to engage in identity play without fear of failure. This iterative process strengthens employees' sense of

agency over their professional identity while enhancing their engagement and commitment to the organization.

One of the most valuable aspects of play in identity formation is its capacity to allow employees to experiment with different professional roles before committing to them in real-world settings. Ibarra & Petriglieri (2010) distinguish between identity play, where individuals temporarily explore new identities, and identity work, where they engage in deeper efforts to refine their professional self-concept. Play provides a low-risk setting for identity play, enabling individuals to "try on" new professional identities and assess their fit.

Role-playing, simulations, and gamification in leadership training provide employees with opportunities to enact alternative professional selves, facilitating greater self-awareness and confidence in their evolving identities (Petriglieri, 2011). This process is particularly crucial for emerging leaders, as it allows them to experiment with leadership styles, communication strategies, and decision-making approaches before assuming formal leadership positions.

Beyond shaping identity, play also enhances creativity and adaptability — two competencies essential for navigating today's complex organizational environments. Play disrupts rigid thinking patterns, encouraging employees to engage in divergent thinking and explore unconventional solutions (Mainemelis & Ronson, 2006). By fostering a playful mindset, leaders empower employees to redefine their roles and adapt to evolving organizational needs. Moreover, play nurtures a sense of agency over one's professional trajectory. When employees perceive their identity as fluid and adaptable, they are more likely to embrace change, seek out growth opportunities, and remain engaged in their work. Organizations that integrate play into their culture not only support individual identity development but also cultivate a workforce that is more resilient, innovative, and aligned with strategic goals.

The play-based leadership identity building model

The research presented in this study aims to investigate the role of playful leadership in fostering creativity, innovation, and identity development within organizations. Specifically, it seeks to explore how incorporating playful activities into leadership practices can contribute to the development of more adaptive, resilient, and innovative leaders. The objective of the study is to provide a theoretical model that connects playful leadership with organizational outcomes such as enhanced creativity, improved team dynamics, and the fostering of an organizational culture that encourages experimentation and collaboration. This study employs a narrative literature review as part of a qualitative, theory-building approach. The selection of relevant publications was guided by the following criteria: relevance to the central theme of playful leadership, publication in peer-reviewed journals, and alignment with established theories of leadership, identity development, and organizational behavior. The sources included in this review span across organizational behavior, psychology, and leadership theory, ensuring a comprehensive understanding of the interplay between leadership practices and play. The rationale for using this methodology is to build a robust theoretical framework that synthesizes existing research, identifies gaps in the literature, and offers new directions for future studies.

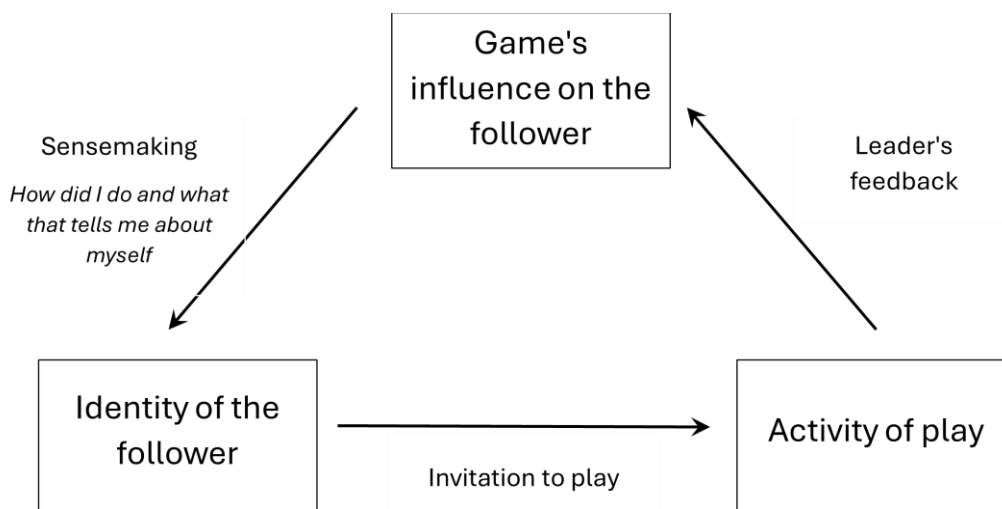
Building on the previous discussion of play as a mechanism for learning and identity formation, we propose a model that integrates Aristotle's triadic structure of subject, activity, and object into the leadership development process. This model conceptualizes leadership identity

formation as a cyclical process in which play serves as the catalyst for evolving leader-follower dynamics and aligning organizational purpose.

Aristotle's framework of subject (the self), activity (action and influence), and object (outcomes and purpose) provides a structured approach to understanding leadership identity formation (Aristotle, 2004). Within the organizational context, this triad manifests as: (1) Subject: The identity of the leader and followers in relation to organizational purpose; (2) Activity: The leader's authority and influence, particularly in fostering playful learning and feedback mechanisms; (3) Object: The effects of leader-follower interactions on achieving organizational goals and shaping shared identity.

This model highlights the dynamic nature of leadership identity, where the leader's identity is not static but continuously shaped through interactions with followers and engagement in playful learning experiences. Likewise, followers undergo identity transformation as they experiment with roles and behaviors in psychologically safe environments (Exhibit 1).

Exhibit 1: The play-based leadership identity model



Play is the key mechanism that facilitates movement within the triad. By creating safe spaces for identity experimentation and leveraging feedback as a formative tool, leaders help shape both their own identity and that of their followers. The model can be broken down into the following four phases.

1st phase: Formation of leader identity through play-based learning

Leadership identity is not a static trait but an evolving process of self-discovery and adaptation. Play provides an ideal environment for leaders to test, refine, and experiment with different leadership styles and behaviors in a low-risk setting. Through role-playing, gamified leadership challenges, and interactive problem-solving exercises, leaders gain valuable insights into their strengths and areas for growth (Ibarra & Petriglieri, 2010).

Leadership training programs that incorporate simulations, role-playing, and gamification serve as laboratories for identity testing. These programs encourage leaders to navigate complex decision-making scenarios, handle team dynamics, and practice adaptive leadership techniques without real-world repercussions. By engaging in playful leadership experiments, individuals

gain the confidence and flexibility required to shape an authentic and adaptable leadership identity in real-world settings.

2nd phase: Influencing follower identity through play and feedback

A leader's role is not just about self-development; it is also about shaping the identities of their followers. Play provides an inclusive, low-pressure space where employees can experiment with their professional identities, test new roles, and expand their self-concept. Leaders who create playful environments allow followers to explore and refine their professional selves, increasing both engagement and self-efficacy.

Constructive feedback is essential during play-based learning sessions, acting as a mirror that helps followers reflect on their actions and align their evolving identity with organizational expectations (Ashforth & Schinoff, 2016). Leaders who incorporate feedback loops into playful activities provide employees with continuous identity validation and reinforcement, ensuring that followers internalize leadership behaviors in a way that is meaningful and sustainable. This iterative process of feedback and play strengthens the psychological contract between leaders and followers, enhancing motivation and team cohesion.

3rd phase: alignment with organizational purpose and adaptation

Identity formation through play does not occur in isolation; rather, it must be aligned with a larger organizational purpose. As leaders and followers engage in playful interactions, creative problem-solving, and experiential learning, their individual identities begin to align with the collective mission and values of the organization. This phase is essential for ensuring that play-based identity formation is not merely a personal endeavor but a strategic organizational function (By, 2021).

Organizations that cultivate purpose-driven play environments help employees internalize company values in a natural and engaging way. Instead of enforcing rigid compliance with organizational norms, play creates intrinsic motivation, leading to stronger identification with the company's mission. This alignment fosters a culture of innovation, adaptability, and shared vision, which is essential for sustaining long-term organizational success.

4th phase: continuous identity evolution

Because leadership is a process of becoming rather than a fixed state, identity formation is never truly complete. Leaders and followers must continuously evolve, adapt, and redefine their professional identities in response to changing challenges, organizational shifts, and personal growth trajectories (Williams et al., 2023).

Play remains a crucial driver of this evolution, keeping the leadership identity process dynamic, responsive, and flexible. Through iterative cycles of play, feedback, and adaptation, leaders and followers are better equipped to navigate uncertainty, embrace complexity, and innovate within their roles. Organizations that sustain a culture of playful learning and experimentation ensure that leadership identity development remains a lifelong process, rather than a one-time training event.

Implications of proposed model: Integrating play to leadership practice to drive creativity and innovation in organizational settings

The study is structured around the proposed conceptual model that links playful leadership with identity work and innovation. The results demonstrate that playful leadership contributes to the creation of psychologically safe environments that encourage risk-taking, open communication, and collaborative problem-solving. The findings highlight that mechanisms such as role-playing, gamification, humor, and storytelling facilitate leadership identity development and promote an innovative organizational culture. By embedding play into leadership practices, organizations can cultivate more dynamic, creative, and adaptive teams. This research also emphasizes the iterative nature of leadership identity formation, suggesting that play serves as a continuous driver of leadership development and organizational learning.

The integration of play into leadership identity formation has far-reaching implications for organizations seeking to cultivate adaptive, creative, and purpose-driven leaders. By viewing leadership as a dynamic and evolving process rather than a fixed set of competencies, organizations can foster innovation, enhance engagement, and strengthen long-term strategic alignment. In this context, we outline four key ways in which play contributes to leadership development: play as an identity accelerator in leadership development, play as a driver of creativity and innovation, feedback-driven identity formation and organizational learning, and play as a mechanism for enhancing psychological safety and engagement.

Studies show that creativity is crucial to effective leadership, improving team motivation, and overcoming new challenges (Mainemelis et al. 2015). Although creativity was barely valued in business and governance before the 1980s, it is now widely recognized as essential to organizational survival and sustainable growth. Both corporate leaders and governments are increasingly focusing on promoting creativity and innovation. The integration of play into organizational settings to drive creativity and innovation is a key challenge of modern organizational leadership.

In today's dynamic and competitive business environment, organizations are constantly looking for ways to promote creativity and innovation. Leadership plays a key role in this search, and integration of play into leadership strategies has become a powerful approach to drive these results. It is important to explore the key components of leadership that effectively integrate play to improve creativity and innovation in organizational environments. Leadership styles and their characteristics may have a significant impact on fostering creativity and innovation among employees (Lee et al. 2019).

Leadership styles differing from one another can significantly influence the creative processes within an organization by engaging employees into play, shaping how ideas are generated, developed, and implemented. Moreover, the interplay between leadership styles and organizational culture cannot be overlooked when considering their impact on creativity and innovations. A culture that embraces risk-taking and values diverse perspectives can amplify the positive effects of both servant and transformational leadership, enhancing employees' willingness to innovate (Scharp et al., 2023). Conversely, in environments dominated by transactional or authoritarian leadership, where adherence to established protocols is prioritized, creative potential may remain stifled. This highlights the necessity for leaders to not only adopt effective leadership styles but also actively cultivate a supportive cultural framework that nurtures creativity, thereby ensuring that innovative ideas are not just generated but also effectively implemented within the organization.

In addition to the above leadership styles, playful work design (PWD) is also a key component of leadership, incorporating play into work processes to enhance creativity and innovation (Dishon-Berkovits et al. 2024). PWD is defined as a set of proactive strategies implementing fun and self-challenge at work, in order to actively create better work conditions (Caracuzzo et al. 2024). Empirical evidence suggests that PWD facilitates the relationship between staff leadership and innovative working practices, underlining its importance in fostering a creative work environment (Scharp et al., 2023). By incorporating play elements such as autonomy, exploration and experimentation, leaders can create a work environment that encourages employees to engage in divergent thinking and develop new solutions. The effectiveness of playful working design in promoting innovation is strongly influenced by organizational climate and leadership approaches that promote collaboration and open communication. Research indicates that environments characterized by transformational leadership not only stimulate creativity, but also create a culture in which employees feel safe enough to take calculated risks and propose unconventional ideas (Zhou & Pan, 2015; Hughes et al. 2018). This is consistent with the findings that show a strong correlation between supportive leadership practices and greater employee engagement, which is crucial to maintaining innovative behavior over time. In addition, the integration of iterative feedback mechanisms into playful work designs can increase its impact (Mainemelis et al. 2015). The continuous input of team members promotes ownership and collective problem solving, ultimately leading to stronger and more diverse innovations within the organization. This approach is in line with the principles of design thinking and agile methodology that emphasize rapid prototype and user-centered design in the innovation process.

Play is not only a tool to improve creativity and innovation, but also a means of developing leadership skills. Analog role-playing games (RPGs) have been identified as a transformational approach to leadership development that promotes collective creativity and collaboration (Lasley, 2024). RPG provides a platform for leaders to participate in symbolic stories and identity development, which are crucial to adaptive change and effective leadership. By using the power of play, leaders can develop the skills needed to face complex challenges and drive innovation. In addition, the integration of playful work designs into leadership development not only improves creativity, but also promotes resilience between leaders and employees. By participating in role-play scenarios, participants can simulate real challenges, allowing them to experiment with different strategies and responses without fear of failure often associated with traditional training methods (Lasley, 2024). This experiential learning approach cultivates an innovative mindset, as individuals learn to navigate uncertainty while working with different teams. In addition, research shows that environments where risk-taking is promoted – characteristics of transformational leadership – can lead to greater employee satisfaction and retention, ultimately strengthening an organization's capacity for sustainable innovation (Sawyer & Henriksen, 2024). These findings emphasize the importance of creating a culture that focuses on playfulness not only as a tool for creativity, but also as a fundamental aspect of effective leadership development in organizations.

Psychological empowerment is an important mediator of the relationship between leadership styles and the creativity and innovation of employees (Mainemelis et al., 2015). Employees with power are more likely to take initiative, explore new ideas and engage in creative problem solving, which is essential to drive organizational innovation. Furthermore, the interaction between psychological empowerment and the organizational climate plays an important role in improving creativity and innovation. The supportive environment, which encourages risks and values employee contributions, can strengthen the effects of psychological empowerment and

promote a culture in which innovative ideas are generated and adopted (Carmeli et al. 2010; Hughes et al. 2018). In this respect, organizations must recognize the importance of aligning their leadership practices with a conducive climate in order to maximise creative potential. For example, research shows that organizations led by transformational leaders tend to cultivate such climates, leading to higher employee engagement and satisfaction levels, which are essential for sustainable innovation (Mainemelis et al., 2015; Hughes et al., 2018). This suggests that leaders who actively promote psychological empowerment along with an inclusive organizational culture can significantly improve the innovation capacity of their team, ultimately driving the organization to greater success.

Intrinsic motivation plays a key role in improving employee creativity and organizational innovation (Hunter et al., 2011; Mainemelis et al., 2015). Research has shown that intrinsic motivation moderates the relationship between transformational leadership and employee creativity, underlining the importance of aligning leadership practices with employees' internal efforts (Hughes et al., 2018). Leaders who foster an environment that supports intrinsic motivation can create a workforce driven by genuine passion for creativity and innovation. Furthermore, the role of external factors such as organizational structure and industry-specific demands cannot be underestimated in shaping the effectiveness of intrinsic motivation in creativity and innovation. For example, organizations operating in rapidly changing industries may need a more flexible leadership approach that adapts to changing market dynamics, thus improving employees' intrinsic motivation through autonomy and empowerment (Cheong et al., 2019; Sawyer & Henriksen, 2024). Furthermore, the integration of cross-cultural perspectives highlights how different cultural attitudes towards creativity can influence motivational landscapes; leaders must navigate these differences in order to cultivate a multicultural environment that encourages different contributions and aligns with organizational goals (Leung & Wang 2015). This complexity underscores the need for customized leadership strategies that not only focus on individual employee motivations, but also consider broader organizational contexts to effectively exploit collective creativity and drive sustained innovation across different sectors.

Leader fun pursuit is another important element of leadership that integrates play into the work process. Research has shown that leaders who want to be fun are more positively perceived by followers, which is more pronounced among women leaders (Zhang et al., 2024). Using fun activities, leaders can create a positive work environment that promotes creativity, collaboration and innovation. This approach not only enhances leadership perceptions, but also contributes to a more engaged and motivated workforce. In addition, the concept of leader fun pursuit not only enhances leadership perceptions, but also serves as a catalyst for team cohesion and collective creativity. When leaders prioritize pleasure at work, they foster an atmosphere that encourages collaboration between team members, ultimately leading to innovative results (Zhang et al., 2024). This is consistent with findings suggesting that fun work environments can significantly improve employees' engagement and satisfaction, which are crucial components for organizational success (Scharp et al., 2023; Dishon-Berkovits et al., 2024). However, it is essential to balance this approach with recognizing individual differences; what one employee considers to be fun can distract or detract from another. Thus, adapting fun initiatives to various teams' preferences can further expand their positive effects on creativity and innovation while ensuring inclusiveness across different cultural backgrounds. Creating a culture that values both playfulness and individual preferences not only promotes creativity, but also strengthens team cohesion, as members feel more valued and understood by their unique contributions.

Although existing literature highlights the importance of leadership practices in fostering creativity and innovation, there remains a limited exploration of the specific role that play can have in shaping leadership behaviors and organizational outcomes. Most research tends to focus on traditional leadership models, overlooking the potential of playful activities to influence leadership identity and team dynamics. Furthermore, while the concept of play has been extensively studied in educational and developmental contexts, its application to leadership and organizational settings remains underexplored.

Future empirical research should aim to assess the impact of playful leadership on organizational performance across different industries and organizational cultures. Longitudinal studies could help track the evolution of leadership identities over time and assess the long-term effects of integrating play into leadership development. Additionally, experimental research could explore the effectiveness of specific playful mechanisms, such as role-playing or gamification, in fostering innovation and problem-solving capabilities within teams.

From a practical standpoint, organizations can benefit from integrating playful leadership practices into their training and development programs. The model presented in this study can serve as a framework for designing leadership programs that emphasize creativity, risk-taking, and team collaboration through play. Implementing such practices can enhance employee engagement, promote a more inclusive organizational culture, and drive sustainable innovation. Future studies could further refine this model by testing its application in diverse organizational contexts to determine best practices and measure its impact on organizational outcomes.

Conclusion

By integrating Aristotle's triadic framework with contemporary theories of play and identity, this study presents a novel perspective on leadership development. Play is not merely an instrument for engagement; it is a fundamental mechanism that shapes both leader and follower identities, fostering cognitive flexibility, creativity, and adaptability. Through iterative cycles of playful learning, feedback, and alignment with organizational purpose, leaders can cultivate more resilient, innovative, and purpose-driven teams.

The findings highlight that playful leadership encompasses multiple elements, including organizational humor, storytelling, gamification, and fun-based work strategies. These components collectively contribute to the creation of a playfulness climate—an environment that encourages risk-taking, reduces fear of failure, and enhances collaboration. Leaders who embrace play as a strategic tool can break down hierarchical barriers, stimulate open communication, and inspire creativity within their organizations. Furthermore, the conceptual model developed in this study underscores the role of play in identity formation, demonstrating that leadership identity is not static but continuously shaped by interactions between leaders and followers.

Despite these contributions, this study has several limitations. First, while the proposed conceptual model offers a framework for understanding playful leadership, it requires empirical validation through quantitative and qualitative studies across diverse organizational settings. Future research could explore the impact of playful leadership on different organizational cultures, industries, and leadership levels. Additionally, longitudinal studies would provide deeper insights into how play influences leadership identity over time. Another important

avenue for exploration is the potential drawbacks of playful leadership—such as resistance from traditional organizational structures, the risk of trivializing serious leadership challenges, or the varying effects of play across different personality types and cultural contexts.

By embedding play into leadership development, organizations can not only enhance employee engagement but also drive sustainable innovation and long-term competitive advantage. However, achieving this balance requires intentional leadership strategies that align play with organizational goals and employee needs. Future studies should examine how organizations can design structured play interventions that maximize creativity and innovation while maintaining professional integrity and productivity.

Ultimately, work and play should not be seen as opposing forces but as complementary elements that, when effectively balanced, unlock human potential in the workplace. Organizations that embrace playful leadership will be better positioned to navigate complexity, foster creativity, and cultivate an adaptive workforce ready to meet the challenges of an ever-evolving business landscape.

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INDIVIDUAL-LEVEL PARADOXES AND EMPLOYEE PERFORMANCE OUTCOMES: TESTING SUFFICIENCY AND NECESSITY CONDITIONS ACROSS CROATIAN ORGANIZATIONS

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Abstract

Research within organizational paradox theory has garnered increasing attention in recent decades, yet studies from an individual-level perspective remain limited. Due to the limited empirical evidence on the relationship between individual-level paradoxes and employee performance, this study employs a multimethod, time-lagged, multisource research design, incorporating questionnaires for unit managers and their employees in Croatian organizations as a primary data collection tool. It aims to examine five theoretically and practically relevant individual-level paradoxes (individual ambidexterity, coopetitive personality, human capital paradox, job demands-resources fit, and paradoxical mindset), exploring their distinct connectedness with employee performance. To determine which individual-level paradoxes serve as sufficient and necessary conditions for employee performance, we applied Ordinary Least Squares (OLS) regression and Necessary Condition Analysis (NCA). Our study's findings indicate that individual ambidexterity is sufficient for enhancing employee performance. Conversely, the job demands-resources fit emerges as a necessary condition for achieving higher employee performance, supporting the notion that balancing job demands and resources fit is essential for optimal employee performance. Our analysis did not reveal significant correlations between employee performance and the other individual-level paradoxes investigated.

Keywords: individual-level paradox*, employee performance, sufficiency, necessity, Croatian organizations

JEL classification: L2, M19

Introduction

Research on organizational paradoxes has gained significant momentum in recent decades. It refers to persistent contradictions within organizations that cannot be resolved by choosing one

option over another; instead, they must be managed (balanced or navigated) simultaneously to sustain performance. While much of this research focuses on organizational-level tensions, it also extends to the important yet underexplored micro level—that is, the individual or employee level (Berti et al., 2021, p. 43). Within this established academic field (Braun & Lampel, 2020, p. 83; Cunha & Putnam, 2017), an increasing number of scholars are exploring managerial challenges (Smith & Lewis, 2011) and framing organizational strategies through a paradoxical lens (Bednarek et al., 2021, p. 130). Following a bottom-up approach to navigating paradoxes, the research focus shifts from top-level strategies to the lived experiences of employees who actively engage with paradoxes in a dynamic and situated context within their organizational units. Typically, modern workplaces are becoming increasingly complex, filled with conflicting demands that employees must navigate daily. While traditional approaches focus on resolving tensions, paradox theory suggests that employees, as frontline responders (Fairhurst & Putnam, 2024, p. 2), can embrace contradictions, which can enhance their performance. Therefore, having a paradoxical personality or exhibiting paradoxical behavior can help employees perform better within their units. Since unit managers are responsible for allocating tasks and responsibilities to employees, as well as monitoring their growth and performance at both the organizational (Sutherland & Smith, 2011) and individual (job or employee) levels (Shen et al., 2018), it is crucial to understand the dynamics between unit managers and employees (Besharov & Mitzinneck, 2021, p. 40) in order to design more effective single-level practices (Englmaier et al., 2018). These unit manager–employee interactions are not only operationally significant but also serve as a key context in which individual-level paradoxes emerge. Indeed, individual-level paradoxes are often experienced in relation to others within the organization, as employees frequently encounter paradoxical tensions through their interactions with unit managers, teammates, and other teams (Cunha et al., 2021, p. 39).

It has been noted that many individual (employee) level perspectives remain underexplored, with several key questions still unanswered—such as how employees can navigate opposing challenges (Berti & Simpson, 2021), which strategies support effective paradox management (Schad et al., 2016), whether this can enhance performance (Krautzberger & Tuckermann, 2024), and how employees should behave in paradoxical situations (Bakker, 2015; Bakker & Demerouti, 2017). Understanding the strategies that enhance employee performance requires a clear grasp of individual-level paradoxes, which enable employees to adapt their behavior and effectively navigate challenges, ultimately leading to peak performance (Quinn, 1991, p. 13). In practice, employees do not encounter individual-level paradoxes in isolation; instead, they are confronted with multiple, co-occurring paradoxes simultaneously. The simultaneous interplay of these paradoxes is increasingly recognized as crucial for gaining a deeper understanding of employee performance (Braun & Lampel, 2020, p. 171). However, there is limited understanding of how any given individual-level paradox, whether it involves balancing competing tasks, roles, or values, is connected to employee performance. Further research is needed to uncover the underlying mechanisms that drive these effects. In some cases, the connection may be unclear or imperceptible, while in others, the relationship may be either positive or negative. This suggests that certain individual-level paradoxes may not be directly linked to performance outcomes or may not necessarily result in improved employee performance. Gaining insights into how specific individual-level paradoxes affect employee performance is essential for evaluating the effectiveness of diverse strategies that provide multifaceted responses to managing organizational tensions (Achtenhagen & Melin, 2003).

To date, empirical research examining the interconnection between individual-level paradoxes and employee performance remains insufficient. Scholars have identified multiple paradoxes at the individual level (Jarzabkowski et al., 2013; Miron-Spektor et al., 2018); however,

researchers have yet to empirically explore most of them. Beyond theoretical assumptions, empirical knowledge remains limited regarding how individual-level paradoxes, such as tensions between tasks, personalities, skills, behaviors, or demands and resources, are connected with employee performance. Moreover, studies testing which individual-level paradoxes serve as sufficient or necessary conditions for employee performance outcomes remain scarce (Hernaes et al., 2024). More precisely, what remains unclear is which individual-level paradoxes have the most significant impact on employee performance and which have a limited impact. Without a better understanding of which paradoxes employees should prioritize—and which can be reasonably set aside—there is a risk that employees will invest time and energy in managing tensions that yield little or no return in terms of performance outcomes.

Therefore, building on Janssens & Steyaert (1999), this study identifies two prevalent categories of paradoxes at the individual level: strategic and people management paradoxes. The strategic category is represented by individual ambidexterity. In contrast, the people management paradox category includes the coopetitive personality, human capital paradox, job demands–resources (JD-R) fit, and the borderline case of the paradoxical mindset. This study focuses on five particularly salient individual-level paradoxes encompassing a broad spectrum of paradoxical challenges, selected for their theoretical relevance, practical frequency, and conceptual diversity. These 'Big 5' individual-level paradoxes are well-established in scholarly discourse within paradox theory, offering robust conceptual foundations for empirical investigation. They frequently manifest in contemporary workplaces, reflecting the complex and recurring tensions employees navigate in daily practice. Collectively, these five individual-level paradoxes span behavioral (e.g., individual ambidexterity), cognitive (e.g., paradoxical mindset), and contextual (e.g., JD-R fit) domains, enabling a multidimensional understanding and influencing employee performance through diverse mechanisms. Their continued relevance underscores the need to understand their impact more deeply, informing the development of targeted HR, leadership, and organizational strategies that aim to enhance employee performance outcomes.

Individual-level paradoxes

Research on *individual* (employee or job) *ambidexterity* as a strategic paradox is still in its early stages of development (Melkić, 2025) and has not been sufficiently explored (Chang et al., 2016; Good & Michel, 2013). It refers to an employee's ability to simultaneously balance between operational (exploitative) and innovative (exploratory) tasks through cognitive and behavioral capabilities (Mom et al., 2015; Raisch & Birkinshaw, 2008). This dual capability requires employees to dynamically shift between routine efficiency and adaptive learning behaviors, depending on situational demands. This concept emphasizes how employees balance their tasks, roles, and responsibilities to be both efficient and innovative, leveraging available resources and knowledge (Caniels et al., 2017). Recent studies suggest that the more ambidextrously employees behave, the more effectively and responsibly they perform job tasks and contribute to achieving team and organizational goals (Mom et al., 2019).

Within many diverse people management paradoxes, a *coopetitive personality* represents a contradiction between the personalities of cooperative and competitive employees (Berti et al., 2021, p. 91). Highly cooperative employees are more likely to collaborate, consider others' perspectives, and enjoy working with others. Highly competitive employees exhibit achievement-focused behavior, tend to outperform their peers, tap into their full potential, and

are less tolerant of failure (Su et al., 2012). While cooperation is essential for organizations to grow, competition serves as a driving force that motivates employees to strive for personal and professional growth (Chen et al., 2011). Emerging theory suggests that employees with both cooperative and competitive personalities in dynamic work environments may foster adaptive performance (Luo et al., 2006). However, it is still not empirically proven whether cooperative personality may positively or negatively affect employee performance.

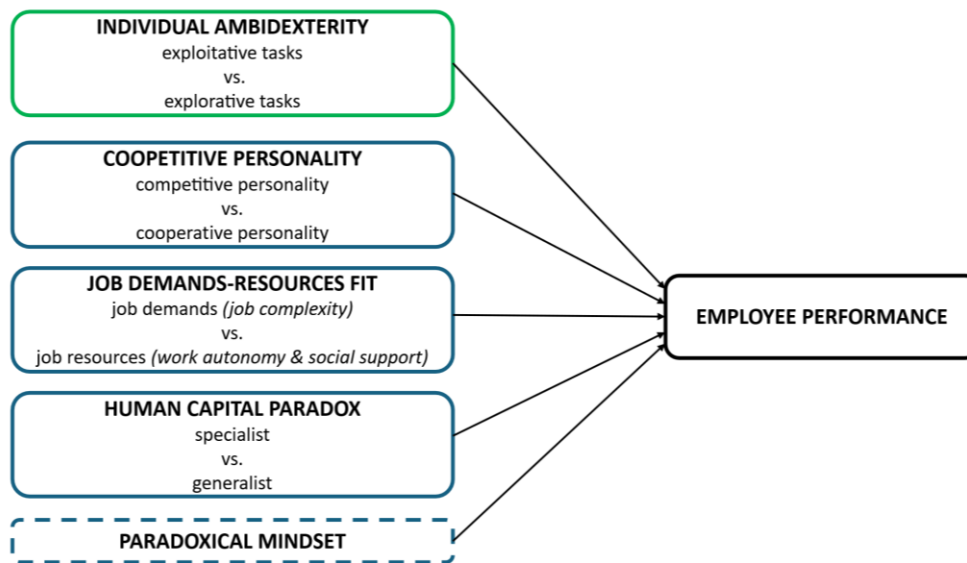
Another people management paradox, *job demands-resources (JD-R) fit*, arises from the interplay between job demands and available job resources, shaping employee motivation, well-being, and performance (Bakker & Demerouti, 2017). While work autonomy and social support can enhance job satisfaction and affective commitment, excessive job complexity and job interdependence may lead to mental overload and strain (Chung-Yan, 2010). This paradox highlights that employee performance occurs when job demands and resources are balanced—too few challenges cause disengagement, while excessive demands induce burnout (Chung-Yan, 2010). In line with the JD-R theory, employee performance is higher when high job demands are met with commensurately high levels of resources, such as supervisor support, task control, or developmental opportunities (Bakker et al., 2007). Therefore, understanding JD-R fit is crucial for effectively managing employee performance.

On the other hand, *human capital paradox* reflects the polarities between being specialist and generalist, where employees may either possess deep, domain-specific expertise and occupy specialized, narrowly defined roles or adopt broader, boundary-spanning positions requiring cross-disciplinary knowledge and a diverse skill set (Kang & Snell, 2009; Kelly et al., 2011). This paradox highlights the tension between developing highly specialized skills for efficiency and expertise, versus cultivating a more adaptable and versatile skill set for dynamic and complex work environments. However, there is still no definitive answer regarding how the human capital paradox impacts employee performance, as the outcomes of specialization and generalization can vary depending on the context and individual circumstances (Souitaris et al., 2023).

Although set as a borderline paradox for this study, the *paradoxical mindset* is an individual-level phenomenon (Gaim et al., 2022) characterized by confrontational acceptance, where employees acknowledge and embrace paradoxes rather than seeking to resolve or eliminate them. It reflects the extent to which employees feel comfortable with and energized by contradictory demands, enabling them to develop paradoxical practices (Bednarek et al., 2021, p. 198; Miron-Spektor et al., 2018, p. 38). This mindset predisposes employees to perceive contradictions as inherent to reality rather than obstacles (Miron-Spektor et al., 2018). A paradox-friendly mindset, incorporating "more than one identity" (Cunha et al., 2021, p. 186), can be a positive attribute that fosters adaptability, creativity, and improved performance.

As illustrated in the conceptual research model (Figure 1), this study aims to examine the relationships between previously defined, distinct yet conceptually relevant individual-level paradoxes (independent variables) and employee performance (dependent variable). Accordingly, the following research questions are addressed: RQ1: Which individual-level paradoxes function as sufficient conditions for enhancing employee performance?; and RQ2: Which individual-level paradoxes serve as necessary conditions for achieving high employee performance?

Figure 1: Conceptual research model



Source: authors

Methodology

Building on the paradox theory that highlights how employees function within complex systems and structures that influence individual-level outcomes (Shen et al., 2018), this study examines the interplay among individual-level paradoxes and their impact on employee performance. A multimethod research design was employed to examine one-way connectedness through two (separate, unit and individual levels) questionnaires collecting time-lagged multisource data.

The research team initially contacted organizational representatives, who assisted in recruiting participants for the survey using a snowball sampling strategy. Individual-level data were collected from unit managers (strategy or organization design professionals) who are key in navigating paradoxes within their units (Schad et al., 2016), as well as their employees. The sampling criteria recommended selecting five units per organization, with five employees chosen from each unit. As a prerequisite for inclusion in the study, each participating organization was required to provide a minimum of two complete and valid responses (Jansen et al., 2016).

Organizational representatives provided us with email addresses for unit managers and their respective employees. The study gathered online survey data from 250 employees and, separately, from their 86 unit managers, all of whom work in 19 large private organizations across various industries in Croatia. On average, each organization had 15.16 respondents, while each organizational unit had 3.03 respondents, indicating variability in response distribution across units. Employees first completed a self-evaluation of their paradoxical behavior at Time 1, followed by unit managers assessing supervisor-rated data on the performance of multiple employees who participated in the research at Time 2, with a three-month temporal gap between the two assessments (Miller et al., 1997). By incorporating diverse data sources and multiple time frames, we strengthened our ability to draw causal inferences while intentionally mitigating the risk of single-informant and standard method bias. Each

manager assessed multiple employees, and the responses were analyzed at the individual (employee) level, enabling us to proceed with a single-level (individual-level) analysis.

Online survey data were collected through questionnaires in the Croatian language, which were carefully developed using the translation-back-translation method to ensure accuracy and consistency. Both surveys assessed perceptions using five-point Likert-type agreement scales, ranging from 1 ("disagree entirely") to 5 ("completely agree"). We used established scales to collect self-reported measures of the variables of interest, capturing the observed individual-level paradoxes. In the study, the examined paradoxes were measured by computing the product of distinct orthogonal constructs (Hayes, 2022; Ricciardi et al., 2022), with the corresponding paradoxical dimensions derived from the averaged values of their ordinal manifest items.

Specifically, the strategic paradox of *individual ambidexterity* was evaluated using an eight-item construct, with four items measuring exploitative tasks (e.g., "Activities of which much experience has been accumulated by yourself.") and four items measuring explorative tasks (e.g., "Activities requiring you to learn new skills or knowledge.") Schnellbacher et al. (2019) adopted this construct by measuring two polarities.

The people management paradoxes—such as coopetitive personality, job demands-resources (JD-R) fit, human capital paradox (specialist vs. generalist), and borderline, paradoxical mindset—were assessed using a range of variables. The paradox of *coopetitive personality*—encompassing both cooperative and competitive personality—was assessed using a seven-item construct developed by Lu et al. (2013). We measured competitive personality with a four-item scale (e.g., "Being outperformed by other members in the group annoys me."). Moreover, we evaluated cooperative personality using a three-item scale that captured affective responses to collaboration (e.g., "Working with team members makes me happy.").

Job demands-resources (JD-R) fit was computed as the product of manifest paradoxical dimensions using four variables developed by Morgeson & Humphrey (2006). Job demands were measured through job complexity (four-item scale, e.g., "The job requires that I only do one task or activity at a time.") and task interdependence (six-item scale, e.g., "Other jobs depend directly on my job."). Meanwhile, job resources were assessed using work autonomy and social support (each measured with a three-item scale, e.g., "The job allows me to make many decisions on my own.").

The *human capital paradox*—balancing specialist and generalist skills—was assessed using a six-item construct adopted from Subramaniam & Youndt (2005) and Kang & Snell (2009). Specialist expertise was measured with a three-item scale (e.g., "I am highly skilled in a very particular knowledge domain."), while generalist capabilities were captured using another three-item scale (e.g., "I am an expert in my particular jobs and functions.").

Finally, completing the quartet of a borderline one, the *paradoxical mindset* developed by Miron-Spektor et al. (2018) comprises a nine-item scale designed to assess an employee's comfort and engagement with contradictory demands (e.g., "I feel energized when I manage to address contradictory issues.").

Besides these key individual-level paradoxes, which serve as independent variables in this study, *employee performance* was measured as a dependent variable using a four-item scale adopted from Liden et al. (1993). Employee performance was assessed as a mean score and

evaluated by multiple unit managers. An example item from the scale includes: “The overall level of performance that I have observed for this employee is outstanding.”.

Building upon the research design proposed by Hernaus et al. (2024), this study employs a dual-analytical approach to explore the connectedness between each individual-level paradox separately and employee performance. Specifically, we utilize ordinary least squares regression analysis (OLS) to examine the direct effects of predictors on employee performance. In contrast, we applied necessary condition analysis (NCA) to identify factors that serve as essential preconditions for high performance. More common regression analyses allow us to assess the extent to which job characteristics predict creativity and innovation (LeBreton et al., 2013). Introduced by Dul in 2016, NCA is a relatively recent data analysis technique designed to identify necessary conditions within data sets (Dul, 2016; Dul, 2023). If a particular factor is missing, organizations cannot achieve the desired employee performance, regardless of other paradoxes, since a necessary condition cannot be substituted or compensated for (Hernaus et al., 2024). Our approach enables us to determine which strategic and people management paradoxes are both sufficient and necessary for achieving optimal employee performance, identifying those that drive high performance. Both analyses were conducted using R software. For NCA, we employed the NCA software package (version 3.2.0) within R to ensure precise and robust assessments.

Results

Table 1 displays the means, standard deviations, and correlations among the key variables in this study. Notably, only the individual-level paradoxes of individual ambidexterity ($r=0.21$, $p<0.1$) and JD-R fit (0.27 , $p<0.1$) exhibit positive associations with employee performance. In contrast, paradoxical mindset, coopetitive personality, and human capital paradox are unrelated to employee performance.

Table 1: Means (M), standard deviations (SD), and correlations

Variable	M	SD	1	2	3	4	5	6
1. Job demands-resources (JD-R) fit	14.40	3.38	-	0.16*	0.21**	-0.06	0.18**	0.27**
2. Individual ambidexterity	11.90	3.20	0.16*	-	0.16**	0.07	0.15*	0.21**
3. Paradoxical mindset	3.25	0.51	0.21**	0.16**	-	0.3**	0.23**	0.02
4. Coopetitive personality	8.15	2.86	-0.06	0.07	0.30**	-	0.04	0.07
5. Human capital paradox	14.50	4.47	0.18**	0.15*	0.23**	0.04	-	0.07
6. Employee performance	4.05	0.75	0.27**	0.21**	0.02	0.07	0.07	-

Notes: $N=250$; M = Means, SD = Standard deviations; * $p < .05$; ** $p < .01$

Source: authors

Multiple regression analysis results

The regression analysis reveals that individual ambidexterity and JD-R fit are the strongest predictors of employee performance (see Table 2). Specifically, individual ambidexterity exhibits a significant positive correlation with employee performance ($B = 0.05$, $p < 0.01$), indicating that employees capable of managing conflicting demands between exploratory and exploitative tasks tend to perform better. JD-R fit also significantly impacts employee performance ($B = 0.06$, $p < 0.001$). This supports the JD-R framework, which highlights that having adequate resources (i.e., work autonomy and social support) enables employees to handle job demands better (i.e., job complexity, task interdependence), thereby improving their

performance (Bakker, Demerouti, & Verbeke, 2004). The cooperative personality exhibits a marginally significant positive relationship with employee performance ($B = 0.03$, $p = 0.06$), suggesting that switching between cooperative and competitive personality types may enhance employee performance; however, further research is warranted. A paradoxical mindset exhibits a negative yet marginally significant association with employee performance ($B = -0.19$, $p = 0.06$), suggesting that specific cognitive approaches to addressing paradoxical demands, such as intensively reflecting on tensions, may be associated with lower performance on average. However, this does not imply that paradoxical mindset is inherently detrimental; instead, its effects may vary depending on contextual factors such as job characteristics, cognitive load, or the availability of adequate resources and support (e.g., JD-R fit), which can moderate the relationship between mindset and performance outcomes. On the other hand, the human capital paradox showed no statistically significant effect on employee performance ($B = 0.00$, $p = 0.86$), indicating that balancing between being a specialist and a generalist is not a key factor in determining employee performance.

Table 2: OLS regression results

Variable	<i>B</i>	<i>S.E.</i>	<i>t</i>
Human capital paradox	0.00	0.01	0.17
Coopetitive personality	0.03	0.02	1.88
Individual ambidexterity	0.05**	0.02	2.93
Paradoxical mindset	-0.19	0.10	-1.89
Job demands-resources (JD-R) fit	0.06**	0.02	4.19

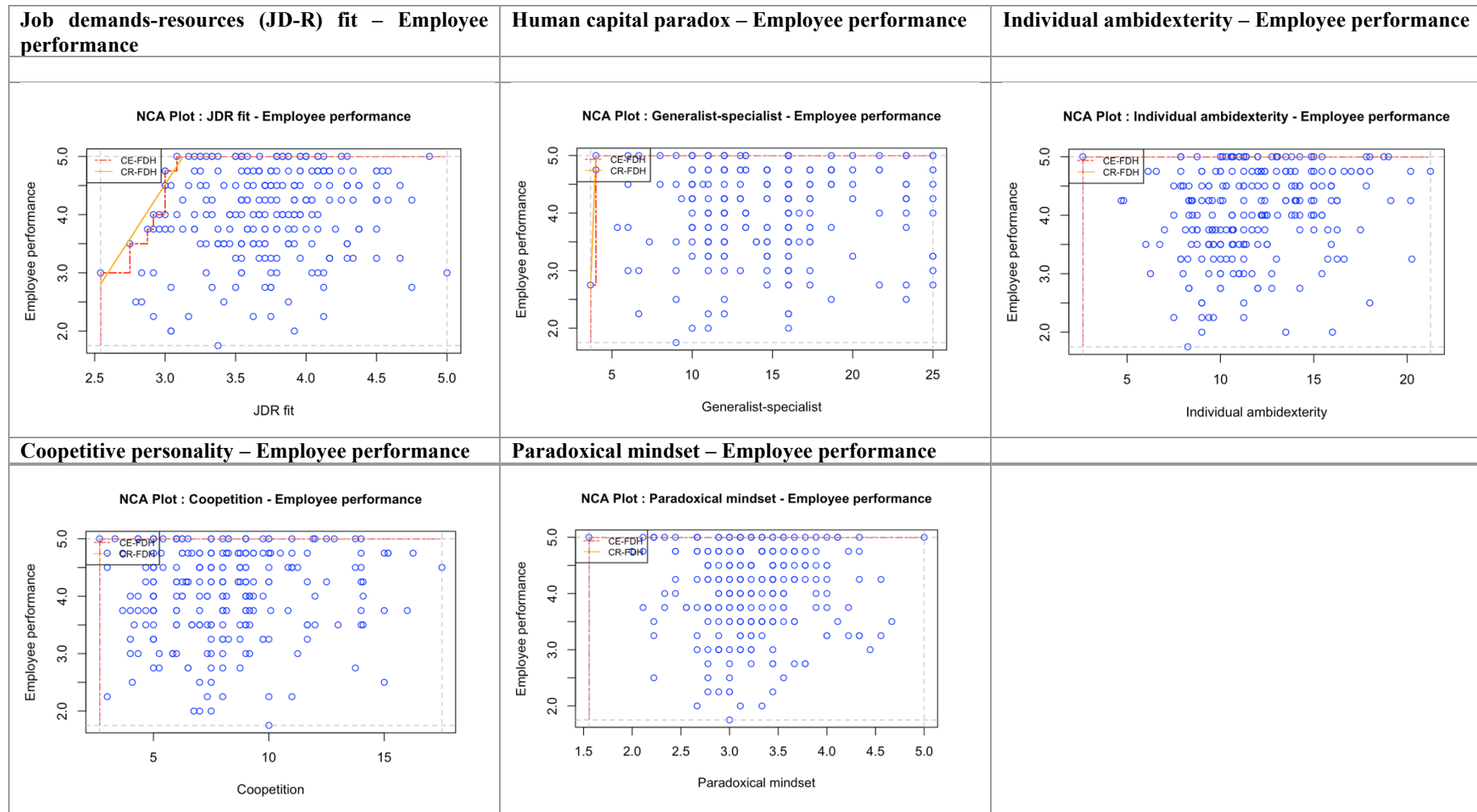
*Notes: * $p < .05$; ** $p < .01$; B – unstandardized regression coefficients; S.E – standard error; t-test statistic.*

Source: authors

NCA results

We conducted a necessary condition analysis to complement the regression analysis and determine whether any predictors function as necessary conditions for employee performance. We began visually inspecting data dispersion (Dul et al., 2023). NCA identifies necessary conditions by analyzing scatter plots, which detect empty spaces and draw a ceiling line to separate areas with and without observations. Figure 2 displays scatter plots where the x-axis represents individual-level paradoxes, and the y-axis depicts employee performance as an outcome. The scatterplots illustrate a clear ceiling zone in the upper-left portion of the graph, where high levels of employee performance do not occur when JD-R fit falls below a certain threshold (approximately 3.0). This visual blank space signifies that a minimum level of JD-R fit is a necessary condition for achieving high performance. In other words, employees with low alignment between JD-R fit are structurally constrained from reaching top performance levels, regardless of other factors. This finding empirically supports the idea that JD-R fit is a sine qua non condition—a foundational prerequisite without which high performance cannot manifest. Therefore, contextual support through adequate resources is not merely beneficial but essential for enabling superior individual outcomes.

Figure 2: Scatterplots for the relationship between individual-level paradoxes and employee performance



This visualization is further supported by calculated NCA parameters (see Table 3)—the effect sizes and significance levels, which indicate that only JD-R fit demonstrated a (medium) necessary effect on employee performance ($ce\_fdh = 0.10$, $p = 0.003$; $cr\_fdh = 0.08$, $p = 0.002$). This suggests that while the JD-R fit does not fully determine performance, a minimum level is essential for employees to achieve higher performance.

Table 3 NCA: parameters of the necessary conditions for employee performance

	Employee performance			
	CE-FDH		CR-FDH	
	<i>d</i>	<i>p-value</i>	<i>D</i>	<i>p-value</i>
Human capital paradox	0.01	0.572	0.01	0.588
Coopetitive personality	0.00	1.000	0.00	1.000
Individual ambidexterity	0.00	1.000	0.00	1.000
Paradoxical mindset	0.00	1.000	0.00	1.000
Job demands-resources (JD-R) fit	0.10	0.003**	0.08	0.002**

Notes: *d* – effect size.

Source: authors

We conducted an in-degree bottleneck analysis to examine the JD-R fit paradox and identify critical levels of JD-R fit necessary for achieving high employee performance (see Table 4). Findings show that the JD-R fit is not crucial for low to moderate employee performance (below 40%). However, the required JD-R fit level increases as performance expectations increase. To achieve a medium-to-high level of employee performance (70-80%), the JD-R fit must be at least 21.6%; for peak performance (90-100%), it must reach at least 22.1%.

Table 4: Bottleneck table of the necessary conditions (“in degree”) for enabling employee performance

Condition Outcome	Job demands-resources (JD-R) fit
Employee performance	NN
0	NN
10	NN
20	NN
30	NN
40	4.2
50	4.2
60	4.2
70	21.6
80	21.6
90	22.1
100	27.5

Notes: CE_FDH ceiling zone was applied; NN was not necessary.

Source: authors

This means that a minimum of 22.1% of the theoretically possible JD-R fit must be present for an employee even to have the potential to perform at peak levels. In other words, without this threshold level of fit between job demands and resources, achieving top performance is impossible, regardless of other favorable conditions. That highlights the role of JD-R fit as a necessary condition for peak performance rather than a factor that incrementally contributes across all performance levels. These findings suggest that organizations aiming to enhance employee performance should offer suitable JD-R fit, particularly for those tasked with high-level performance. Failure to ensure adequate JD-R fit makes attaining superior performance more challenging.

Discussion

Conclusion

The study enhances our understanding of a range of individual-level paradoxes related to employee performance, contributing new insights to paradox and JD-R theory at the individual level of analysis. It provides a roadmap for exploring workplace dynamics to advance research on the emerging paradox-performance linkage. Results demonstrate that two individual-level paradoxes, JD-R fit and individual ambidexterity, are strong predictors of employee performance. JD-R fit emerges as a necessary (“must-have” or “*sine qua non*”) condition, while individual ambidexterity represents a sufficient (“nice-to-have”) condition that complements JD-R fit. That suggests that while individual ambidexterity enhances employee performance, which reaffirms previous research (Jyoti & Choudhary, 2024; Kao & Chen, 2016; Mom et al., 2015), it is not a strict requirement. In contrast, without JD-R fit, employees cannot achieve high-performance levels, regardless of their ambidexterity. Even if the JD-R fit stays too low, employee performance cannot be optimized regardless of any other factor (Dul, 2021; Hauff et al., 2021). In contrast, the coopetitive personality yielded theoretically ambiguous and inconclusive results, highlighting the need for re-examination, given their inconsistency with earlier research (Raza-Ullah et al., 2014; Ritala, 2012; Tidstrom, 2014). The human capital paradox and borderline paradoxical mindset exhibit limited or context-dependent effects. Consequently, this study raises the assumption that a paradoxical mindset universally benefits employees, yet it does not significantly enhance their performance. These findings highlight the conditional nature of certain individual-level paradoxes, emphasizing their dependence on specific job demands and contextual factors.

The study adopted a dual (OLS and NCA) analytical approach, which enhances causal inference and advances knowledge accumulation (Dul, 2016). This novel method introduces a fresh logical perspective, enabling us to test theoretical propositions, contributes to a more comprehensive understanding of the topic of interest, and advances disciplinary knowledge (Ding & Kuvaas, 2025). This study mitigates common method bias by employing time-lagged, multisource data, using separate questionnaires for unit managers and their employees. By having managers assess multiple employees and employees assess their managers, the design reduces self-report bias and enhances the validity of findings. This approach provides a robust and reliable dataset for individual-level analysis, particularly valuable in the context of paradox research.

From a practical perspective, the study suggests that employees should prioritize balancing high-impact paradoxes, such as individual ambidexterity and JD-R fit, while avoiding overinvestment in paradoxes that offer limited value for their performance. Conversely, unit

managers (strategy or organizational design professionals) should act as supporters and be motivated to create conditions that enable their employees to perform at their best, which can be reflected in the organization's success. Unit managers should empower employees by delegating tasks that encourage both efficient and innovative behavior in their daily work. To support employees in becoming top performers, unit managers need to equip them with the necessary resources, enabling them to manage complex tasks more effectively and reduce excessive task interdependence. This implies that unit managers should provide employees with sufficient autonomy at work (e.g., addressing frequent overtime through time management training, and reducing frequent interruptions by limiting micromanagement) and enough social support (e.g., supporting complex problem-solving with mentorship programs, and managing workplace conflicts with resilience training), even by tailoring it for each employee by ensuring that they are neither overwhelmed nor under-stimulated in their job. Since a paradoxical mindset is not a significant predictor of employee performance, managers should reconsider the one-size-fits-all approach and instead strategically form teams based on employees' individual preferences or cooperative personality. Although organizations often promote balance in formal messaging, these ideals frequently clash with day-to-day practices and workplace realities (Berti et al., 2021, p. 87). Achieving optimal performance in such paradoxical environments requires more than rhetoric—it depends on strategically aligning individual capacities with contextual support systems. This highlights the vital interplay between personal adaptability and structural enablers in navigating complexity.

Research limitations

This study analyzed individual-level paradoxes in isolation despite their dynamic interplay in real-world settings. Consequently, the study adopts a correlational approach, limiting causal inferences. As a result, the research design aligns more closely with theoretical assumptions than practical organizational realities. Since we conducted the empirical study among Croatian private organizations across various industries and organizational sizes, the findings may have limited generalizability when discussing the connectedness between each individual-level paradox and employee performance. Beyond the limited cross-industry representation, self-report survey elements may still introduce common method bias.

Future research

Despite the relatively rare integration of OLS and NCA methods in paradox research (Hernaus et al., 2024), there is a need for more studies to employ these methods to examine the sufficiency and necessity conditions of a broader range of individual-level paradoxes and their impact on various performance outcomes. Integrating objective performance measures, such as financial key performance indicators (KPIs), could reduce reliance on subjective performance ratings and potentially alter the results by introducing new theoretical perspectives. Additionally, there is a need to examine these approaches regarding a few knotted individual-level paradoxes (Sheep et al., 2017) to gain a deeper understanding of how to effectively navigate (“surf”) them collectively rather than perceiving them as dysfunctional or unsustainable (Berti et al., 2021, p. 98).

Following the study's results, future research should empirically explore the interplay between individual ambidexterity and JD-R fit as 'nice-to-have' drivers of employee performance, using methods such as fuzzy set qualitative comparative analysis (fsQCA). More specifically, researchers should investigate whether individual ambidexterity mediates the relationship between JD-R fit and employee performance. Understanding this linkage could clarify how the

alignment between job demands and available resources enables employees to balance exploratory and exploitative tasks effectively, which in turn drives higher performance. While the findings indicate that a coopetitive personality may function as a marginally sufficient predictor of employee performance, further empirical validation is necessary. Rather than treating the paradoxical mindset as a standalone individual-level paradox, given its borderline nature, it may be more appropriate to examine its potential role as a moderator influencing the relationship between other individual-level paradoxes and employee performance.

By adopting a paradoxical lens, researchers should investigate whether each pole within individual-level paradoxes is sufficient to support employee performance. For example, if ambidextrous behavior in task execution is found to be sufficient for achieving employee performance, it becomes essential to determine whether both explorative and exploitative behaviors are independently sufficient, which one is necessary, and how they should be balanced. The same applies to examining which pole of the JD-R fit, recognized as a necessary 'must-have' condition, contributes more directly to higher employee performance. In line with JD-R theory, it is worth exploring gain spirals related to job performance (Lesener, et al., 2019)—for example, the possibility that improved performance enhances personal resources, which in turn fosters greater work engagement.

Following research limitations, novel research building on these theoretical concepts could further investigate which individual-level paradoxes function as sufficient or necessary conditions by incorporating control variables such as job type (e.g., manual worker, administrative worker, professional – specialist or expert, lower-level manager or middle-level manager), education (e.g., secondary school diploma, college degree, university degree, univ. specialist or PhD), gender (male or female), and job tenure (years of tenure in current job position or organization). Considering that specific employee roles or job types may inherently favor one pole of a paradox—such as exploration over exploitation or autonomy over control—could provide deeper insights into how individual-level paradoxes manifest and impact performance.

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MAPPING THE RESEARCH LANDSCAPE OF WORKPLACE PHYSICAL ACTIVITY: A BIBLIOMETRIC REVIEW OF ITS IMPACT ON JOB PERFORMANCE AND EMPLOYEE WELLBEING

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Abstract

This study presents a bibliometric analysis of research on employee physical activity (PA) and job performance, mapping the intellectual structure and key research themes. Using co-citation, co-occurrence, and bibliographic coupling techniques, we systematically examine the evolution of workplace PA research and its connections to productivity, cognitive function, and employee wellbeing. Our findings highlight PA's dual role both as a driver of performance and a critical component of occupational health, reinforcing the shift from an individual lifestyle choice to a strategic workplace investment. Despite existing initiatives, participation barriers persist, underscoring the need for tailored interventions, flexible schedules, and mandatory workplace PA education. This study contributes by offering empirical-driven perspective, identifying influential studies, emerging trends, and providing actionable insights for organizations and policymakers. By embedding PA into workplace health promotion policies and corporate social responsibility frameworks, organizations can enhance both employee wellbeing and long-term performance outcomes.

Keywords: physical activity, exercise, workplace, job performance, health

JEL classification: I12, I19, J24, J28, M54

Introduction

Modern workplaces have become increasingly sedentary, driven by technological advancements and the rise of remote work, especially after the Covid-19 pandemic (Church et al., 2011; Fukushima et al., 2021; Woessner et al., 2021;). As a result, 31% of adults worldwide fail to meet WHO's minimum physical activity (hereafter: PA) requirements per week, increasing the risk of noncommunicable diseases like cardiovascular disorders, type II diabetes, and cancer, which accounted for 75% of all deaths worldwide in 2021 (WHO, 2024). This trend also contributes to higher health care costs and lower productivity (Ding et al., 2016). In response, WHO (2024) aims to reduce physical inactivity by 15% by 2030.

Additionally, employees spend an average of 60% of their daily hours at the workplace. Given that job performance is a crucial indicator of team and organizational success, it is increasingly important to maintain and enhance individual job performance in today's rapidly changing business environment (e.g., Koopmans et al., 2014; Sonnentag & Frese, 2002). Organizations therefore play a vital role in encouraging healthy lifestyle habits, including regular PA, understanding that promoting health and prevention is far more effective than addressing issues after they arise (e.g., Bakker et al., 2013; ECORYS, 2017).

While health related benefits of PA are well-documented (e.g., Pronk & Kottke, 2009; WHO, 2024), the organizational research on employee PA remains sparse (Calderwood et al., 2015b), especially one that has thoroughly considered job performance implications (Calderwood et al., 2021; Lopes & Miragaia, 2023). The most comprehensive review to date is Calderwood et al.'s (2021) systematic review, which synthesized existing theoretical and empirical work on employee PA and job performance developing a resource-based framework to explain how PA affects job performance through physiological, affective, and cognitive mechanisms. Additionally, also the meta-analyses of Cao et al. (2016), Rongen et al. (2013) and Tarro et al. (2020) have been conducted on related but distinct aspects of the topic, including the effects of active workstations on job performance, workplace health promotion, and randomized controlled trials (hereafter: RCT) examining absenteeism, productivity and work ability. While these studies offer valuable insights, they focus on specific interventions, broader health promotion efforts (including nutrition, lifestyle factors and counseling), or limited study designs, leaving gaps in understanding the field's overall research landscape.

Our study applies a bibliometric analysis, a quantitative approach that maps the intellectual structure, key themes, and evolving trends in a research field. Unlike systematic reviews and meta-analyses, which synthesize existing findings, bibliometric methods analyze citation networks and research clusters to reveal the broader development and trajectory of a topic, highlighting emerging areas that may not be as apparent in qualitative synthesis. Having identified the studies conducted within this framework, and aiming to contribute to the development of this research field, our work seeks to answer the following research questions:

RQ1. What is the underlying intellectual structure of the body of research concerning employee PA and job performance-related outcomes?

RQ2. How has the research of the relationship between PA and job performance-related outcomes evolved over time?

RQ 3. What are the most impactful key trends and widely discussed topics in recent research on PA and job performance-related outcomes?

RQ4. Which future research directions and emerging themes can be identified in the field of PA and job performance-related outcomes?

We address these research questions by triangulating data across different bibliometric techniques to create snapshots of the past, present, and future. After the explanation of the methodology, the article then presents the results and discussion of the findings, conclusions with theoretical and practical implications.

Methodology

Research design

This study employs three main bibliometric techniques—co-citation, co-occurrence, and bibliographic coupling—to map the origins, development, and future directions of research on employee PA and job performance-related outcomes. Following Zupic & Čater's (2015) guidelines, which were further expanded upon by Lamovšek & Černe (2023), our process involved five steps: (1) research design, (2) data collection, (3) bibliometric analysis, (4) visualization, and (5) interpretation. Bibliometric analysis, though not new (Kessler, 1963; Small, 1973), has gained attraction in business research with the rise of digital databases (e.g., Scopus, Web of Science (WoS)) and advanced bibliometric software (e.g., VOSviewer, BibExcel, Gephi). This method enables science mapping by identifying key research clusters, themes, and relationships within a field (Zupic & Čater, 2015). Common units of analysis include documents, journals, authors, cited references, and keywords (Cobo et al., 2011). In our approach, we distinguish between two categories of documents. Primary documents form the basis for our bibliometric review and are identified through keyword searches. Secondary documents are those cited by the primary documents (Vogel et al., 2020).

Given the rapid expansion of academic literature, bibliometric analysis helps uncover complex relationships between studies while minimizing subjectivity by quantifying qualitative data. However, interpretation of results remains partly subjective.

Data collection, search protocol and sampling

For data search and export, we used the Thomson Reuters WoS, which is by far the most commonly used database in bibliometric studies (Zupic & Čater, 2015; Prancutė, 2021). The search was done on January 6th, 2025. To maximize the number of documents obtained, the “topic” option was used to identify keywords in the title, abstract and keywords. Before identifying the final search terms several documents were first analysed in order to identify most commonly used synonyms of “physical activity” and “work”. Our final search query was: ("physical activity" OR “physical exercise” OR “physical fitness” OR gym* OR “sports activity” OR “aerobic exercise”) AND (work* OR “staff” OR employee* OR “job” OR labour* OR labor* OR “company” OR “firm” OR “organization” OR “organisation” OR “corporation” OR “enterprise”) AND (“performance” OR “productivity”).

The search returned 6,977 SSCI-indexed documents published between 2001 and 2024. The 21st century has witnessed significant changes in workplace environments, including the integration of technology, shifts towards sedentary job roles, making sedentariness “one of the more serious yet insufficiently addressed public health problems of our time” (WHO, 2002) or “disease of the 21st century” (Rodulfo, 2019) and increased focus on employee wellbeing (Litchfield et al. 2016; Deloitte, 2022), has further driven interest in understanding how employee PA mitigates health- and job performance-related outcomes (Calderwood et al., 2021). Advances in research methods enabled more robust studies, while growing organizational and policy interest in employee health and wellbeing further spurred research into interventions that promote PA within the workplace addressing employee health- and job performance-related outcomes (e.g., Conn et al., 2009; Martinez, 2021; Santos & Miragaia, 2022; Schaller et al., 2024). This time frame captures the most relevant and active years in this field, reflecting contemporary understandings and the evolving nature of work and occupational health dynamics.

We filtered for articles in the business and economics domain and were left with 1,291 studies, thereof 941 from the field of public environmental occupational health, followed by psychology applied (277), ergonomics (108), management (45), business (23), economics (17), and business finance (3).

In the first phase we removed articles that were not written in English as commonly done in such research (e.g., Santos & Miragaia, 2022; Cvetkoska et al., 2024), followed by a manual check of the relevance of each article based on an analysis of the title and abstract. Exclusion criteria included studies that focused on (1) academic performance, (2) physical or mental conditions (e.g., dementia, anxiety), and (3) on specific occupations that would be difficult to generalize to other occupations (e.g., nurses, military personnel, firefighters, construction workers). We included articles that focused on both indirect influences on job performance (e.g., fatigue, mood, affect, work ability) as well as direct outcomes (e.g., task, cognitive or creative performance). Some of the documents that raised doubts about the fulfilment of previously defined criteria were full-text screened before the final sample was set to 132 studies.

We analyzed the data from WoS using VOSviewer software (van Eck & Waltman, 2010), which uses influence and proximity measures to form clusters, each representing a closely connected group of nodes. Nodes are assigned to a single cluster, and the number of clusters is determined by a resolution parameter. The software displays clusters in different colors, with node size indicating importance and link strength representing the connection between items, such as co-occurrence or bibliographic coupling (van Eck & Waltman, 2010).

Co-citation

To test the semantic similarity between selected studies and identify influential works, key contributors, thematic clusters, and the historical dynamics of the research field, we conducted a co-citation analysis (Small, 1973) of secondary documents. Co-citation occurs when two documents are cited together by a third document, indicating a potential relationship (Zupic & Čater, 2015). The frequency of co-citation reflects the proximity between authors (Nerur et al., 2008), as authors in a research stream often cite each other and are frequently co-cited by others working on similar topics. This process creates an intellectual map of relationships based on co-citation frequency. We followed these steps (e.g., Lamovšek & Černe, 2023): (1) create a map based on bibliographic data, (2) read data from bibliographic databases, (3) perform co-citation analysis with full counting of cited references, and (4) set minimum citation threshold to 6 (Zupic & Čater, 2015).

By applying this analysis, we (1) outlined the intellectual structure of the research field by identifying primary clusters, (2) examined relationships between clusters, (3) identified key papers and authors within clusters, (4) pinpointed papers bridging multiple research subfields, and (5) visualized the conceptual foundations through cluster relationships.

Co-occurrence

Next, we performed a co-word analysis (Cobo et al., 2011) to examine the co-occurrence of author keywords in the primary documents of our review. Unlike citation or co-authorship analysis, co-word analysis uses the content of the documents, specifically the keywords, to measure similarity (Zupic & Čater, 2015). By calculating the co-occurrence of frequently used

terms, this method identifies thematic clusters representing the main concepts of the research field (Callon et al., 1991). Actions were: (3) Type of analysis: co-occurrence; unit of analysis: all keywords; counting method: full counting, (4) Set minimum number of occurrences of a keyword to 4 (Waltman et al., 2010).

Bibliographic coupling

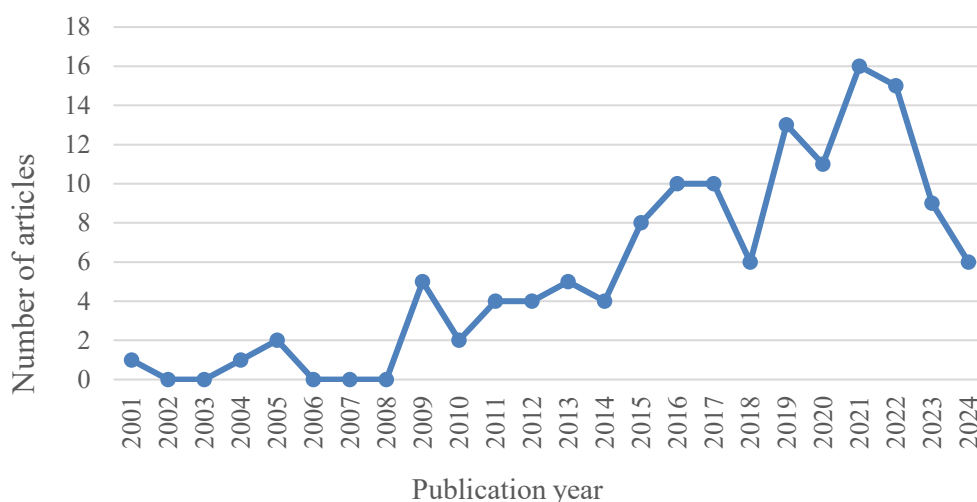
Finally, to identify the most impactful topics, key contributors, and ongoing research trends, we performed bibliographic coupling (Kessler, 1963), which links primary documents based on shared references. The stronger the overlap in bibliographies, the stronger the connection between the documents. Unlike co-citation, which reflects past research, bibliographic coupling provides a more current view (Vogel et al., 2020). We perform bibliographic coupling, with (3) documents as the unit of analysis and full counting and (4) minimum of 4 occurrences per source (Donthu et al., 2021).

Results and discussion

General descriptive analysis

Figure 1 presents the annual trends of 132 articles published in 40 different journals. Even though publishing trends have been somehow cyclical, overall trend is positive, which indicates that this is a contemporary subject that has gained growing interest from researchers to contribute their efforts. The mid-2010s saw a rise in the use of technology and digital tools that facilitated remote work and increased sedentary behavior, which was further impacted by Covid-19 and rise of telecommuting. First obvious jump is seen in 2015, when Calderwood et al. (2015) conceptualized employee PA construct, which provides a foundational framework for subsequent empirical work. Additionally, their identification of physiological, affective, and cognitive mechanisms linking PA to health- and job performance-related outcomes is crucial for interpreting findings across studies and understanding why different PA interventions may yield varying effects on employees. Most importantly, they called upon scholars for empirical work to validate workplace PA initiatives and establish their impact on job performance. In terms of typology, 31 studies were classified as randomized control trials, the preferred design to identify which public health interventions work best (Petticrew & Roberts, 2003), 17 experiments, while most studies included questionnaires and self-reported data.

Figure 1: Annual trends of articles



Source: Authors' analysis

The peer-reviewed journals that seem to have favored the publication of studies on this subject were *Journal of occupational and environmental medicine* ($n=25$), *BMC Public health* ($n=24$), and *International journal of environmental research and public health* ($n=18$). This is consistent with the fact that in the final selection 80% of the studies ($n=106$) in the WoS database belong to Public Environmental & Occupational Health category. This indicates PA is seen as one of the most important contributors to (occupational) health. Studies in this category focus on workplace PA interventions that (a) replace traditional long sitting times with active workstations (e.g., sit-stand workstation (Graves et al., 2015; Hall et al., 2019), treadmill workstation (Giumetti et al., 2021), and cycling workstation (Koren et al., 2016)); (b) add recreational PA within work (e.g., sports lunch break (e.g., de Vries et al., 2022) or before/after work schedule as a leisure time activity (e.g., Li et al., 2023); (c) ergonomics and neck specific exercises (e.g., Pereira et al., 2019) and short bouts of boxing (Wollseiffen et al., 2016) within work schedule, and (d) step-count challenges (e.g., Ryde et al., 2022).

These interventions result in benefits that go beyond just health related ones - reductions in risk for a variety of diseases and improvements in functional ability. They are studied in relation to employee wellbeing (e.g., Puig-Ribeira et al., 2015, 2017), mental health aspects such as stress, fatigue, negative affect, vigour (e.g., Bakker et al., 2013; de Vries et al., 2022), indirect job performance-related factors as energy and alertness (e.g., Hall et al., 2019), vitality (e.g., Hendriksen et al., 2016a), focus and attention (e.g., Hervieux et al., 2021; Giumetti et al., 2021), as well as productivity (e.g., Graves et al., 2015), absenteeism (e.g., Hendriksen et al., 2016a; Cox et al., 2022), presenteeism (e.g., Pereira et al., 2019), work engagement (e.g., Li et al., 2024), cognitive performance (e.g., Koren et al., 2016), task and creative performance (e.g., Li et al., 2023).

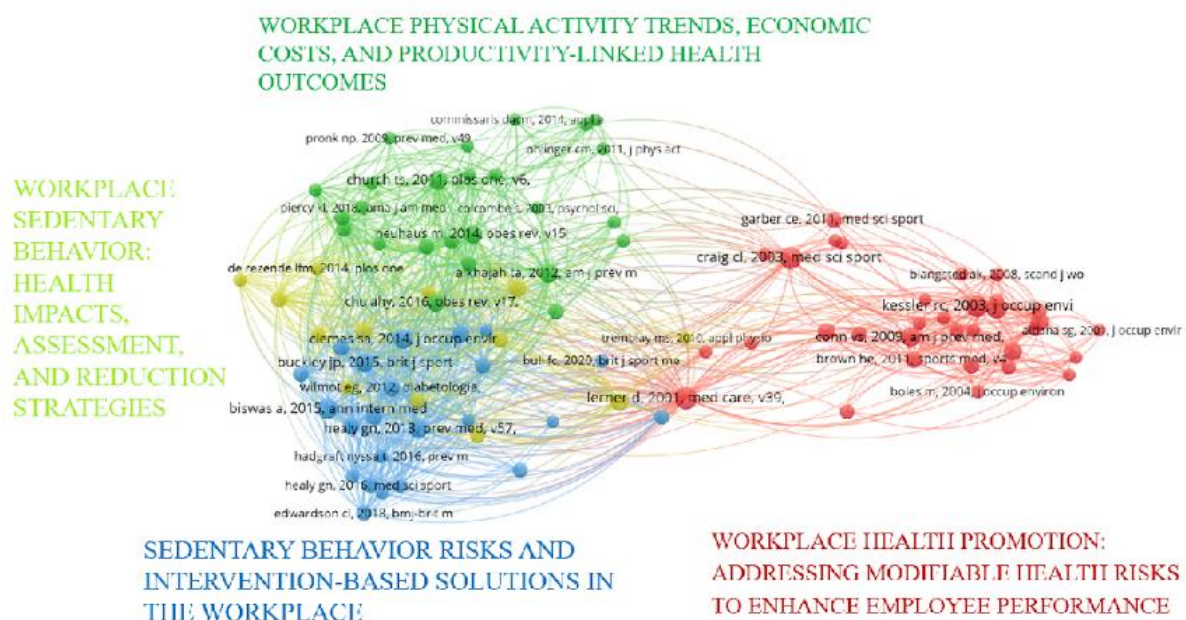
The most cited article (179 citations in WoS) in our dataset is study from Pronk et al. (2004) which emphasizes the critical role of PA in enhancing work performance and managing obesity, which is linked to higher absenteeism, and worse interpersonal relationships among employees. Investing in workplace wellness initiatives can lead to improved productivity, better team dynamics, and lower healthcare costs (Pronk et al., 2004, 2009).

Co-citation analysis

In this timeframe 132 studies included altogether 4,942 references. The choice of minimum 6 citations (where only one document had maximum 18 citations) resulted in 94 references, providing a good balance between capturing the intellectual structure of the field and avoiding excessive noise. It includes highly cited works while still being comprehensive enough to reflect the broader research landscape. 4 clusters were formed with 2,114 links between the references and a total link strength (hereafter: TLS) of 3,822.

Studies positioned closer together have stronger relatedness, with co-citation links shown by lines. Higher TLS indicates frequent co-citation with key works, highlighting a document's influence and centrality in the field.

Figure 2: Co-citation map of employee PA, health- and job performance-related outcomes



Source: Authors' analysis

The smallest cluster (yellow color in Figure 2) focuses on the detrimental effects of prolonged sitting in office settings, emphasizing importance of measuring sedentary behavior (e.g., Thorp et al., 2012; Parry & Straker, 2013) and the need for behavioral-change interventions (e.g., Owen et al., 2011) to mitigate prolonged sedentariness' health-related risks, including mortality, cardiovascular disease, type 2 diabetes, metabolic syndrome risk factors, obesity, and cancer (e.g., Hamilton et al., 2007; Thorp et al., 2011; de Rezende et al., 2014). In line with these concerns, this cluster aligns with the development of Health and Work Questionnaire (HWQ) by Shikiar et al. (2004) and the Occupational Sitting and Physical Activity Questionnaire (OSPAQ) by Chau et al. (2012), which assess workplace productivity in relation to worker health and measure sedentary behavior in occupational settings, respectively.

The red cluster in the co-citation analysis centers on workplace health promotion programs (WHPPs) aimed at mitigating modifiable health risks (e.g., obesity, physical inactivity) and their impact on job performance, absenteeism, and productivity. Key studies in this cluster highlight the effectiveness of workplace interventions in improving employee work-related and organizational outcomes (e.g., Proper et al., 2002, 2003, Conn et al., 2009).

Across these studies, obesity emerges as a key risk factor affecting job performance, absenteeism, and presenteeism (e.g., Kessler et al., 2003, 2004; Pronk et al., 2004; Schultz & Edington, 2007; Cancelliere et al., 2011). Building on this, research from Goetzel et al. (2004) and Aldana (2001) highlight the financial benefits of well-structured WHPPs—incorporating PA, nutritional support, and environmental modifications—showing that reducing modifiable health risks lowers absenteeism, presenteeism, and healthcare costs, enhancing both employee wellbeing as well as deliver measurable cost savings and productivity gains for organizations.

Beyond intervention effectiveness, this cluster also highlights the development and validation of assessment tools essential for measuring workplace health outcomes and guiding intervention strategies. The International Physical Activity Questionnaire (IPAQ) (Craig et al., 2009) is frequently cited for monitoring PA levels, while adherence to American College of Sports Medicine (ACSM) guidelines (Garber et al., 2011) ensures scalable and evidence-based programming. Additionally, the World Health Organization's Health and Work Performance Questionnaire (HPQ) (Kessler et al., 2003) is recognized for estimating workplace costs related to health problems, including reduced job performance, and sickness absence.

Interestingly, these validated tools serve as conceptual bridges across multiple subfields, attracting attention beyond workplace health promotion and connecting with broader themes in occupational health, productivity research, and public health policy. This highlights the increasing emphasis on structured, data-driven approaches to workplace wellbeing, ensuring that interventions not only improve employee health but also contribute to enhanced organizational performance.

The blue cluster emphasizes the detrimental effects of sedentary behavior with systematic reviews and meta-analyses (e.g., Wilmot et al., 2012, Biswas et al., 2015; Ekelund et al., 2016) providing strong evidence linking excessive sedentary time to increased risks of diabetes, cardiovascular disease, and mortality.

A second major theme in this cluster are workplace interventions aimed at reducing sedentary time through sit-stand desks and multicomponent strategies. Several randomized RCTs (e.g., Dunstan et al., 2013, Healy et al., 2013; Neuhaus et al., 2014a; Graves et al., 2015; Hadgraft et al., 2016; Healy et al., 2016; Edwardson et al., 2018) evaluate the effectiveness of behavioral prompts, structured interventions (i.e., *Stand-Up Victoria*, *SMaRT Work*) and active workstations in reducing occupational sitting time. Researchers further investigated whether these interventions can effectively balance the benefits of using active workstations compared to traditional setups with maintaining or improving work productivity and cognitive function. In the RCT from Edwardson et al. (2018) intervention group using height-adjustable workstation showed improvements in work engagement, job performance, recovery from occupational fatigue, and cognitive function, particularly in attention, compared to the control group. Additionally, Clemes et al. (2014) provide insight into how workplace environments and job demands shape overall sedentary behavior, reinforcing the importance of context-specific interventions that consider both individual behaviors and workplace policies to effectively reduce sedentary time. The *Take-a-Stand Project* (Pronk et al., 2012) and *Stand-up Victoria* (Healy et al., 2017) further demonstrates the benefits of reducing occupational sitting for worker cardiovascular and metabolic health. Buckley et al. (2015) strengthen this cluster by providing an expert consensus advocating for a shift in workplace culture to integrate movement throughout the workday to support long-term reductions in sedentary time while maintaining productivity.

The green cluster has a similar message to the blue cluster, as evidenced by the proximity and overlap of nodes in Figure 2. It builds upon Neuhaus et al. (2014b) systematic review on activity-permissive workstations, highlighting their potential to reduce sedentary time. Church et al. (2011) provided a broader perspective, linking declining occupational PA to rising obesity rates. Reviews by Chu et al. (2014) and van Uffelen et al. (2010) explored workplace interventions' effects on mental health and metabolic risks, respectively. Karakolis & Callaghan (2014) and MacEwen et al. (2015) highlighted active desks' benefits for productivity and health, while Colcombe & Kramer (2003) linked their use to cognitive gains.

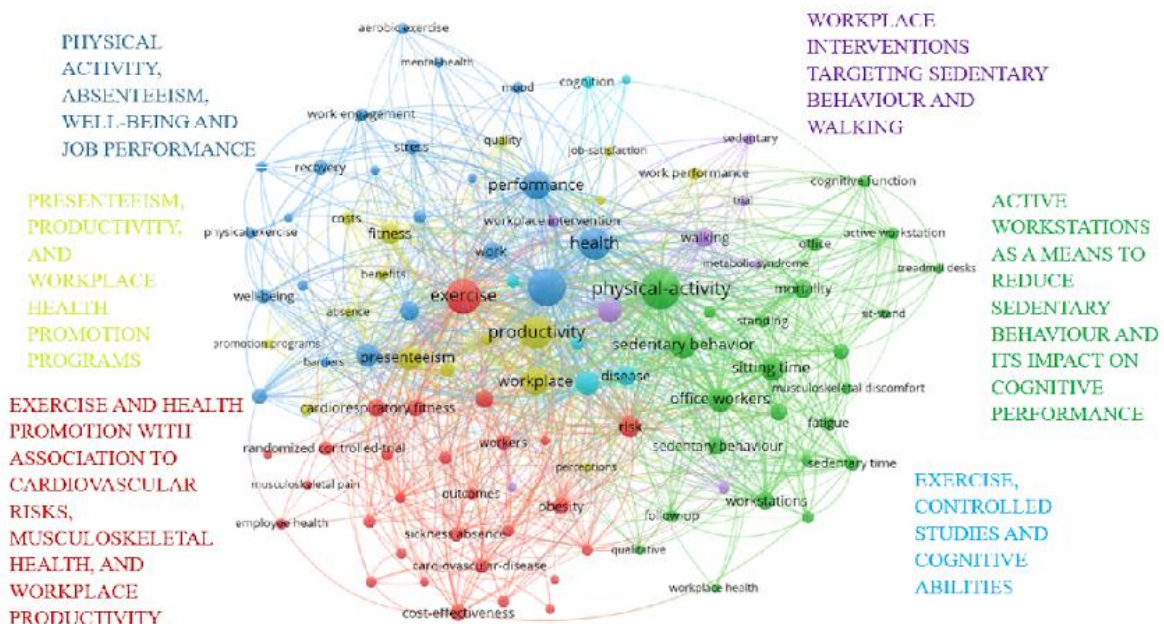
Empirical studies provided additional evidence: Healy et al. (2008) demonstrated the metabolic benefits of interrupting sedentary time, Alkhajah et al. (2012) found sit-stand desks effectively reduced office sitting time, while Thorp et al. (2011) showed standing breaks alleviated fatigue and musculoskeletal discomfort. Pronk (2009) provided broader recommendations for integrating PA into business strategies. Finally, Ding et al. (2016) quantified the economic burden of physical inactivity (\$54 billion worldwide in 2013), underscoring the broader societal and financial consequences of sedentary work environments.

The intellectual structure of both clusters reinforces the importance of reducing workplace sedentary time by promoting standing and walking as alternatives, but the green cluster adds a more comprehensive lens by considering trends, economic costs, and mental health outcomes, alongside intervention-based strategies.

Co-word analysis

The choice of a threshold of 4 keyword occurrences balances detail and interpretability, ensuring the map captures central themes without becoming cluttered. With 88 keywords (13% of 664 total) and 1,508 total links, the analysis highlights significant trends while avoiding noise from rarely occurring terms. The resulting map of 6 clusters, as illustrated in Figure 3, with a total link strength of 3,030, provides a clear, cohesive visualization that effectively conveys the relationships and patterns within the dataset.

Figure 3: Co-word (keywords co-occurrence) network visualization



Source: Authors' analysis

In terms of TLS among the most impactful terms in my research field besides PA and exercise are productivity, health, workplace (PA programs applied or studied in a work context), performance, sedentary behavior, and presenteeism. The increasing recognition of presenteeism (attending work while ill) (Johns, 2010) over absenteeism (being absent due to illness or disability) (Hemp, 2004), highlights its growing impact on workplaces. Unlike absenteeism, presenteeism is harder to measure, often unrecorded, and more costly (Hemp, 2004; Lohaus & Habermann, 2019). Remote and hybrid work trends have exacerbated this issue, leading to more research on its effects on mental health, burnout, and overall performance (Lohaus & Habermann, 2019; Støren & Grønningsæter 2024). Organizations are now prioritizing presenteeism due to its hidden costs and its significance in health and wellbeing promotion (Westover, 2024).

Due to space limitation, we summarized the clusters' most frequent key words (without PA and exercise) and its main focus below:

Table 1: Summary of the co-word analysis results for the employee PA and job performance field

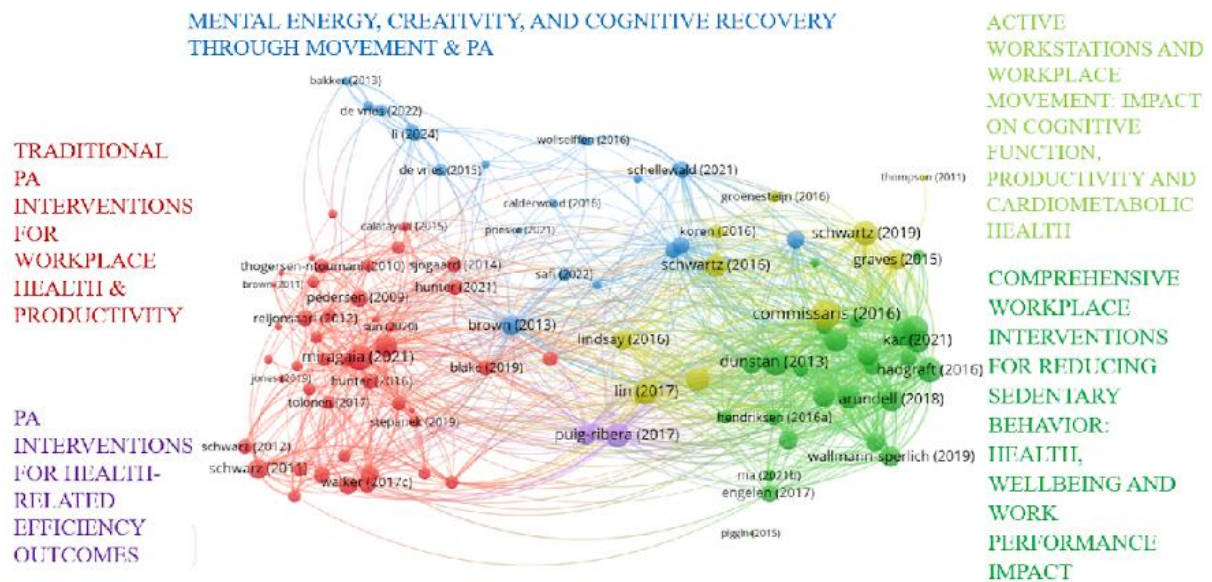
Cluster (no. of keywords)	Top 5 keywords by occurrences	Key Focus
● Exercise, Health & Workplace Productivity (22)	Cardiorespiratory fitness, obesity, risk, sickness absence, cost-effectiveness	Exercise reduces leading cause of global deaths, i.e., cardiovascular risks, and obesity, and leading cause of European work absence (accounting for up to 2% of Europe's GDP annually), i.e., musculoskeletal discomfort, while improving productivity and reducing absenteeism. Cost-effective workplace interventions play a crucial role.
● Active Workstations & Sedentary Behavior Reduction (21)	sedentary behaviour, sitting time, office workers, mortality, cognitive function	Active workstations help reduce sedentary behavior and musculoskeletal discomfort, with mixed effects on cognitive performance but some benefits for absenteeism, engagement, and alertness.
● Presenteeism Productivity & Workplace Health Promotion Program (16)	presenteeism, workplace, productivity, costs, benefits	WHPP show mixed effects on productivity and presenteeism, but active employees generally experience fewer absences and cost savings.
● PA, Absenteeism & Job performance (14)	health, absenteeism, impact, performance, wellbeing	Regular PA improves wellbeing, reduces absenteeism, enhances work engagement, by supporting recovery from work-related strain.
● Sedentary Behavior, Walking & Metabolic health (11)	intervention, sedentary, walking, financial incentives, metabolic syndrome	Walking-based and sedentary behavior interventions aim to reduce metabolic risks, with some evidence of improved productivity and absenteeism outcomes.
● Exercise, Controlled Studies & Cognitive Abilities (4)	intervention, disease, cognition, executive functions	Controlled studies suggest PA enhances cognitive abilities like memory and attention, but effect vary by activity type and intensity.

Source: Authors' analysis

Bibliographic coupling

With bibliographic coupling we identified common research areas, currently most impactful topics and emerging trends in the field (Kessler, 1963; Donthu et al., 2021). Since the topic is relatively new (i.e., majority of the selected articles were published between 2019 and 2024) we established a minimum threshold of 4 citations per document (Donthu et al., 2021). The criterion led to the selection of 103 articles, grouped into 5 clusters, as shown in Figure 4, where the most relevant protagonists of the clusters are represented by the largest circles. Newer articles may have few citations but can still show strong coupling if they reference widely cited key works. TLS among these documents was 3,701, with a total of 1,726 links between them.

Figure 4: Bibliographic coupling map



Source: Authors' analysis

Table 2: Summary of the bibliographic coupling results: main themes, intervention types and key focus areas

Feature/ Cluster	● Traditional PA Interventions for Workplace Health & Productivity	● Mental Energy, Creativity, and Cognitive Recovery Through Movement & PA	● PA Interventions for Health-Related Efficiency Outcomes	● Active Workstations and Workplace Movement: Impact on Cognitive Function, Productivity and Cardiometabolic Health	● Comprehensive Workplace Interventions for Reducing Sedentary Behavior: Health, Wellbeing and Work Performance Impact
Main focus	PA, health, and work performance	Cognitive function, recovery, and creativity	Sedentary behavior, mental wellbeing, and productivity	Active workstations & dynamic movement strategies for cognitive performance	Workplace design & interventions for reducing sedentary behavior: health & productivity impacts

No. of documents	44	20	2	11	26
Intervention type	Workplace PA programs, self-initiated activity, structured interventions	Dynamic workstations, leisure-time PA, exercise breaks	'Sit Less, Move More' initiatives	Sit-stand, treadmill & cycling desks, active workstation trials	Sit-stand workstations, ergonomic interventions, multicomponent behavior change programs
Work performance component	Absenteeism, presenteeism, self-rated productivity, organizational outcomes	Task focus, cognitive performance, work engagement, creativity	Efficiency-related outcomes and perceived productivity	Cognitive workload, task performance, reaction time, executive functions	Work engagement, job satisfaction, productivity impact of workstation design
Health-component	Cardiorespiratory fitness, obesity, sickness presenteeism, musculoskeletal health	Mood, fatigue, vigor, stress, daily recovery	Mental wellbeing, interaction of sitting & activity levels	Cognitive fatigue, mental energy, cardiometabolic markers	Sedentary behavior reduction, musculoskeletal & metabolic outcomes
Distinguished feature	Strongest link to traditional workplace PA programs and organizational performance metrics	Focus on mental energy, creativity, and work-related cognitive benefits of PA	Only two studies but strongly interconnected with broad PA-performance literature	Cognitive and motor performance outcomes under different dynamic office setups	Broader workplace interventions beyond workstations addressing productivity & musculoskeletal health

Source: Authors' analysis

Table 2 categorizes emerging themes within PA - job performance framework, highlighting their main focus, intervention types, and impacts on job performance and health. It distinguishes between traditional PA programs, cognitive benefits of movement, efficiency outcomes, active workstations, and broader workplace interventions, providing a structured overview of how different PA approaches influence employee wellbeing and productivity.

The largest red cluster focuses on structured PA programs at the workplace and their impact on productivity, absenteeism, and presenteeism. Studies highlight how workplace PA interventions, such as structured exercise programs and active breaks, enhance job efficiency and reduce sickness-related work impairments (e.g., Von Thiele Schwarz & Hasson, 2011, 2012; Justesen et al., 2017; Walker et al., 2017a, b). Additionally, this cluster examines PA's role in mitigating health risks like cardiovascular disease, metabolic syndrome, and musculoskeletal pain (e.g., Pronk, 2004; Pedersen et al., 2009).

Meanwhile, the blue cluster emphasizes how PA supports psychological resources—physical (sleep quality), affective (vigor), and cognitive (focus and engagement). Research suggests that active commuting, sports during lunch breaks, and exercise in leisure time can improve mood, recovery, energy, and creativity while reducing fatigue and cognitive strain (Bakker et al., 2013; de Vries et al., 2017; Fyhri et al., 2023). Ten Brummelhuis et al. (2022) found that end-of-day PA positively impacts work focus when its intensity matches an individual's exercise

motivation. Similarly, Li et al. (2023) highlight that even with short PA boosts—around 20 minutes daily—can enhance the next-day task and creative performance, particularly when motivation is high.

Common theme in green cluster are organizational-, environmental- and individual (behavioral) change strategies, such as sit-stand desks, activity-based working, other workplace modifications, and movement breaks, which aim to reduce prolonged sitting and musculoskeletal discomfort without compromising productivity (e.g., Daneshmandi et al., 2019; Wallmann-Sperlich et al., 2019., Kar & Hedge, 2020). Relatedly, the yellow cluster explores how different dynamic workstations—sit-stand and treadmill desks, bicycle ergometer, or elliptical trainer—affect cognitive function and productivity, showing mixed but promising results for text accuracy, memory and engagement (e.g., Commissaris et al., 2014; Koren, et al., 2016; Schwartz et al., 2019).

Lastly, the smallest purple cluster examines low-intensity movement strategies and behavioral economics-based nudges that promote sustained PA, linking them to mental wellbeing and productivity improvements (Puig-Ribera et al., 2015, 2017).

Contributions, limitations and conclusion

In our bibliometric analysis of employee physical activity (PA) and job performance, we contribute to the research field by mapping the underlying intellectual structure and key research trends in this area. Our study identifies four thematic clusters in the relationship between PA and job performance, offering a structured overview of the connections between workplace PA, employee wellbeing, productivity, and cognitive function. We have traced how this body of research has evolved over time, revealing a growing emphasis on the strategic importance of PA within organizational contexts rather than merely as a tool for improving performance.

Our findings reveal an evolving intellectual structure with multiple research streams, ranging from the physiological and cognitive benefits of PA to its role in workplace interventions and organizational performance. The intellectual structure of this research suggests a shift toward understanding PA as a comprehensive aspect of workplace wellbeing, where the boundaries between physical, mental, and organizational health become increasingly intertwined.

Over time, research in this field has evolved from focusing primarily on the individual benefits of PA to recognizing its broader organizational implications. Early studies tended to emphasize PA's direct impact on productivity and absenteeism, while more recent research underscores the importance of integrating PA into organizational strategies for overall employee wellbeing. The growing recognition of PA as a key component of Corporate Social Responsibility initiatives is indicative of this evolution.

Recent trends highlight the dual role of PA—not only as a performance-enhancing factor but as a crucial component of employee health and wellbeing. Studies increasingly advocate for embedding PA into workplace policies rather than treating it as an optional benefit. Global initiatives like the WHO's Let's Get Physical campaign and the European Commission's Move@Work project exemplify efforts to integrate PA into workplace culture, promoting sustainable behavioral change.

As with any bibliometric review, this study has its limitations. Bibliometric analysis relies on citation patterns, which may not always reflect the true impact or quality of a study, as citations can be made for reasons beyond agreement, including critique or methodological comparison. Furthermore, while bibliometric techniques provide objective insights, the interpretation and labeling of clusters remain inherently subjective. Different researchers may categorize themes in varying ways based on their individual perspectives, which could influence the classification and interpretation of the data. These limitations highlight the need for caution when interpreting bibliometric results and the importance of combining quantitative and qualitative approaches for a more comprehensive understanding of the field.

Despite growing adoption of PA programs, employee participation remains a significant challenge. Future research should explore the barriers to employee participation and develop more tailored, role-specific approaches to integrating various forms of employee PA into their daily routines. Longitudinal studies are needed to assess the sustained impact of workplace PA on performance and employee retention. Emerging themes include the intersection of PA with mental health and cognitive functions, as well as the role of flexible work environments in facilitating employee to be physically active. Additionally, research on personalized PA interventions and their effectiveness across different job roles could offer valuable insights into optimizing workplace PA strategies.

The practical implications for organizations align with these findings. To encourage greater participation in PA programs, organizations should consider implementing structured initiatives tailored to different job roles, incorporating PA within working hours through flexible schedules, and measuring participation as part of broader workplace wellbeing efforts. Just as professional training is mandatory, workplace PA education and movement programs could become essential components of employee development. By embedding PA into workplace culture rather than treating it as an optional perk, organizations could drive lasting behavioral change, improving both employee wellbeing and organizational performance.

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MARKETING

TRACK 1: Contemporary Marketing Strategies and Consumer Engagement

PREFACE

MARKETING – TRACK 1: CONTEMPORARY MARKETING STRATEGIES AND CONSUMER ENGAGEMENT

In the dynamic realm of modern business, effective marketing depends on a deep understanding of consumer behavior, the strategic leverage of communication channels, and adaptation to technological advancements. This thematic section explores current trends and challenges in marketing, from navigating consumer perceptions of data privacy to understanding the intricate networks that influence product promotion and optimizing internal communication for organizational effectiveness. The papers presented here contribute to achieving the defined aim and scope of the Odyssey conference by collectively illuminating how contemporary marketing strategies must evolve in an increasingly digital and interconnected world. The papers presented in this track focus on understanding and optimizing communication and influence in various marketing contexts.

BuntiĆ, Damić and Matijević, examine Generation Z's perceptions of sharing personal data for marketing purposes, highlighting the importance of trust, transparency, and personalized strategies in engaging this crucial consumer segment. Domanski, Reif, Schaab, Schötteler and Schuhbauer investigate the formation of book testimonial networks, revealing the significant roles of reciprocity, transitivity, and homophily in shaping promotional ties within the publishing industry. Špoljarić analyzes the impact of digital channel acceptance on internal communication channel satisfaction among employees, underscoring the necessity for organizations to provide adequate resources and foster social influence to optimize both traditional and digital communication strategies.

GENERATION Z CONSUMERS' PERCEPTION OF SHARING PERSONAL DATA FOR MARKETING PURPOSES

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Abstract

This paper examines Generation Z's attitudes toward personal data sharing for marketing purposes, focusing on their perceptions of data collection and usage and its influence on marketing strategies. Our primary aim is to understand how Generation Z views personal data practices and how these perceptions shape the development and adaptation of effective marketing strategies. The theoretical section of the paper defines personal data and explores types of personal data collected for marketing, from basic to complex - alongside data collection and utilization methods, including cookies, software, exchanges, and data centers. The empirical section investigates Generation Z's privacy views and their conditions for sharing data with companies. A mixed-method approach was used, combining secondary data from academic sources with primary data collected via a survey distributed through social media and personal communication. Survey findings reveal factors influencing Generation Z's willingness to share data, highlighting the importance of trust, transparency, and personalized marketing strategies in building loyalty. The study also links privacy awareness to consumer behavior and identifies successful marketing approaches targeting Generation Z through personalized campaigns. Our study underscores the need for marketers to align strategies with Generation Z's privacy concerns, balancing data-driven personalization with ethical practices. These insights benefit both consumers and businesses by fostering trust and optimizing marketing effectiveness.

Keywords: personal data sharing, GDPR, personalized marketing, generation Z, data collection, data exchanges

JEL classification: M31, M37, M39

Introduction

In contemporary marketing, considerable emphasis is placed on the personalization of campaigns to optimize their effectiveness, i.e., to deliver value to customers and cultivate strong relationships that drive profitable actions (Wertenbroch, 2021). The key input for these campaigns is different type of personal data that can provide significant insights into consumer habits, thereby aiding in the optimization of the marketing mix (Mahmoud et al., 2020).

However, consumer awareness of data privacy and the ways they can evade data collection is growing (Wolford, 2018). Therefore, marketing professionals must consider this factor when developing strategies, as consumers can significantly influence the success of campaigns reliant on diverse data collection by opting not to share personal information, rejecting web cookies, or exercising their GDPR rights to data deletion and confidentiality (California Consumer Privacy Act, 2018).

In this paper, we study attitudes of Generation Z on personal data sharing for marketing purposes. This upcoming generation of young people will soon represent a significant portion of the working-age population and possess considerable purchasing power. As the most tech-savvy generation, they are generally more informed about contemporary technological, social, economic, and geopolitical issues than previous generations (Bagshaw, 2015). Personal data has long been a valuable resource for marketers, but aligning data collection methods with Generation Z's attitudes and privacy concerns is crucial for the future of personalized marketing strategies and tailored advertising campaigns. Therefore, in this paper we ask the following research question: *What are Generation Z's attitudes towards privacy and data sharing for marketing purposes?*

Personal information and data collection in marketing

Personal information encompasses data that allows the identification of individuals, with classification being key to privacy protection (Wertenbroch, 2019). Basic identification data (name, address, email) are less sensitive, while sensitive information, such as financial and medical data, can lead to severe consequences if misused (Mahmoud et al., 2020). Highly sensitive data, including biometric details and government identifiers (e.g., social security numbers), are extremely confidential due to identity theft risks (The New Rules of Data Privacy, 2022). Behavioral data, such as online activities, are used for targeted marketing but can reveal personal details through analysis (McKinsey and Company, 2024). Location data track movements in real time, raising concerns and ethical debates (Compliant: Consent Management mit Usercentrics, 2024). Contextual data relate to user preferences, often applied in personalized marketing. Professional data, like employment history, can be used in marketing purposes but also create issues if misused (Compliant: Consent Management mit Usercentrics, 2024). This classification helps define privacy protection measures and establish frameworks for secure information handling. GDPR and CCPA serve as key legal frameworks for data protection in the EU and the US, with varying legal definitions and approaches across countries, necessitating adaptation to global standards (California Consumer Privacy Act, 2018).

WP29 adopts broad definitions of "identified" and "identifiable." Identified individuals are already known, while identifiable ones can be recognized with additional information. Identification standards consider reasonable means for identification, including costs, processing purposes, and technology availability. WP29 interprets "any information" broadly, covering data directly or indirectly linked to individuals through content, purpose, or impact. This includes data generated from observing people, their activities, and device use, potentially influencing behavior, treatment, and status. Any information can potentially be linked to an individual, especially with detailed analysis of correlated data (Article 29 Data Protection Working Party, 2007)

Personal data is the key in personalization of marketing efforts. Personalization is defined as

tailoring products and services to the right user at the right time and place, synonymous with individualization and one-to-one marketing (Wertenbroch, 2019). Previous studies define personalization as relationship building with customers (Pepper and Rogers, 1997) and delivering relevant offers (Ho, 2006). Models like Instone's two-dimensional construct (2000) and McCarthy's four-dimensional approach (2001) describe personalization through content, delivery mechanisms, and access methods. Fan and Poole (2006) consider personalization in terms of who initiates it, its audience, and what is tailored. Technology has significantly enhanced relationship marketing by shifting from one-way to two-way communication and fostering interactive marketing. Information technology advances enable two-way dialogues via telemarketing and digital channels, optimizing every step in the purchase process, including product development aligned with customer preferences. Modern marketing increasingly relies on electronic relationships to build enduring customer loyalty (Mahmoud et al., 2020).

Technological advancements have transformed communication between marketers and consumers. From the Information Era (1950–1980) with targeting concepts and "customer is king" slogans, to the Era of Individualization (1980–present), technology has enabled a shift from one-way to interactive two-way marketing, making customer relationships more dynamic (Exclaimer, 2024). Digital channels allow more efficient and invasive approaches, facilitating personalization and tracking the entire purchasing process.

Another important aspect of personal data use is the market segmentation it allows. In this way customers can be categorized by geographic, demographic, psychographic, and behavioral criteria. Geographic segmentation analyses markets on national or local levels. Demographic segmentation considers variables like age, income, and gender. Psychographic segmentation, like VALS, examines lifestyles, values, and consumption patterns, identifying groups such as innovators, achievers, and experiencers. Psychographic segmentation allows more precise targeting but requires a mix of intuition and demographic data for accurate application. Market segmentation helps create competitive advantages by understanding different group needs and adapting offerings accordingly.

Personal data can be collected in different ways. Surveys and questionnaires are traditional tools that can be used to collect attitudes and preferences online or offline, supporting quantitative and qualitative analyses (Wavetec, 2024). Digital surveys offer real-time analysis and wider reach. Social media monitoring uses tools to analyze user content and engagement, providing insights into trends and consumer preferences for strategy adjustments. Web analytic tools like Google Analytics track user behavior to optimize content and increase conversion rates. Mobile applications gather location and habit data, enable service personalization and timely data delivery to marketers (Verified Market Research, 2024). Third-party data brokers that build consumer profiles from public and private sources for targeted campaigns, raising privacy concerns (RStreet, 2023). IoT devices that collect user habit data, enabling personalized strategies but posing security challenges (OVIC, 2024).

Research highlights the efficiency and cost-effectiveness of online methods such as cookies and trackers. (Emeritus, 2024). Social media data generate real-time personas, reducing segmentation costs and time while enabling detailed consumer analysis (Mentionlytics, 2024). Technology strengthens links between behavioral and demographic segments, allowing deeper personalization and precision in marketing (The Decision Lab, 2024).

Based on all of the above, it can be stated that personalization is a critical competitive strategy for companies offering online services, directly impacting user satisfaction, retention, and

profitability (Wertenbroch, 2021). With tech-savvy users, understanding their preferences is essential for developing recommendation algorithms and individualized marketing strategies. Traditional personalization models relied on interpersonal interactions (Bettencourt & Gwinner, 1996; Mittal & Lassar, 1996), while modern approaches leverage technologies such as algorithms, databases, and artificial intelligence. However, research suggests that consumers often lack stable preferences and construct them at the moment of decision-making (Bettman et al., 1998; Slovic, 1995).

In the EU, GDPR has significantly impacted advertising-based business models that rely on personal data collection for user targeting (Aridor et al., 2020). This regulation has reduced the ability to track users and requires explicit consent for data processing, leading to lower advertising effectiveness and revenue. Restrictions on data collection have resulted in decreased user engagement with ads, increased costs for advertisers, and reduced overall revenue, negatively affecting the sustainability and quality of content offered by providers (Aridor et al., 2020).

In addition to reducing competitiveness, GDPR has increased market concentration, giving large platforms like Google and Facebook an advantage in collecting and using data. Smaller firms are limited in accessing the data needed for successful operations. This concentration further hinders new market entrants and increases the dominance of large platforms in digital markets (Geradin, 2022).

According to Enthoven (2019), the increasing use of ad-blocking software, especially among Generation Z, drives marketers to alternative advertising methods, such as social media content, including paid posts and "meme" marketing. This approach enables companies to enhance brand visibility at lower costs compared to traditional advertising like Google Ads, which younger consumers often ignore. Netflix exemplifies this strategy by using "meme" content and social media interaction to foster a sense of connection with Generation Z consumers. Leung et al. (2022) state that personalized strategies, including collaborations with local influencers on platforms like TikTok and Instagram, create a more authentic brand image and strengthen consumer trust, as younger audiences value a more personalized approach than traditional mass advertising.

The research objective of this paper is to understand the perception of Generation Z consumers regarding sharing personal data for marketing purposes. According to Zukowski et al. (2007), increasing concerns about online privacy have led users to change their attitudes toward internet privacy. Personal data, as the most critical asset users seek to protect, has become a key area of interest for large corporations. Data markets and data collection for resale purposes have become prevalent business models in the modern marketing and IT industries. According to Sagiroglu et al. (2013), large data sets have become highly sought after in the marketing and social media industries. Data collection practices have expanded, and the quantity and type of data critical for optimizing the marketing mix have changed. With these shifts in data collection dynamics, regulations like GDPR and CPRA have emerged to protect users from obscure and potentially harmful industry practices.

Generation Z, being more informed than previous generations, is well-acquainted with internet services and social media. They are also more aware of the risks associated with internet use and data sharing. This awareness makes them vital to the future of the market as many members of Generation Z are reaching an age where they become active participants in the workforce, increasing their purchasing power. As such, they are becoming a significant consumer segment,

and marketers must ensure data collection practices and marketing strategies are adapted to their needs and expectations.

Therefore, the aim of this exploratory paper is to provide insights on the primary research question: *What are Generation Z's attitudes towards privacy and data sharing for marketing purposes?* To further explore this topic we explore the level of trust Generation Z consumers have in specific data collectors, examining the factors that influence their willingness to share personal data. Additionally, we assess whether these consumers are aware of the consequences of sharing their data, particularly regarding how it is used and what happens to it once it is shared.

Methodology and Research findings

The data was collected through a structured survey questionnaire created on the Google Forms platform. The questionnaire was developed based on questions and measurement scales found in the works of Norberg (2007), Marreiros et al. (2017), Popoli (2010), and Silva (2021), with the questions adapted to more specifically address the topic of the research.

The first section of the questionnaire examined age, gender, level of education, the number of household members belonging to Generation Z, and how many hours per day respondents use the internet in any form. The second section explored whether respondents know what web cookies and web trackers are, if they are familiar with their functionality, and if they are aware of GDPR. Given that the research was conducted in Croatia, where data sharing and privacy are regulated by GDPR, respondents were also asked if they had ever exercised their privacy and data deletion rights guaranteed by GDPR. Respondents were queried about their awareness of data marketplaces and whether they know how their data would be processed when shared. The third section investigated whether respondents have accounts on any social media platforms and if they are aware that social media usage involves the collection of various data points, such as activity, geolocation, and device performance. In this section, a Likert scale from 1 to 5 was used to assess their level of concern about data collection, whether they agree that collected data is used for their benefit, and whether they believe that the advertisements they receive after sharing data are accurately targeted to their interests.

In the fourth section, respondents were asked whether they play video games, as video games, alongside social media, represent another significant source of personal data collection. Respondents were requested to specify which games they play, allowing for a more detailed analysis of potential correlations between specific titles and attitudes toward data sharing. Additionally, they were asked if they are aware that personal data is collected during gameplay and how concerned they are about it, as expressed through a Likert scale.

The fifth section examined whether respondents agree with the statement that their personal information is safe online and whether they are willing to share personal data in exchange for personalized offers and experiences. In the final section, respondents were asked if they believe companies misuse the personal data they obtain from users, which institutions they trust to share personal data with without hesitation, and under what conditions they would consent to online activity tracking and accept the use of web cookies.

The questionnaire was distributed on the social media platform Instagram and the communication platform WhatsApp and was distributed among the students of the University of Zagreb. Data collection took place over two months (from June 20, 2024, to August 20, 2024). Respondents were asked to complete the questionnaire only if they belonged to

Generation Z and to share the survey with household members who also belong to Generation Z. The final sample consisted of 99 questionnaire answers. The sample is not large due to time and budget constraints, also given the fact that most querants did not bother opening the survey after it was sent to them. The analysis of the survey data reveals important insights into the attitudes, awareness, and behaviour of Generation Z regarding personal data sharing, online privacy, and marketing practices. It is representative because the questionnaire was sent out to a broader audience, so the research can be conducted somewhat equally on the whole generation Z age range.

Table 1: Demographic data

What is your age?		What is your gender?		What is your highest achieved level of education?	
Less than 18 years	2	Male	24	Masters degree	44
18 - 20 years	6	Female	74	Bachelor degree	28
21 - 23 years	27	Other	1	Secondary school	24
24 - 27 years	64			Primary school	2
				Other	1

Source: Authors

The majority of respondents (64.6%) belong to the 24-27 age group, followed by 27.3% in the 21-23 range, and a smaller proportion (6.1%) aged 18-20. A very small fraction (2%) are younger than 18. In terms of gender, 74.7% of participants are female, which reflects a significant gender skew in the respondent pool. As for education, the majority of respondents (44.9%) have completed a master's degree, followed by those with bachelor's degrees (28.6%), and a smaller percentage (24.5%) having completed high school.

Table 2: Internet use and web cookies awareness data

How many hours a day do you use the internet in any form (social networks, online video games, web browsing, streaming services, etc.)		Do you know what web cookies are?	
Less than 4 hours	21	Yes	90
4 - 6 hours	34	No	9
6 - 8 hours	23		
8 - 10 hours	8		
More than 10 hours	12		

Source: Authors

The respondents exhibit significant internet engagement, with 34.7% reporting moderate usage of 4-6 hours daily. This aligns with the understanding that Generation Z spends considerable time online, making them a valuable demographic for digital marketing. A vast majority (90.9%) are aware of web cookies, though fewer are familiar with their detailed functionality. Only 7.1% are fully knowledgeable, with many respondents indicating limited understanding of the inner workings of cookies and web trackers.

Table 3: Web cookies and GDPR familiarity data

How familiar are you with the functionality of web cookies and web trackers?		How familiar are you with the GDPR (General Data Protection Regulation)?		Have you ever personally exercised your rights to privacy and deletion of personal data, which are guaranteed to you by the GDPR?	
Not familiar at all	11	Not familiar at all	13	Yes	31
Partially familiar	42	Partially familiar	27	No	41
I am familiar	19	I am familiar	24	Not sure	27
Very familiar	20	Very familiar	24		
Completely familiar	7	Completely familiar	11		

Source: Authors

Despite a high awareness of web cookies, fewer respondents are well-versed in GDPR (General Data Protection Regulation), with only 25% expressing moderate to full familiarity with the regulation. Interestingly, 31.3% of participants have exercised their GDPR rights to data deletion, while 41.4% have not, pointing to a gap between awareness and action. Additionally, a concerning 60.6% are unaware of how their data is processed upon sharing, emphasizing a need for greater transparency in how personal data is handled.

Table 4: Attitudes towards data collection on social networks

Did you know that while using a social network, various metrics about your behavior while using the network, as well as device performance and other personal data, can be collected? (geolocation, device model, contacts, etc.)		How concerned are you about the collection of the above data while using a social network?		To what extent do you agree that the collected data is used for your benefit?	
Yes	94	I am not very concerned	5	Strongly disagree	12
No	5	I am not concerned	41	Disagree	29
		I am indifferent	27	Undecided	32
		I am concerned	18	Agree	22
		I am very concerned	8	Strongly agree	4

Source: Authors

Almost all respondents (98%) have accounts on social media platforms, and 94.9% are aware that their data is collected while using these services. However, concerns about data collection vary, with 41.4% expressing moderate concern, and 18.2% being highly concerned. Interestingly, while 23.5% of respondents are willing to share their data for personalized offers, a larger portion (43.8%) either disagree or are undecided, signaling a reluctance to share personal information, especially when the benefits are unclear.

Table 5: Attitudes towards private data sharing and security

I am willing to share my personal information if I receive personalized offers/experience in return.		I believe that companies misuse the personal data they receive from users.		I trust that my personal information is safe when I share it online.	
Strongly disagree	20	Strongly disagree	4	Strongly disagree	25
Disagree	23	Disagree	6	Disagree	44
Undecided	26	Undecided	25	Undecided	25
Agree	23	Agree	40	Agree	4
Strongly agree	6	Strongly agree	23	Strongly agree	1

Source: Authors

When asked about the safety of their personal information online, a significant portion (25.5%) strongly disagrees that their data is secure, and 44.9% disagrees. This indicates a lack of trust in the current data security practices of online platforms. Similarly, 22.2% of respondents expressed agreement that companies misuse personal data, reflecting growing concerns over privacy violations and unethical data practices.

Table 6: Personal data sharing willingness (by perceived benefits)

Under what conditions would you accept the use of web cookies and give consent to the tracking of other online activities?	Number of consumers
Percieved benefits	
If it will improve my user experience in the future.	51
If they will provide me with personalized offers and user experience.	27
If they will ensure the security of my dana.	76
If I get discount or special offers.	35

Source: Authors

This table shows certain situations in which the consumers would consent to the tracking of other online activities, showing that security of data is the most important factor, followed by the improvement of the user experience in the future. This graph shows that the examinees value their security and positive user experience the most.

Table 7: Personal data sharing willingness (by organization type)

To which of the above choices are you willing to give your personal information without hesitation?	Number of consumers
Banks	78
Gambling/betting companies	4
Small and medium size enterprise	15
Social media companies	19
Marketing agencies	9
Streaming services	9
Video game companies	7
Educational institutions	84
Medical institutions	85

Source: Authors

Examinees stated that banks, medical and educational institutions are the most trustworthy among the list, yet gambling/betting companies and marketing agencies along streaming services and video game companies don't seem to be trustworthy.

Regarding the willingness to share personal data, 51.5% of respondents would consent to tracking if it improves their user experience, and 76.8% would agree if data security were guaranteed. These findings suggest that Generation Z is open to data collection under conditions that promise security or enhanced user experience. On the other hand, institutions such as banks (78.8%) and healthcare (85.9%) are seen as more trustworthy recipients of personal data, while less trusted entities include video game companies (7.1%) and marketing agencies (9.1%).

The data suggests that Generation Z is highly aware of data collection methods, particularly through cookies and social media, but remains cautious and skeptical about how their personal information is used. While they are willing to share data for personalized experiences or security guarantees, their trust in companies and data collectors is conditional. This presents both a challenge and an opportunity for marketers to align their strategies with the privacy concerns of Generation Z, emphasizing transparency, security, and value in data-sharing practices.

Discussion

The primary objective of this study was to examine how Generation Z consumers perceive the process of sharing personal data for marketing purposes. The goal was to determine whether short-term or long-term changes are necessary to ensure that data collection practices in marketing can continue smoothly, as they did with previous generations. Additionally, the study aimed to assess the limits of data collection before it causes discomfort or damages consumers' trust in the marketing profession.

A survey of 99 Generation Z respondents in Croatia provided insight into current consumer perceptions of data sharing in marketing. While some findings confirmed previous research, notable differences emerged. Key insights revealed that young consumers, at least in this sample, hold slightly negative attitudes toward sharing personal data for marketing purposes. They are moderately familiar with GDPR and web cookies but lack a clear understanding of how their personal data is used.

A concerning finding is that many respondents believe companies misuse their data. Moreover, Generation Z consumers in this study hesitate to share their personal data with marketing agencies, indicating a lack of trust in institutions that use their data for product placement.

The study highlights various issues related to personal data sharing in marketing and the negative perceptions held by this generation regarding current practices. These findings suggest a need to explore why consumer attitudes have changed and how trust in marketing institutions can be restored. If consumer perceptions of data sharing in marketing continue to decline, it may only be a matter of time before stricter regulations are introduced to protect privacy. Such regulations could severely impact several economic sectors, making it crucial to address these concerns and maintain a balance between data-driven marketing and consumer privacy rights.

Conclusion

Despite the increasing use of the internet and significant changes in the way the marketing mix is managed, as well as changes in the dynamics of personal data collection for marketing purposes, consumer attitudes toward sharing personal data for marketing purposes remain insufficiently researched, with contradictory results across studies. Given that Generation Z is a group of individuals who are now entering the age where their purchasing power significantly increases and they are becoming a significant part of the global economy, marketing professionals should focus more on adapting existing outdated practices to this new, different generation. Attitudes about sharing personal data play a crucial role in the future of marketing because personalized marketing is easily subject to various legal regulations such as GDPR and CCPA.

In the literature, personal data is defined in slightly different ways, but most studies agree on the issues surrounding the privacy of personal data and the avoidance of scandals related to the misuse of personal data and violation of consumer privacy. In addition to personal data, the literature notes that the perception of actions related to sharing personal data varies from person to person.

The main goal of this study was to explore how Generation Z consumers perceive the process of sharing personal data for marketing purposes in order to understand whether short-term or long-term changes are necessary for the current process of collecting personal data for marketing purposes (as with previous generations), so that it can proceed smoothly, and to more easily predict the limits to which data collection can go without alarming users or destroying their attitudes toward the marketing profession.

Research conducted on 99 Generation Z respondents in Croatia provided insight into current consumer perceptions of sharing data for marketing purposes. Some results confirmed previous research, while others significantly differed. The most important findings from this study suggest that young consumers, at least from this sample, have slightly negative attitudes toward sharing personal data for marketing purposes, are moderately familiar with GDPR and cookies, but are not well-versed in how their personal data is used. It is concerning that a larger proportion of respondents believe their data is being misused by companies, and another concerning fact is that Generation Z consumers in this sample hesitate when it comes to providing personal data to marketing agencies. This indicates a lack of trust in institutions that use their data to engage in product placement.

The results of this study provide insight into the issue of sharing personal data for marketing purposes and reveal a range of problems related to the attitudes of a generation toward existing practices. Based on the insights gained from this research, it is necessary to consider why consumer attitudes have changed and how can marketing experts regain consumers' trust so that marketing activities can continue smoothly in the future. If consumer perception of data sharing for marketing purposes worsens further, it is only a matter of time before regulations are introduced that completely prohibit the collection of personal data to protect individuals' right to privacy, which could have negative consequences for several sectors of the economy.

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JUDGED BY ITS COVER: UNDERSTANDING THE FORMATION OF BOOK TESTIMONIAL NETWORKS

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Abstract

Testimonials, short promotional statements often written by notable authors or critics, are a crucial marketing tool in the publishing industry, contributing to a book's market success. This study investigates the formation of ties in testimonial networks, focusing on both network-endogenous factors (reciprocity, transitivity and preferential attachment) and exogenous factors tied to social homophily, such as shared publisher, genre and gender. A network of 575 authors was constructed from testimonials in fiction books published between 2020 and 2024 and analyzed using Exponential Random Graph Models (ERGM). The results reveal strong effects of reciprocity, transitivity, and homophily, particularly with respect to publisher and genre. Reciprocity appears to play a key role in testimonial exchanges, suggesting that authors who provide testimonials are significantly more likely to receive testimonials in return. Authors are likely to form connections through shared relationships. However, the network does not exhibit significant inequality in tie distribution, indicating that preferential attachment is not a dominant mechanism. The results strongly confirm that shared attributes, especially publisher and genre, significantly influence testimonial formation, with publisher-based homophily being the most impactful. This reflects the role of publishers in orchestrating testimonial exchanges, as they may actively encourage authors within their networks to provide testimonials for one another. These findings offer insights into the structural dynamics of testimonial networks and provide practical implications for emerging authors seeking to establish connections in the competitive publishing market. The strong evidence for reciprocity underscores the importance of actively engaging in the testimonial exchange process. The lack of evidence for preferential attachment is a promising finding for emerging authors, as it suggests they are not disadvantaged by having fewer initial connections.

Keywords: social network analysis, testimonials, book market, ERGM

JEL classification: M30, M31, M37

Introduction

The book market is heavily marketing-driven (Baverstock, 2008) and to succeed in it, authors or their management must master book marketing. One popular marketing tool in the publishing industry is the use of blurbs, which often include testimonials – short, promotional statements that highlight the quality of a book. Oxford University Press (2025) defines a blurb as „a short description of a book, a new product, etc., written by the people who have produced it, that is intended to attract your attention and make you want to buy it.“ Studies have shown that more than 80% of the examined blurbs contain testimonials (Grossi, 2015; Godis, 2017). These testimonials typically consist of excerpts from reviews written by literary critics in newspapers or requested comments, which may be as short as a single sentence or even a word, typically authored by famous writers (Grossi, 2015). Due to their prevalence, the term "blurb" is often used synonymously with "testimonial," even though testimonials are only one part of a blurb. Although on the surface the primary function of testimonials is to persuade potential readers to purchase the book, some experts argue that they play an equally crucial role in securing a book's initial placement in bookstores and appealing to industry professionals (Grossi, 2015, Qasim & Shakir, 2016). Thus, testimonials act as endorsements that attract the attention of retailers and reviewers, helping to position the book in a competitive market. As Dwyer (2015) explains in his National Public Radio (NPR) article, testimonials are not necessarily intended for readers alone; by the time they reach the reader, prominently displayed on a book, they have already accomplished much of their intended purpose. This underscores the critical role testimonials play in determining a book's market success. New authors are especially reliant on testimonials written by well-known authors to gain immediate recognition and visibility within the reading community (Qasim & Shakir, 2016). Without recommendations from established writers, it may be difficult for emerging authors to successfully market their upcoming book. A testimonial from a famous person is a good indicator that the book will attract media attention and reach an audience interested in purchasing books, thereby contributing significantly to its success.

However, securing these valuable testimonials demands both time and dedicated effort. Authors must build connections with influential figures in the industry who can amplify their reach. Yet for those without pre-existing ties to prominent players, this task may appear significantly more challenging. Understanding how ties between authors in testimonial networks form and the mechanisms that drive their structure could offer new authors practical strategies for establishing these critical connections. These mechanisms can be categorized into endogenous and exogenous factors: while endogenous mechanisms describe structural tendencies emerging from the network itself, such as reciprocity, transitivity and preferential attachment, exogenous mechanisms involve attributes external to the network structure, like shared characteristics among actors (e.g., gender, publisher, or genre), that affect tie formation (Contractor et al., 2006). Accordingly, this study addresses the following overarching research question: Which network endogenous and exogenous factors influence the formation of ties in testimonial networks? To investigate this question, we constructed a dataset of testimonials and employ Exponential Random Graph Models (ERGM) to systematically test how reciprocity, transitivity and preferential attachment, as well as exogenous factors tied to social homophily (shared publisher, genre, or gender) shape network formation. By exploring these mechanisms,

this work aims to uncover strategies that can assist emerging authors in establishing the critical connections needed to thrive in a competitive market.

The next section provides the theoretical background, including related work and the formulation of hypotheses based on existing theories and prior research. The following section outlines the methodology, covering data collection, preprocessing and the network modeling approach using ERGM. The next section focuses on the results, including descriptive network metrics and the outcomes of the ERGM analysis. In the following, the findings are evaluated and discussed, alongside the study's limitations. Finally, the last section concludes with a summary of the key insights and directions for future research.

Theoretical Background

Related Work

When analyzing the topic of book testimonials, one frequently encounters the term blurb in the literature. However, its usage is not consistent. Most commonly, blurb refers to the text found on the back cover of a book, which typically includes a description of the book's content, excerpts from reviews and biographical details about the author (Valor, 2005). In contrast, Cronin and La Barre (2005) understand blurbs more narrowly as testimonials or endorsements appearing on the back cover. To avoid ambiguity, this study employs the term testimonial to refer explicitly to the promotional statements or endorsements typically written by notable figures such as authors, critics, or industry professionals and are frequently part of a blurb.

The majority of existing work focuses on blurbs and their linguistic and rhetorical features, analyzing how they function as promotional texts. Common findings include the use of elliptical syntactic patterns, imperative forms, and direct address through "you" to create a persuasive tone (Valor, 2005). Cacchiani (2007) analyzed the most frequently occurring words in blurbs, identifying intensifying adverbs ("very", "most"), positive evaluative adjectives ("brilliant", "powerful") and hyperbolic expressions ("screamingly funny") as key linguistic features used to emphasize a book's qualities.

Other studies have examined blurbs in a cross-cultural context, showing how socio-cultural factors influence their structure and content. Önder (2013) compared online fiction blurbs from Amazon UK and Okuoku TR, a Turkish online bookstore, and identifies differences in schematic structure and promotional strategies. Similarly, Kathpalia (1997) analyzed blurbs from international and Singapore-based publishers, highlighting how cultural constraints shape their organization and communicative purpose.

While these studies provide insights into the textual and cultural aspects of blurbs, the social dynamics underlying testimonials as a networked phenomenon remain largely unexplored. One of the few studies addressing this perspective is by Cronin & La Barre (2005), who analyzed a sample of 450 non-fiction books in the fields of business and history, focusing on 1,850 testimonials. Using data manually collected from bookstores, they recorded the number of testimonials per book, the names of endorsers, and their institutional affiliations. Their analysis examined aspects such as the frequency of reciprocal testimonials, the distribution of endorser affiliations (e.g. media, academia, industry), and the presence of high-frequency endorsers or "serial blurbers". The study found that media professionals were the most common source of testimonials, followed by individuals from industry and academia. Business books featured

more testimonials on average than history books, while reciprocal endorsements were rare, with only three cases identified in the business book subset. However, the study is limited by its purely descriptive approach, which provides an overview of patterns but lacks analytical depth regarding the underlying mechanisms of testimonial formation. While the authors hypothesized about broader social dynamics, such as reciprocity and professional networks, these were not systematically tested. Our work addresses this gap by employing a hypothesis-driven approach to investigate the factors influencing testimonial networks, using methods that allow for a deeper understanding of the structural and social dynamics at play.

Hypotheses

The formation of ties in social networks can be explained by several well-established theories. The Social Balance Theory, introduced by Heider (1946), explains how individuals strive for consistency and stability in their relationships and attitudes within a network. A balanced state exists when relationships among entities are harmonious, meaning that all relations within a configuration are consistently positive or consistently negative. Conversely, imbalance, such as an unreciprocated tie where one individual holds a positive attitude toward another but does not receive the same in return, creates psychological tension. This tension motivates individuals to adjust their relationships to restore balance. Heider's theory applies not only to dyads but also to triads. In dyadic relationships, reciprocity serves as a key balancing mechanism, as individuals aim to maintain symmetrical relations, such as mutual liking or admiration. For instance, an author who endorses another may expect a testimonial in return, fostering balanced and reciprocal ties. In triadic configurations, transitivity emerges as another mechanism for achieving balance: if two individuals are connected through a shared third party, a direct connection between them can help align attitudes and stabilize the network. Preferential Attachment, as described by Barabási & Albert (1999), explains the mechanism by which nodes in a network acquire connections over time. The theory posits that new nodes are more likely to connect to existing nodes that already have a high degree of connectivity. This phenomenon, often described as the "rich-get-richer" effect, results in networks where a small number of nodes become highly connected, dominating the structure. Such networks exhibit a scale-free topology, meaning the probability $P(k)$ that a node has k connections follows a power-law distribution. The principle of Homophily, often summarized as "birds of a feather flock together", states that connections between individuals with similar characteristics occur at a higher rate than between dissimilar individuals (McPherson et al., 2001). This phenomenon is pervasive across various types of social networks and relationships, including friendships, work associations, and information exchange. Homophily results in the formation of networks that are highly homogeneous with respect to attributes such as gender, age, ethnicity, and shared values. This structural tendency has significant implications, as it localizes the flow of information and resources within specific groups, reinforcing existing social divides and creating cohesive subgroups within the broader network.

Cronin & La Barre (2005) raise several questions that align with these theoretical considerations. Their inquiry into whether reciprocal testimonials exist aligns with reciprocity, while their focus on shared organizational affiliations or backgrounds influencing testimonial ties reflects homophily. The question of whether certain individuals act as central nodes by frequently giving or receiving testimonials corresponds to preferential attachment. While their study provided descriptive insights, it did not systematically test these dynamics.

Building on these ideas and the theoretical frameworks, we propose the following hypotheses:

H1 - Reciprocity: Authors who provide testimonials are more likely to receive testimonials in return, strengthening bilateral relationships between authors.

H2 - Transitivity: Authors in the network who share mutual connections are more likely to form additional ties, indicating a high degree of transitivity.

H3 - Preferential Attachment: Authors with a higher number of existing testimonials are more likely to attract additional endorsements, leading to a "rich-get-richer" phenomenon.

H4 - Homophily: Authors in the network who share similar attributes are more likely to form testimonial ties. This hypothesis is further specified:

H4a: Authors in the network who share the same genre are more likely to form testimonial ties (homophily by genre).

H4b: Authors in the network who share the same gender are more likely to form testimonial ties (homophily by gender).

H4c: Authors in the network who are associated with the same publisher are more likely to form testimonial ties (homophily by publisher).

Methodology

Data Collection and Preprocessing

The absence of publicly available datasets capturing testimonials created a critical challenge in studying testimonial networks. To address this, we constructed a custom dataset. The source for the dataset was Hudson Booksellers, a prominent online book retailer with an extensive catalog of contemporary works across diverse genres (Hudson Booksellers, 2024). This retailer was particularly suited for analyzing testimonial networks due to its inclusion of a dedicated testimonial section for each book and its structured website layout, which facilitated efficient and reliable data extraction. Preliminary analysis of a random sample of 100 books across various genres revealed notable disparities in the presence of testimonials. Non-fiction genres had testimonial absence rates as high as 99%, whereas fiction genres exhibited richer testimonial data, with absence rates as low as 25%. We therefore focused on fictional genres to ensure the dataset was representative of meaningful testimonial relationships and robust for network analysis. After establishing the feasibility of data collection, we gathered metadata for books across 61 genres. To ensure balanced representation, genres with fewer than 1,000 entries were excluded. Books were ordered using the website's default browsing settings. The metadata, including book titles, authors and testimonials, was systematically collected (Data was accessed on October 26, 2024). The data cleaning process included the following steps: Duplicate entries, such as audiobooks or different editions, were removed. Only English-language books were retained to ensure linguistic consistency. Testimonials were limited to authors who had published within the fiction genres considered, excluding testimonials from authors without published books, organizations, or critics. Books with multiple authors were excluded to avoid ambiguity and the dataset was restricted to books published between 2020 and 2024 to maintain temporal relevance. Finally, the dataset was refined to focus on the ten most popular fiction genres, as identified by ISBNdb, one of the largest online databases of book information: Fantasy, Science Fiction, Romance, Thriller, Horror, Mystery, Literary

Fiction, Action & Adventure, Historical Fiction and Young Adult (Hilgeman, 2024). Metadata on publishers, genres and author genders was collected to analyze external factors. To ensure clarity and avoid complications with ERGM, the dataset included only authors who published within a single genre and with a single publisher, enabling direct use of metadata as features. Gender classification was conducted manually through internet research into each author's self-identified gender, limited to binary categories (male and female). A second reviewer independently verified each classification to ensure accuracy and minimize bias. Authors with undetermined or non-binary gender were excluded. The final dataset comprised a directed network edge list, where each edge represents a testimonial labeled with the corresponding book title, along with a metadata file containing attributes such as author gender, genre and publisher.

Network modeling: ERGM

In this paper, we estimated and calculated the model parameters using the 'statnet' and 'ergm' packages in R software (version 4.4.2) (Goodreau et al., 2008). Statnet is a collection of R packages designed for the representation, visualization, analysis, and simulation of network data. Ergm (Exponential Random Graph Models) is a statistical modeling package for analyzing network structure. It is a core component of the statnet suite. To test our hypotheses, we constructed a series of models, progressively building upon one another to identify the best-fitting overall model. The modeling process began with Model M0, which included only the baseline term for edges to capture the probability of a tie occurring in the first place. To refine this initial model, we incorporated the variable mutual for reciprocity, resulting in Model M1. Building upon Model M1, Model M2 introduced the geometrically weighted edgewise shared partner statistic (GWESP) to capture triadic closure (or transitivity). Prior to selecting GWESP, both transitivity and triangle terms were tested but resulted in model degeneracy. Given its robustness against such issues and its enhancing model reliability and more accurately capturing the network's dynamic behavior and structural characteristics (Song et al., 2024), GWESP was chosen with a decay parameter of 0.1, identified as the optimal value to prevent degeneracy. Triadic closure, as noted by Newman (2003), is a widely used mechanism to model transitivity, as it reflects the process by which edges form preferentially between nodes with a common neighbor, completing triangles and increasing transitivity within the network. Model M3 examined preferential attachment, leveraging gwidegree and gwodegree with a decay parameter of 0.8 to evaluate the formation of ingoing and outgoing connections in the directed network as proposed by Hunter (2007). The model also contained the variable mutual but not the GWESP because the model with both variables degenerated. Additionally, the Gini coefficient was calculated to assess the extent of unbalanced degree distribution (Moskowitz et al., 2008). Because in general preferential attachment can be seen as the main driver of inequality (Espín-Noboa et al., 2022) a high Gini coefficient could further second the hypothesis of preferential attachment. To investigate the influence of homophily, nodematch variables for gender, publisher and genre were incorporated into the model. As demonstrated by Hunter et al. (2008), introducing more parameters can significantly improve model fit, which underscores the rationale for including these factors. Combined with the structural terms from the preceding models, these variables formed a comprehensive Model M4 that integrated both endogenous and exogenous determinants. Two versions of Model M4 were evaluated: one including variables for preferential attachment and one excluding them, to determine the relevance of this mechanism in the network. To assess the fit we used measures such as p-value, Akaike information criterion (AIC), Bayesian information criterion (BIC) and Markov Chain Monte Carlo (MCMC) diagnostics.

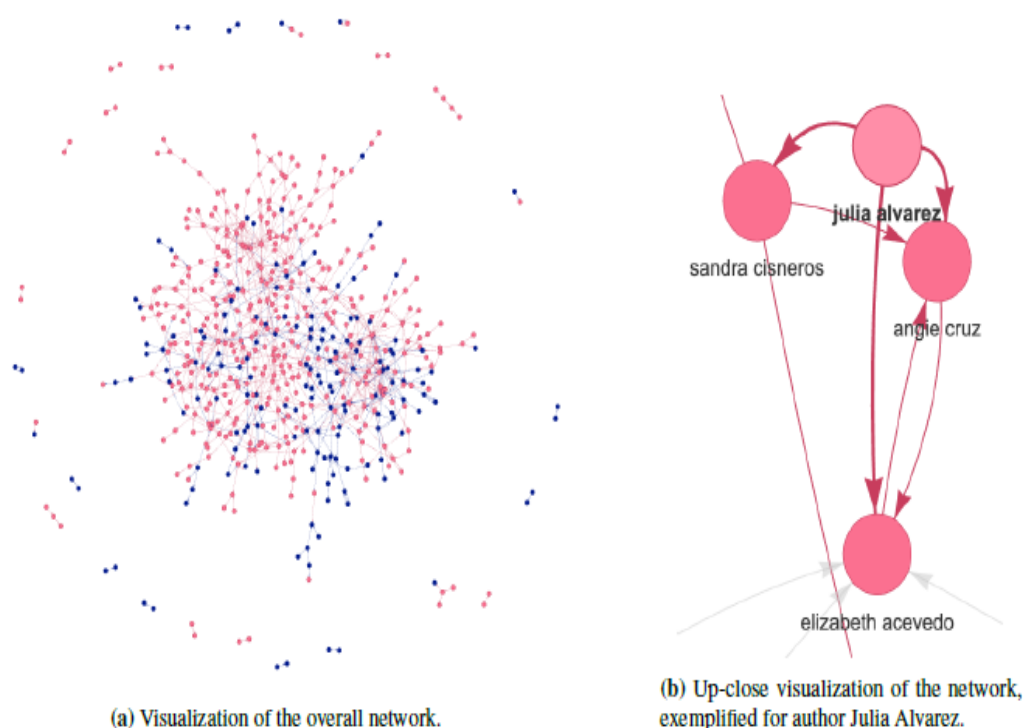
Results

Network Descriptives

The final testimonial network contains 575 nodes and 942 directed ties, resulting in a directed density of 0.00285, which suggests a sparse and not fully connected network structure. The average degree, evenly distributed between In- and Out-Degree, indicates that each author maintains approximately 3.2 testimonial connections, reflecting a relatively low level of overall engagement in the testimonial exchange process. The average normalized betweenness centrality of 0.00033 highlights that authors rarely act as intermediaries, with most testimonial exchanges occurring directly between pairs of authors. In terms of geodesic distances, the average closeness centrality is 0.249, suggesting moderate accessibility among authors. This indicates that testimonials form a reasonably connected structure where authors are accessible as both recipients and providers. Clustering measures provide further insights into the network's dispersed nature. The Global Clustering Coefficient is 0.099, revealing limited triadic closure at the global level. Similarly, the Average Clustering Coefficient of 0.088 indicates sparse local clustering within authors' immediate neighborhoods. These metrics collectively highlight a testimonial network where ties are scattered and do not form cohesive, tightly-knit groups, pointing to a fragmented exchange process.

Figure 1 provides visualizations of the testimonial network, with Subfigure 1a illustrating the entire network structure and Subfigure 1b focusing on a detailed view of a specific example author.

Figure 1: Visualizations of the testimonial network using library visNetwork. The colors represent genders (blue: male, pink: female)



Source: authors' own work

ERGM Results

Table 1 presents the fits of the six models, which were examined using the summary() command. The stars accompanying the p-values indicate the statistical significance of the coefficients, with all coefficients being highly significant.

The models build incrementally upon one another. Model M0 serves as the baseline, including only the edges term with a negative coefficient of -5.92. This indicates that, in the absence of other structural or attribute-based factors, the probability of forming ties in the network is low, reflecting its sparsity. Model M1 highlights the importance of reciprocity (mutual), as evidenced by its coefficient value of 3.68, indicating a strong and significant effect. Model M2 introduces the GWESP term to capture the tendency for triadic closure, which also shows a positive and significant coefficient of 2.23, underlining the importance of this structural feature in the network. In Model M3, the inclusion of gwidegree and gwodegree allows for the measurement of preferential attachment. However, both coefficients are negative, suggesting that preferential attachment does not characterize the network's structure. Although the final Model M4+, which includes all variables, achieves superior AIC and BIC scores, the MCMC diagnostics reveal a potential linear dependency between GWESP and gwodegree. This suggests that these variables may negatively interact, compromising the model's robustness. In contrast, Model M4 demonstrates significantly better MCMC diagnostic values, making it a more reliable choice as the final model. Excluding preferential attachment is preferable to accepting a potentially flawed model. The conclusion that preferential attachment is not significant in this context is further supported by the Gini coefficients for indegree (0.51) and outdegree (0.65). While a Gini coefficient closer to 1 would indicate a high degree of inequality, the observed values remain moderate, suggesting that the network exhibits relatively balanced degree distributions, which contradicts the core assumption of preferential attachment—where highly connected nodes should disproportionately attract more ties. Thus, the exclusion of preferential attachment from the final model is well-justified based on the diagnostics and statistical evidence. Based on the results from M3 and the Gini coefficients, we reject H3 (preferential attachment). Model M4 incorporates exogenous variables for gender, publisher and genre with the endogenous variables such as mutual and GWESP. The coefficient for edges (-6.79) is negative and statistically significant, indicating that forming ties is overall unlikely unless supported by additional structural or attribute-based mechanisms. This reflects the sparsity of the network, where connections require specific driving factors. The coefficients for nodematch.gender (0.49), nodematch.publisher (1.30), and nodematch.genre (1.14) are positive and statistically significant, highlighting the strong influence of homophily in shaping the network structure. The inclusion of GWESP (coefficient 1.69) captures the tendency for triadic closure and therefore transitivity as explained earlier. Reciprocity, represented by mutual, continues to show a positive and significant effect, reinforcing its importance in the network's formation. The AIC (11031) and BIC (11095) scores further affirm the model's fit while maintaining robustness. Thus, Model M4 strikes a balance between explanatory power and model stability, emphasizing reciprocity, triadic closure and homophily as the dominant mechanisms in the network's formation. Therefore, we confirm H1 (reciprocity), H2 (transitivity) and H4 (homophily), including its sub-hypotheses H4a, H4b and H4c.

Table 1: Model Fit Statistics

No	Configurations	Estimated value (standard error)	Z-value	P-value	AIC	BIC
Model M0	edges	−5.9210 (0.0337)	−175.7	< 1e-04 ***	12227	12238
Model M1	edges	−6.01485 (0.03439)	−174.90	< 1e-04 ***	12015	12037
	mutual	3.68748 (0.17677)	20.86	< 1e-04 ***		
Model M2	edges	−6.15395 (0.03592)	−171.341	< 1e-04 ***	11616	11649
	mutual	2.14569 (0.24220)	8.859	< 1e-04 ***		
	gwesp.fixed.0.1	2.23489 (0.08272)	27.019	< 1e-04 ***		
Model M3	edges	−4.69655 (0.07971)	−58.918	< 1e-04 ***	11671	11713
	mutual	3.65916 (0.17124)	21.369	< 1e-04 ***		
	gwideg.fixed.0.8	−0.64388 (0.14043)	−4.585	< 1e-04 ***		
	gwodeg.fixed.0.8	−2.21432 (0.10835)	−20.437	< 1e-04 ***		
Model M4	edges	−6.79368 (0.06520)	−104.194	< 1e-04 ***	11031	11095
	mutual	1.71698 (0.24694)	6.953	< 1e-04 ***		
	nodematch.gender	0.48918 (0.06525)	7.497	< 1e-04 ***		
	nodematch.publisher	1.29534 (0.09463)	13.688	< 1e-04 ***		
	nodematch.genre	1.13554 (0.06822)	16.644	< 1e-04 ***		
	gwesp.fixed.0.1	1.69108 (0.09447)	17.901	< 1e-04 ***		
Model M4+	edges	−6.46627 (0.08150)	−79.340	< 1e-04 ***	10929	11014
	mutual	1.79762 (0.24277)	7.405	< 1e-04 ***		
	nodematch.gender	0.46226 (0.06211)	7.443	< 1e-04 ***		
	nodematch.publisher	1.28613 (0.09389)	13.698	< 1e-04 ***		
	nodematch.genre	1.11329 (0.06650)	16.741	< 1e-04 ***		
	gwesp.fixed.0.1	1.46549 (0.09703)	15.104	< 1e-04 ***		
	gwideg.fixed.0.1	0.20410 (0.13401)	1.523	0.128		
	gwodeg.fixed.0.1	−1.27827 (0.12700)	−10.066	< 1e-04 ***		

***P < 0.001

Source: authors' own work

Discussion

Theoretical and Practical Contributions

Building on the results, the proposed hypotheses and their practical implications are evaluated. First, reciprocity appears to play a key role in testimonial exchanges, suggesting that authors who provide testimonials are significantly more likely to receive testimonials in return. This finding aligns with the theoretical expectation that balanced dyadic relationships foster stability, as predicted by the Social Balance Theory. Interestingly, it contrasts with the findings of Cronin & La Barre (2005), who observed limited reciprocity in their study of non-fiction books. This discrepancy may reflect differences in the relational dynamics of fiction versus non-fiction authors, as the former may rely more heavily on interpersonal connections and mutual support. Transitivity also plays a noteworthy role. The positive and significant coefficient for the GWESP term demonstrates a strong tendency for transitive triadic closures in the network. While the global and local clustering coefficients indicate limited clustering overall, the ERGM results reveal that transitivity still plays a critical role in the network's formation. This suggests that, although the network is sparse, authors are likely to form connections through shared relationships, contributing to the creation of cohesive substructures. Taken together, the confirmation of reciprocity and transitivity supports the

Social Balance Theory at both the dyadic and triadic levels, demonstrating that authors actively seek to align their relationships to reduce psychological tension and maintain structural balance. In contrast, preferential attachment does not appear to shape the network's structure. The negative coefficients for gwidegree and gwodegree, along with moderate Gini coefficients for indegree and outdegree, indicate that authors with more existing testimonials are not disproportionately likely to attract additional endorsements. Instead, the results suggest that factors like reciprocity and shared attributes are more important in driving tie formation. This finding challenges the assumption of a "rich-get-richer" effect in testimonial networks and suggests that relational and contextual factors play a more significant role in shaping connections. Finally, the results for homophily strongly confirm that shared attributes significantly influence testimonial formation. Positive and significant coefficients for nodematch variables—particularly publisher and genre—underscore the importance of similarity in driving tie formation. Among these factors, homophily based on publisher is the strongest. This may reflect the role of publishers in orchestrating testimonial exchanges, as they often have a vested interest in promoting their authors and may actively encourage authors within their networks to provide testimonials for one another. The results also underscore the importance of shared thematic alignment, as seen in the strong effect of genre, and to a lesser extent, shared demographic characteristics such as gender. Interestingly, the prominence of homophily by publisher over homophily by gender can be further interpreted through the lens of Distinctiveness Theory (Di Tommaso et al., 2020). While gender might appear as a salient characteristic, with 408 female and 167 male authors in the network, the relatively balanced distribution reduces its distinctiveness as a basis for tie formation. In contrast, publisher affiliation, where the largest group includes only 37 authors and the remaining publishers represent even smaller subsets, becomes a more distinctive characteristic. According to Distinctiveness Theory, individuals are more likely to form connections based on attributes that are rare or less evenly distributed in their social context. This could explain why publisher affiliation emerges as the strongest predictor of homophily in the network.

These findings offer several practical implications for authors, particularly those who are emerging in their careers, on how to navigate testimonial networks effectively. By understanding the dynamics that drive these networks, authors can strategically position themselves to benefit from them. The strong evidence for reciprocity underscores the importance of actively engaging in the testimonial exchange process. Authors who provide testimonials to others significantly increase their chances of receiving testimonials in return. For emerging authors, this finding highlights the value of proactively endorsing peers' works, especially within similar genres or shared publishing networks. The confirmation of transitivity underscores the value of shared connections in facilitating new ties. Authors can benefit from engaging with mutual collaborators or participating in communities where such relationships naturally emerge. For example, being introduced to peers through shared connections can open pathways to collaboration and new testimonial opportunities. This highlights the importance of active participation in spaces such as writer communities, events, or online platforms, where shared relationships are likely to form and foster further engagement. The lack of evidence for preferential attachment is a promising finding for emerging authors, as it suggests they are not disadvantaged by having fewer initial connections. Instead, factors like reciprocity and shared attributes hold greater weight in tie formation. This underscores the importance of adopting diverse endorsement strategies. Rather than focusing solely on highly visible authors, both authors and publishers should consider distributing testimonial opportunities more evenly across the network. The pronounced role of homophily, particularly by publisher affiliation, further emphasizes the importance of leveraging professional contexts. Shared affiliation with a publisher and thematic alignment through genre both serve as strong bases for connections,

highlighting the value of engaging with peers in similar professional and creative contexts. This is especially relevant for emerging authors, as these networks can provide a foundation for building relationships and gaining visibility. Additionally, publishers can facilitate connections by creating initiatives or platforms that encourage collaboration among their authors.

Limitations

Although this study provides valuable insights into testimonial networks, several limitations must be acknowledged to ensure transparency and guide future research. These constraints highlight areas where improvements could enhance the generalizability, inclusivity, and depth of understanding regarding the formation and dynamics of testimonial networks. First, relying on one single retailer as the primary data source introduces potential biases. This limitation affects the generalizability of the findings to other platforms or the broader publishing industry. Additionally, reliance on the default sorting algorithm for browsing books introduces uncertainty, as its proprietary nature makes it unclear how the algorithm prioritizes or ranks books. Despite this, the retailer provided the most extensive accessible testimonial collection, enabling meaningful analysis within the study's practical constraints. The dataset's size and scope posed challenges, leading to data reduction decisions like focusing on single-genre, single-publisher authors and excluding multi-author books. While addressing ERGM's computational limits, this may have biased the focus toward the ten most popular fiction genres. As a result, the findings may not generalize to less-represented genres, multi-genre authors, or non-fiction networks. Another limitation is the use of binary gender categories, excluding non-binary authors and limiting the study's inclusivity. Finally, the analysis of preferential attachment is subject to limitations resulting from both methodological challenges and the constraints of the data source. The inclusion of the parameters *gwidegree* and *gwodegree* in the ERGM model caused issues of linear dependency, which made their exclusion necessary to ensure model stability. As a result, the Gini coefficient was used as an alternative indicator. While this suggested that preferential attachment is not a dominant mechanism in the network, it does not allow for a direct comparison with the other mechanisms examined in this study, namely reciprocity, transitivity and homophily. A more comprehensive analysis would require temporal network data that includes a time dimension to observe how ties form dynamically and whether preferential attachment emerges over time. However, the data source used to construct the network did not provide the temporal granularity required for such an analysis.

Conclusion

Our analysis of tie formation in testimonial networks with ERGM reveals that although the probability of forming ties in the network is low, reciprocity, transitivity and homophily are the key mechanisms driving tie formation in the network. Reciprocity fosters balanced relationships through mutual exchanges, while transitivity highlights the role of shared connections in forming cohesive substructures, even in sparse networks. Homophily, driven by shared characteristics such as publisher affiliation, genre and gender, significantly influences tie formation. The strong effect of publisher affiliation underscores their role in coordinating testimonial exchanges, while genre alignment further emphasizes the importance of thematic similarity in establishing connections. In contrast, there is no evidence supporting preferential attachment in this context, suggesting that testimonial networks are shaped less by hierarchical dynamics and more by relational and shared characteristics.

In summary, this study provides important insights into testimonial networks, highlighting the key factors driving tie formation. By leveraging the dynamics of testimonial networks and identifying the core mechanisms that drive engagement, authors and publishers can craft targeted strategies to maximize reach, build brand authority, and create a viral ripple effect. These networks act as high-impact marketing assets, boosting credibility, enhancing audience engagement, and driving conversion rates, ultimately positioning books as must-have products in a competitive marketplace. Besides the ERGM Analysis a central contribution of this work is the creation of a novel dataset specifically tailored for ERGM analysis, derived from the book data available in an online bookseller store. Given the limited research on testimonial networks, this work addresses a significant gap in the research and establishes a foundation for future studies in this area.

Building on this foundation, future work could expand the scope of testimonial networks to include additional genres such as non-fiction or examine books authored by multiple writers to explore collaborative dynamics. Temporal analyses could further enhance understanding of how preferential attachment evolves over time. Moreover, future datasets should aim for greater inclusivity by addressing the absence of non-binary authors and could incorporate networks from other bookseller platforms to improve generalizability and robustness of findings.

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EFFECTS OF DIGITAL CHANNEL ACCEPTANCE ON INTERNAL COMMUNICATION CHANNEL SATISFACTION

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Abstract

The purpose of this paper was to determine whether an employee's attitudes towards digital internal communication channels have an impact on their channel perception, including both traditional and digital channels. With technological advances, it is crucial for organizations to understand how to make internal communication channel choices in order to adhere to their employees' preferences while also conveying the message as needed. The study was conducted as a part of a diary method research among 201 participants who reported their daily internal communication activities thought five days. The results showed that facilitating conditions within an organization, which reflect the availability of technical, personnel and educational resources, affects an employee's satisfaction with all internal communication channels and social influence affects only satisfaction with rich internal communication channels. This indicates organizations need to put their focus on facilitating conditions needed for all types of communication, with an emphasis on digital communication. They should also enable and encourage their employees to form strong social relationships among themselves to increase satisfaction.

Keywords: internal communication, internal communication channels, digital channel acceptance, channel satisfaction; media richness theory

JEL classification: M31, M39, M54, M59

Introduction

Communication is a crucial activity within any company. It defines organizational success (Tourish & Hargie, 2009) and innovativeness (Kanter, 1988), affects overall employee performance (Kowan, 2017), engagement (Tkalac Verčič & Pološki Vokić, 2017) and life satisfaction (Sinčić Ćorić et al., 2020). It contributes to employees' employer perception (Špoljarić & Tkalac Verčič, 2022), corporate reputation (Gotsi & Wilson, 2001) and ultimately customer loyalty (Awan et al., 2015). Due to its vast influence, internal communication has been a topic of interest for quite some time. However, it has been studied from many perspectives and only recently have communication experts started to claim this crucial organizational function (Tkalac Verčič, 2025).

Digital advances and new channels have opened a new insight into issues internal communication deals with. Channel choices made by organizations and employee preferences have sparked various studies (i.e., Friedl & Tkalac Verčič, 2011; Tkalac Verčič & Špoljarić, 2020), but at the same time demonstrate the need for further understanding of the topic. Even more so now, with complete transformation of business management organizations have gone through recently (DeFilippis et al., 2022).

This study explores how communication digitalization impacts internal communication channels in order to determine if channel satisfaction increases with unavoidable digital transformation and adoption of technological advances.

Literature review

Internal communication

Internal communication is a strategic function within an organization that promotes two-way communication between management and employees, as well as between peers. It is confined by the organizational boundaries, meaning it is communication among internal stakeholders (Kalla, 2005). However, it is becoming harder to define the exact boundaries of an organization (Tkalac Verčič et al., 2012), especially in recent years post hurried digitalization of communication that occurred after the COVID-19 pandemic (DeFilippis, 2022). Nevertheless, it “inform[s], motivate[s], engage[s] and co-create[s] meaning in order to make organizations more effective” (Tkalac Verčič et al., 2023, 10), no matter where these organizational boundaries begin or end.

The role of internal communication is to enable information exchange that will increase employee performance and ensure understanding within the organization (Bahtijarević-Šiber & Sikavica, 2001). It is crucial in promoting employee engagement (Mishra et al., 2014), which in turn affects even personal life of employees, leading to higher levels of happiness (Lalić et al., 2020). Communication even helps manage culture by fostering relationships within organizations (Men & Stacks, 2014) and creating corporate ambassadors (Men, 2014). It helps create and manage employer perception through (internal) employer branding (Špoljarić & Tkalac Verčič, 2022; Špoljarić, 2023). However, the scope of internal communication has been steadily expanding (Ruck & Men, 2021) with digital transformation society is experiencing (Tkalac Verčič et al., 2024).

Digital internal communication

The biggest changes in internal communication have been happening in recent years with introduction of innovative business models which required a novel approach to communication practices. Reinforced influence of digital transformation on internal communication happened as a consequence of COVID-19 pandemic which brought unexpected, but unavoidable changes to the field (Aced Toledano et al., 2022). It introduced new digital platforms that enabled business to function as normal, assisting communication and collaboration between employees (Tkalac Verčič et al., 2024).

Even prior to COVID-19, research found that some of the most valuable and influential are those employees who actively advocate their organizations on social media (Sakka & Ahammad, 2020; Tench et al., 2017). However, most of digital internal communication efforts have been focused on bridging the gap for remote workers, since the work-from-home employees has been steadily increasing, reaching 28% in 2023 worldwide (Statista, 2025).

These changes to communication practices are so significant that some authors consider digital internal communication to be a completely new dimension of communication (Wuersch et al., 2023), while others extensively explain new aspects of internal communication that are

emerging with digitalization (Men, 2021). Whichever it may be, mode of communication changed significantly, emphasizing the role of digital channels even more than previously.

Internal communication channels

Generally speaking, communication channels are the means through which organizations deliver their messages, to both internal and external publics. In order to do so, they use a mix of channels, i. e. communication mix, that consists of traditional and digital channels (Tkalac Verčič et al., 2023; Tkalac Verčič et al., 2024).

Internal communication channel choice is a management decision based on message requirements and employee channel preferences. However, channel preferences research has surprised many with its findings, considering employees' private channel preferences do not necessarily match their internal communication channel preferences (Friedl & Tkalac Verčič, 2011). It is also imperative for communication experts to understand that different channels will have various levels of efficiency (i. e., satisfaction, reach and ability to convey the message) at different times and to different segments of employees (Kovaitė et al., 2020). Based on these characteristics, organizations will form their internal communication channel mixes, consisting of traditional and digital channels, including face-to-face communication, print media, e-mails, video calls and so on.

However, one of the most significant channel characteristics that always needs to be considered since it has an exponential impact on channel satisfaction (Tkalac Verčič et al., 2020) is the ability to convey rich information. This ability is thoroughly described by media richness theory (Daft & Lengel, 1984; 1986), according to which rich channels are those that are able to deliver rich information (verbal and non-verbal cues), moderate are those that are able to deliver moderately rich information and lean are those that are not able to deliver any rich information. The richest channel is considered to be face-to-face communication, but with technological advances, video call platforms are closely following suit. Moderate channels are the ones that enable two-way communication and interactivity, but fall behind with conveying non-verbal cues as accurately as face-to-face. For example, town hall meetings are considered to be moderate since there are a lot of participants, and corporate social networks are considered moderate because participants are not able to see each other. Lean channels, such as newsletters and information boards, do not offer any level of two-way communication. That being said, all of the channels do have their spot within the internal communication channel mix, since not all communication should be delivered through rich channels, and not all communication is appropriate to be delivered through lean channels (Špoljarić, 2023).

Digital channel acceptance

The idea of digital channel acceptance builds on technology acceptance model (TAM) (Davis, 1986). TAM suggests perception of technology affects how technology-users behave (Marangunić & Granić, 2015). For example, how much someone uses certain technology and how they use it will be dependent on if they perceive that technology to be useful and relatively easy to use.

Digital channels do fall under the TAM, however, the idea of digital channel acceptance was further developed and expanded according to nuances internal communication requires. Therefore, digital channel acceptance combines technology acceptance propositions with internal communication requirements (Tkalac Verčič, Einwiller et al., 2024). It could be

defined as an employee's perception of digital channels used for internal communication based on (1) how efficiently the channel facilitates communication, (2) what is the level of privacy and data security concerns, (3) which personal skills are necessary to use the channel and if they have those skills, (4) what is the level of usefulness of the channel, (5) how extensive is in-organizational support and (6) what are expectations within the organization, regarding the usage of the channel.

Digital channel acceptance, based on its definition, could have a significant impact on channel satisfaction. Therefore, this study aims to test this relationship and proposes the following research question:

RQ: Does an employees' digital channel acceptance level have an impact on their perception of internal communication channels?

Methodology

This study was conducted as a part of an international research project on digital internal communication. The aim of the project is to determine the scope of digital internal communication within organizations and define its impact on various employee behaviors and attitudes, such as the level of employee engagement and employee's life satisfaction. Within this study, the aim was to focus on individual internal communication channels and test how internal communication channels impact internal communication practices.

The data was collected in two waves, first in March and April of 2024, and then in July and August of 2024. It was a requirement of the study the participants used digital channels in their internal communication. The participants were a part of an online survey panel from all over the country and various industries. Data collection was conducted using diary method for five days at four different points during each day. The participants were instructed to reflect on their internal communication activities between each time period by reporting types of internal communication channels they and their colleagues used, duration and frequency of communication, as well as the level of satisfaction with the channel itself. On the last day they were also asked to fill out a survey that measured their digital channel acceptance and internal communication satisfaction.

Participants

A total of 201 participants took part in this research. The demographics are shown in Table 2.

Table 1: Sample demographics (N = 201)

	Number of participants		%		Total
	1 st wave	2 nd wave	1 st wave	2 nd wave	
Gender					
Male	42	30	43.8	28.6	72
Female	54	75	56.3	71.4	129
Age group					
23-30	10	9	10.4	8.6	19
31-40	31	17	32.3	16.2	48
41-50	26	60	27.1	57.1	86
51-60	26	16	27.1	15.2	42
>60	3	3	3.1	2.9	6

	Number of participants		%		Total
	1 st wave	2 nd wave	1 st wave	2 nd wave	
Mode of work					
From the office	79	32	82.3	30.5	111
From home	1	0	1.0	0	1
Hybrid	16	73	16.7	69.5	89
Education level					
High school education	20	12	26.0	11.4	32
Higher vocational education	23	18	24.0	17.1	41
Bachelor's degree	1	22	1.0	21.0	23
Master's degree	40	47	41.7	44.8	87
Master of science	6	4	6.3	3.8	10
PhD	1	2	1.0	1.9	3

Measures

Digital channel acceptance was measured by using digital channel acceptance scale (DICAS) developed by Tkalac Verčič et al. (2024). This 24-item scale consists of six dimensions that reflect employee's digital channel perception from the internal communication perspective. In that regard, *interaction facilitation* measures employee's perception of digital channel effectiveness, efficiency and contributions to internal communication with items such as "Through CommTech, it becomes effortless to engage in productive discussions" and "CommTech promotes effective communication." *Apprehension* is the only dimension that measures negative attitudes towards digital channels. It reflects concerns an employee might have due to using digital channels, such as privacy and data security issues. It is measured with items such as "The potential risks to my privacy make me hesitant when using CommTech" and "Using CommTech makes me feel anxious about the potential threats to my privacy." *Effort expectancy* demonstrates how and employee's personal skills contribute to digital channel usage. This includes both how they manage to embrace new digital channels, as well as how they cope with the channels they are already familiar with. It is measured with items such as "It is easy for me to become skilful at using CommTech" and "I find CommTech easy to use." *Performance expectancy*, on the other hand, displays an employee's expectations of digital channels and the level of their perceived usefulness in everyday work activities. "Using CommTech increases my work productivity" and "CommTech helps me to do my job better" are some of the items that measure this dimension. *Facilitating conditions* is a dimension of DICAS that reflects organizational support in using digital channels by providing all the needed resources, such as education, technical resources and even people whose role is to assist with any issues. It is measured with items such as "A specific person (or group) is available for assistance with any difficulties I have using CommTech" and "My organization provides the technical resources required for using CommTech." The last dimension, *social influence*, illustrates how colleagues and their attitudes and behavior impact an employee's perception of digital channels and their usage. This includes both managers and superiors, as well as team-members. Items such as "People at work who are important to me think that I should use CommTech" and "I believe using CommTech aligns with the organizational expectations" measure this dimension.

Internal communication is usually operationalized through internal communication satisfaction (Tkalac Verčič et al., 2009). It is a measure that shows the level of satisfaction with internal communication practices, activities and channels, both formal and informal. Building on that, internal communication channel perception was operationalized through internal

communication channel (ICC) satisfaction. Since there is no validated scale for measuring ICC satisfaction, the participants were asked to report their channel satisfaction at each data collection point. This means they reported their ICC satisfaction with face-to-face communication, group meetings, e-mails, phone calls, internal communication social media apps and video calls thought a five-day period at 4 different points during the day, but only *after* they have used a certain mode of communication. This way if participants used, for example, e-mails on all five days, at all four data collection points during each day, they would have reported 20 levels of satisfaction with e-mails. However, if they never use, for example, internal communication, social media apps, they would not have reported any satisfaction with apps. Overall ICC satisfaction for each channel was then calculated using participant's reported satisfaction with each channel and determining the mean value.

Results

In order to determine if digital channel acceptance level has an impact on internal communication channel perception, a regression analysis was conducted. All initial steps were conducted, scale reliability was determined with Cronbach's alpha coefficients and Pearson correlation coefficients between all variables were calculated (Table 2). Since channel satisfaction was not measured using a scale, Cronbach's alpha coefficients were not reported. DICAS dimensions Cronbach's alpha coefficients ranged from .783 to .900, making the scale appropriate for further analysis (Nunnally, 1987).

Variable means were also calculated, ranging from 5.77 up to 6.10 for ICC satisfaction and from 3.82 up to 5.90 for DICAS dimensions. Person correlation coefficients showed mostly weak ($.1 \leq r < .4$) to moderate ($.4 \leq r < .7$) but still statistically significant correlations between all variables (Akoglu, 2018). *Apprehension*, as one of the DICAS dimensions, however, was not significantly correlated with any of the ICC satisfactions nor the rest of the DICAS dimensions. *Interaction facilitation* also showed some weak and even some insignificant correlations to ICC satisfactions. Similarly, satisfaction with internal communication (social media) apps also showed mostly insignificant correlations to DICAS dimensions, apart from *facilitating conditions*.

Table 2: Mean, standard errors, Cronbach's alfa coefficients and Pearson correlations between internal communication channel satisfaction and DICAS dimensions

	M	SD	A	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. SwFTF	6.10	.839	/	1											
2. SwGM	5.88	.978	/	.674**	1										
3. SwEM	5.77	.871	/	.740**	.568**	1									
4. SwPC	5.93	.854	/	.767**	.567**	.756**	1								
5. SwAPP	5.90	.887	/	.587**	.441**	.663**	.592**	1							
6. SwVC	6.02	.925	/	.684**	.606**	.622**	.654**	.592**	1						
7. IF	5.65	1.017	.852	.140	.128	.323**	.179*	.139	.263**	1					
8. A	3.82	1.506	.835	-.014	-.056	.064	-.022	-.055	.016	.094	1				
9. EE	5.90	.831	.853	.223**	.225**	.231**	.232**	.181	.208*	.515**	-.044	1			
10. PE	5.83	1.016	.900	.157*	.164*	.293**	.195**	.168	.224*	.739**	-.018	.598**	1		
11. FC	5.63	1.145	.867	.323**	.314**	.350**	.309**	.288**	.353**	.491**	-.090	.604**	.608**	1	
12. SI	5.51	1.076	.783	.299**	.311**	.232**	.195**	.116	.283**	.406**	-.062	.427**	.536**	.514**	1

Note: SwFTF = satisfaction with face-to-face interactions; SwGM = satisfaction with group meetings; SwEM = satisfaction with e-mail communication; SwPC = satisfaction with phone calls, SwAPP = satisfaction with internal communication (social media) apps; SwVC = satisfaction with video calls; IF = interaction facilitation; A = apprehension; EE = effort expectancy; PE = performance expectancy; FC = facilitating conditions; SI = social influence.

** $p < .010$

* $p < .050$

Results from the conducted regression analysis are shown in Table 3.

Table 3: Regression analysis of DICAS dimension's effect on internal communication channel satisfaction

DV	IV	B	SD (B)	β	t	p (t)
SwFTF $R^2 = .142$	IF	.008	.084	.010	.094	.925
	A	.014	.038	.026	.373	.709
	EE	.061	.092	.060	.663	.508
	PE	-.141	.097	-.169	-1.454	.148
	FC	.201	.070	.275	2.887	.004
	SI	.170	.065	.218	2.631	.009
SwGM $R^2 = .135$	IF	-.027	.108	-.030	-.253	.800
	A	-.011	.050	-.018	-.219	.827
	EE	.067	.129	.057	.524	.601
	PE	-.106	.132	-.105	-.804	.422
	FC	.214	.107	.232	1.996	.048
	SI	.208	.092	.223	2.274	.024
SwEM $R^2 = .159$	IF	.169	.086	.197	1.955	.052
	A	.041	.040	.071	1.041	.299
	EE	-.043	.095	-.041	-.453	.651
	PE	-.015	.098	-.018	-.154	.878
	FC	.206	.072	.270	2.876	.004
	SI	.039	.066	.049	.594	.553
SwPC $R^2 = .101$	IF	.034	.091	.040	.377	.707
	A	.004	.041	.007	.098	.922
	EE	.069	.100	.068	.688	.492
	PE	-.052	.102	-.062	-.513	.609
	FC	.193	.074	.261	2.605	.010
	SI	.040	.070	.051	.577	.564
SwAPP $R^2 = .092$	IF	.058	.117	.072	.499	.619
	A	-.039	.054	-.070	-.724	.471
	EE	.018	.136	.017	.133	.895
	PE	-.124	.153	-.152	-.809	.420
	FC	.268	.109	.352	2.449	.016
	SI	-.007	.092	-.008	-.073	.942
SwVC $R^2 = .172$	IF	.138	.114	.147	1.210	.229
	A	.027	.053	.044	.513	.609
	EE	.024	.127	.019	.187	.852
	PE	-.120	.129	-.122	-.931	.354
	FC	.305	.113	.285	2.692	.008
	SI	.189	.092	.195	2.044	.043

Note: For abbreviations, please refer to the note under the Table 2., $p < .050$

The results show that DICAS dimension *facilitating conditions*, which reflects level of support and organizational attitudes towards digital communication, is a significant predictor of satisfaction with all studied internal communication channels. DICAS dimension *social influence*, which reflects social relationships and their impact on individual internal communication channel choices, is a significant predictor of satisfaction with face-to-face communication, satisfaction with group meetings and satisfaction with video calls. Other DICAS dimension, which are *interaction facilitation*, *apprehension*, *effort expectancy* and

performance expectancy, are not significant predictors of any satisfaction with studied internal communication channels.

Discussion

This study was conducted to test how digital channel acceptance impacts employees' perception of internal communication channels, both traditional and digital. According to results, some aspects of digital channel acceptance do in fact influence ICC satisfaction. *Facilitating conditions*, which reflect the availability of technical, personnel and educational resources, affects an employee's satisfaction with all internal communication channels and *social influence* affects only satisfaction with rich internal communication channels, i.e. channels that are able to deliver verbal and non-verbal cues.

The results showcased the importance of *facilitating conditions*. This indicates that ICC satisfaction is significantly influenced by organizational support and attitudes towards internal communication channels. The more support they perceive; employees will report higher levels of channel satisfaction. This support includes assistance from their organization (from an individual or a group) when experiencing any difficulties, or assurance of adequate technical resources necessary for specific channel to be used properly. Also, *social influence* has some significant effects on channel satisfaction. This indicates that perceived social relationships are significantly reflected in rich internal communication channels, which are face-to-face communication, meetings and video calls. Rich internal communication channels are able to transfer rich information, including both verbal and non-verbal cues and large quantities of information. Those channels that are not considered rich, but lean or moderate, such as e-mails, phone calls and internal communication apps, are not impacted by *social influence* dimension, which was to be expected, since they do not facilitate social relationship building and maintaining.

On the other hand, while it was expected some of the DICAS dimensions will not be shown as significant predictors of ICC satisfaction, some of these results were still surprising. For instance, *interaction facilitation* reflects efficiency of colleague-to-colleague or team communication, but it does not have a significant influence on satisfaction with group meetings. This means participants might not have perceived team meetings as part of "group meetings", or that most of the meetings organized were for superiors to address their subordinates. *Apprehension*, which reflects privacy and data security concerns, is not a significant negative predictor of any channel satisfaction, not even satisfaction with communication via e-mail. Perhaps this confirms high level of support participants experience within their organizations, as well as their knowledge on different cyber security measures.

It is also an interesting finding that participants who have a greater acceptance of digital channels also find some traditional channels, such as face-to-face communication, to be more satisfying. The implication of this finding is twofold. First, it seems organizations that are more prone to facilitate conditions necessary for digital channels usage are also more prone to facilitate conditions for traditional channels. Perhaps facilitating conditions are universal for each organization, meaning if certain communication conditions are facilitated, all communication conditions will be facilitated. Organizations that are concerned with their communication will be equally concerned, regardless of the mode of communication. Of course, any investments into communication quality and satisfaction will positively influence relationships within the organization, meaning it is expected social relationships created among

coworkers will directly increase employees' channel satisfaction. Second, employees who are more prone to digital communication and channels are also probably more prone to any type of communication. Perhaps they also have a greater understanding of which information they deem appropriate to be shared via digital channels and which they prefer to receive digitally. It could mean their preferences are therefore better met, which results with greater channel satisfaction. Digital channel acceptance expectedly impacts satisfaction with digital channels. However, only certain aspects of digital channel acceptance play a significant role in channel satisfaction. It should be noted, though, that strong significance of *facilitating conditions* and *social influence* was anticipated. Both of these DICAS dimension represent organizational culture and perceived support, which were previously shown to have a significant impact on internal communication and satisfaction with it (Tkalac Verčič, 2021).

Limitations and future studies

Internal communication channels are a topic of increasing interest in public relations domain (Tkalac Verčič et al., 2023). While this study explored an aspect of this issue, there are some limitations that should be considered. First, the data used for this study was collected in only one country. This means there are no cultural influences being considered in the results reported. It is also not appropriate to generalize the findings due to this. Even though it was measured at 20 different points in time, satisfaction with each internal communication channel was only measured with one item. Also, self-reported data, which was used here, is considered biased (Rosenman et al., 2011). In addition, the data was collected as a part of a diary method research, meaning the sample was small. This was taken into consideration while interpreting levels of statistical significance.

In the future, more culturally diverse samples should be used to confirm the findings of this study. Additionally, along with channel satisfaction, researchers should consider studying employee preferences and building on the internal communication channel preferences literature. Since digital channel acceptance greatly depends on certain personal traits, an additional insight into personality traits' impact could be considered. Also, mixed methods research into the topic could be of great impact since it could further investigate facilitating conditions required for higher levels of channel satisfaction. A study of indirect effects of digital channel acceptance should also be conducted.

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